



United States
Department of
Agriculture

Forest Service

Pacific Southwest
Research Station

General Technical
Report
PSW-GTR-233

April 2013



The Search for Forest Facts: A History of the Pacific Southwest Forest and Range Experiment Station, 1926–2000

Anthony Godfrey



The Forest Service of the U.S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the national forests and national grasslands, it strives—as directed by Congress—to provide increasingly greater service to a growing Nation.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, sex, religion, age, disability, sexual orientation, marital status, family status, status as a parent (in education and training programs and activities), because all or part of an individual's income is derived from any public assistance program, or retaliation. (Not all prohibited bases apply to all programs or activities).

If you require this information in alternative format (Braille, large print, audiotape, etc.), contact the USDA's TARGET Center at (202) 720-2600 (Voice or TDD).

If you require information about this program, activity, or facility in a language other than English, contact the agency office responsible for the program or activity, or any USDA office.

To file a complaint alleging discrimination, write USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410, or call toll free, (866) 632-9992 (Voice). TDD users can contact USDA through local relay or the Federal relay at (800) 877-8339 (TDD) or (866) 377-8642 (relay voice users). You may use USDA Program Discrimination Complaint Forms AD-3027 or AD-3027s (Spanish) which can be found at: http://www.ascr.usda.gov/complaint_filing_cust.html or upon request from a local Forest Service office. USDA is an equal opportunity provider and employer.

Author

Anthony Godfrey is president, U.S. West Research, Inc., 2395 Fisher Lane, Salt Lake City, UT 84109. U.S. West Research, Inc. a public history and cultural resource management firm.

Pesticide Precautionary Statement

This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate state or federal agencies, or both, before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife—if they are not applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

Cover: 1914. John M. Miller (on right), pioneer in Western forest entomology and bark beetle control projects with USDA Forest Service. **Credit:** U.S. Forest Service, Pacific Southwest Research Station.

Abstract

Godfrey, Anthony. 2013. The search for forest facts: a history of the Pacific Southwest Forest and Range Experiment Station, 1926–2000. Gen. Tech. Rep. PSW-GTR-233. Albany CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 542 p.

In 1926, the California Forest Experiment Station, which later became the Pacific Southwest (PSW) Research Station, was established at the University of California, Berkeley. Today, the PSW Research Station represents the research and development branch of the USDA Forest Service in California and Hawaii and the U.S.-affiliated Pacific Islands. The PSW Research Station develops and delivers science-based information, technologies, and applications to help people make informed decisions about natural resource management, conservation, and environmental protection. This comprehensive history covers forestry science in California, Hawaii, and the Pacific Islands by the Forest Service prior to 1926 and then that of the PSW Research Station to 2000. The growth of forestry research in America and California is described. The publication considers forest research in context of the New Deal, World War II, environmental forestry, and ecosystem research in California and Hawaii.

Keywords: Forestry, science, history, California, Hawaii, research.

Acknowledgments

As with any project of this scale, there are countless people and institutions to thank for their contributions.

First and foremost, I would like to thank Pacific Southwest (PSW) Research Station Communications Staff Marilyn Hartley (retired) and Keiko Williams who patiently served as the designated Contracting Officer Representatives (CORs) for this project. In late 2005, as I sat in a tiny windowless backroom at the PSW headquarters in Albany, California, pouring through catalogued and neatly boxed up historical documents and photographs stored in anticipation of my arrival, Marilyn Hartley, along with visual information specialist Martha Shibata, worked closely with me and provided daily kindness and encouragement during the project's initial research stage. In 2006, Keiko Williams picked up responsibility for the project and thereafter carried it diligently through until publication. During this time period, Lynn Sullivan, editor for the Pacific Northwest Research Station, Portland, Oregon, made the necessary formatting and editorial changes to meet Forest Service scientific publication requirements. While the manuscript underwent these revisions, Ms. Williams, along with Beth Purcille at PSW headquarters, conducted the tedious, but very necessary, clerical work involved, such as tracking down literature citations and locating and selecting historic photographs for the manuscript. Additionally, I am grateful to James R. Sedell for initiating the undertaking before his retirement, as Station Director of PSW Research Station.

There are also my debts to various institutions and repositories for their assistance. For instance, I am indebted to Irene Voit, technical information specialist for the Rocky Mountain Research Station Library, Ogden, Utah, for providing valuable Forest Service publications and photocopying services. I am also appreciative for the aid and hospitality of Director Richard Boyden of the National Archives and Records Administration at San Bruno, California, as well as his staff, for working with me to locate critical material in the holdings of Record Group 95 (Records of the Forest Service).

Once a substantial draft was completed, the Forest Service solicited three peer reviewers for the project. They included James Lewis, staff historian for the Forest History Society, Durham, North Carolina, and author of *The Forest Service and the Greatest Good: A Centennial History* (2005), retired assistant director of the PSW Research Station Enoch F. Bell, and former natural resource economist with the USDA Forest Service Daina Dravnieks Apple. James Lewis and Enoch Bell provided astute, knowledgeable, and comprehensive commentary on the manuscript

along with detailed edits, while Apple offered new information on Management Sciences Staff (MaSS), the internal think tank for the Chief's office that was part of PSW from 1962 to 1988.

Others to whom I owe particular recognition for aid in preparing this book are my long-time colleague and friend Roy Webb at the University of Utah Marriott Library for his usual stylistic admonitions, and the staff of U.S. West Research, Inc. in Salt Lake City for the long hours they put into this project, especially Woody "the dog" Mogelthorpe. Finally, I want to extend my gratitude and love to Deborah L. Gardner, my wife. Although she had no active part in the production of the book, her caring support and sacrifices were indispensable during the final stages of this project.

Anthony Godfrey, Ph.D.

U.S. West Research, Inc.

Salt Lake City, Utah

July 2010

CONTENTS

1	Introduction
5	Chapter 1: 1785–1904, Growth of Forestry Research in America and California
41	Chapter 2: 1905–1925, Forest Service Research in California
105	Chapter 3: 1926–1932, Forestry Research Comes of Age in California
167	Chapter 4: 1933–1941, A New Deal for Forest Service Research in California
235	Chapter 5: 1941–1945, Off to War
257	Chapter 6: 1946–1962, Golden State of Research
323	Chapter 7: 1963–1979, Environmental Forestry Research
379	Chapter 8: 1980–1994, Ecosystem Research
433	Chapter 9: 1995–2000, Epilogue
443	Scientific and Common Names
446	References
507	Index of People
520	Index of Subjects

Introduction

The history of the Pacific Southwest (PSW) Research Station nominally began on July 1, 1926, when the California Forest Experiment Station was dedicated. On that day, it occupied a modest four rooms in Hilgard Hall on the campus of the University of California, Berkeley. For the next 33 years, the California campus would be its home. But the Station's roots stretch back in time more than a century when the seed of forestry science first blew ashore from Europe and found fertile ground in America.

Chapters 1 and 2 recount the significant national and California events that led in 1926 to the founding of the California Forest Experiment Station. Intertwined within their pages are the key scientific ideas, principles, and people who appreciably contributed to the growth of forestry science within the branches of federal and California state government from the late 18th and early 19th century to 1926.

From that point, chapters 3 through 5 carry the story from 1926 to the end of World War II. These chapters discuss the coming of age of forestry research at the California Forest Experiment Station as it transformed in 1932 into the California Forest and Range Experiment Station (CFRES). The passage of the McSweeney-McNary Research Act (1928) helped fund, focus, and direct CFRES research projects along six lines, or functional divisions, of research: forest management, utilization of wood and other forest products, forest protection, forest influences, range research, and forest economics. By 1932, CFRES personnel had grown to 26 permanent staff, along with many clerks and cooperating personnel from other U.S. Department of Agriculture agencies. Additionally at that time, CFRES drew upon University of California students, or other short-term assistants to meet the station's research demands. During the remainder of the 1930s, the station continued to grow as it took advantage of the labor and funding provided by Franklin Delano Roosevelt's New Deal programs, like the Civilian Conservation Corps, Public Works Administration, and Works Progress Administration. At this time, CFRES also increased its forestry research program into genetics—a seventh line of research—when in 1935 it acquired the Institute of Forest Genetics, a private research institution located at Placerville, California. The station also acquired several new experimental forests and ranges in California for various research purposes during the New Deal years, such as the Blacks Mountain (1934), San Dimas (1934), and Redwood (1940) Experimental Forests, and the Burgess Spring (1935) Experimental Range. By 1939 and the approach of world war, CFRES had the personnel, funding, facilities, and experimental forests and ranges to match most of its research needs. However, during World War II, the CFRES research program diverted resources to the war effort, and retrenchment nibbled the station's domestic research program to the bone.

From 1946 to 1962, a postwar boom in California energized CFRES, and it eventually regained its former investigative abilities and capacities. By the early 1960s, the station entered into a “golden state” of research. As described in chapter 6, CFRES broke away from traditional ways of doing things through an administrative reorganization that moved the government agency off the University of California campus. At the same time, CFRES sought and acquired significant contributions of cooperative funding. In the 1950s, fundamental forestry knowledge took a back seat as the Forest Service sought to solve intensive management problems through applied science. Additionally, by 1959, as a consequence of the administrative boundary of the station being extended to Hawaii, the station was renamed the Pacific Southwest Forest Research Station. The PSW Research Station had by this time a corps of more than 100 research specialists who had acquired their scientific skills from the country’s finest universities—including the University of California. In addition to the station’s six experimental forests (Blacks Mountain, Yurok, Swain Mountain, Challenge, Stanislaus, and San Dimas), there were four experimental ranges (Burgess Springs, Harvey Valley, San Joaquin, and Teakettle Creek), three insect laboratories (Hat Creek, Miami, and Orleans), a fire laboratory (Pilgrim Creek), two experimental watershed research areas (Sagehen and Big Creek), and the Institute of Forest Genetics. However, while station scientists busied themselves in their research and field laboratories trying to meet California and Hawaii’s practical forestry research needs, national research shifted direction toward university-based forestry that pertained to the public’s growing environmental awareness following the publication of Rachel Carson’s *Silent Spring* (1962).

During the years 1963 to 1979, as told in chapter 7, the PSW Research Station eventually fell in line with the nascent environmental movement, but first had to undergo critical administrative changes. The PSW scientists were given more opportunity to pursue their interests, and the station improved communication between research scientists and the people who used the station’s research results with articles in *Forestry Research: What’s New in the West*. They now worked in research work units (RWUs) instead of the old functional divisions of a long-term national research program, whereby individual RWU project leaders decided independently what aspects of the research to prioritize. At the same time, equal employment opportunity issues arose, and station directors were confronted with calls for an employee union, followed by charges of discrimination against minorities and women in hiring and promotion—particularly the class action lawsuit *Gene Bernardi et al. v. Earl Butz*. Despite management reform issues, station investigations pursued critical research in the environmental era in several ways.

Interdisciplinary RWUs investigated forest insect control strategies that did not use toxic insecticides that disrupted biological systems. Other RWUs investigated the effect of air pollution on California's forests, while yet other PSW scientists studied water management and snowpack density in the Sierra Mountains and the ability to provide adequate supplies to dependent urban areas below. Fire research was as complex as watershed research. Projects such as FIREScope improved communication between agencies fighting fires and developed fire management plans for the wild lands of southern California. Recreation and urban forestry were also new research assignments for the PSW Research Station. Finally, forestry research at PSW included environmental studies in Hawaii, Guam, and elsewhere in the Pacific Islands. They studied how fires, insects, diseases, feral animals, and aggressive noxious and exotic plants damaged native forests. All the above research work was conducted alongside continued research in more traditional areas in California, such as pine and redwood management, genetics, range management, and similar research pursuits. By 1979, the PSW Forest and Range Experiment Station had reached the apex of its growth as an institution. The station's investigations during the environmental era from 1963 to 1979 continued to reflect an applied science philosophical preference.

Starting a year later, faced with high inflation, even higher interest rates and other economic problems, the Reagan administration worked for and achieved unprecedented tax and budget cuts. They seriously affected the PSW Research Station at a time when the public called for ecosystem management of the Nation's resources. By the end of the decade, this new ethos exhibited a concern for a common natural world, and spanned class, region, gender, ethnicity, and political lines in the state. This same movement developed among the Forest Service scientific community as well, resulting in ecosystem management. Naturally, it took time for the station to evolve from a problem-organized institution to an interdisciplinary ecosystem research organization. Chapter 8, the final chapter, explains how this transition in research goals took place in an era of shrinking budgets, retirements, competitive grants, and a relocation to new headquarters. Nonetheless, achievements were made in forest environmental research in California and Hawaii, and the station tackled diverse problems in both regions from the spotted owl controversy in California to saving Hawaii's native rain forests from invasive nonindigenous species.

An epilogue follows that overviews how Forest Service reorganization plans at the end of the 20th century affected the revitalization of the Pacific Southwest Research Station in the 21st century.

Chapter 1: 1785–1904, Growth of Forestry Research in America and California

The beginnings of forestry as a science in North America came in the late 18th and early 19th centuries—a time when modern American science was just emerging. As it materialized, science in America developed along the lines of “fact gathering,” whose ultimate aim was to find some specific economic utilitarian goal for the gathered facts. In short—applied science. To early American scientists, maximum gain clearly overrode any quest or thirst for pure basic scientific knowledge. In practice, as one author noted, American men of science hotly pursued the “nearest visible fact, counted it a goal achieved, then went on to bag the next.... [And] they made no effort to look beyond the necessities of the immediate present” (Bruce 1987). The full value of theoretical science would not be realized until the 20th century.

If early scientific interest in America’s forests began as a matter of applied science, its earliest students were Andre Michaux and his son Francois Andre Michaux—botanical explorers of North America. During the period 1785 to 1796, the elder Michaux traveled around North America’s eastern forests, and his son later extended and intensified the work his father initiated. Their work mixed botanical, horticultural, and forestry cultural observations, which found expression in several successful writings. They also pointed out one driving detail in the history of American forestry research—the Americans’ consumption of the continent’s wooded heritage at an alarming rate with no regard for the future. In 1803, Andre Michaux in his classic *Flora Boreali-Americana* observed that unlike Europe, “neither the federal nor state governments were reserving forest lands to safeguard the nation’s future economy.” Almost 15 years later, Francois Andre Michaux finished his notable three-volume work, *The North American Sylva: A Description of the Forest Trees of the United States, Canada, and Nova Scotia* (1819). Worthy of note in it was Michaux’s warning of the “alarming destruction of trees proper for building.” He again expressed his anxiety over the growing scarcity of timber and the “failure of the Federal government or the states to establish forest reserves.” Both Frenchmen were not alone in their concerns. Several American writers picked up on the theme of an impending timber famine if Americans did not change their lumbering practices. They noted the growing disappearance of the eastern forests—what one author called “the most striking change that man had made in American environment up to the end of the nineteenth century” (Dupree 1957). For instance, J.D. Brown’s *Sylva Americana* (1832) and R.U. Piper’s *The Trees of America* (1855) gave pause to some Americans regarding the growing “devastation” of America’s

American men of science hotly pursued the “nearest visible fact, counted it a goal achieved, then went on to bag the next.... [And] they made no effort to look beyond the necessities of the immediate present.”

forest resources (Dana 1956, Dupree 1957, Rodgers 1968). Nonetheless, prior to the Civil War, most Americans believed the country had inexhaustible forest reserves and treated them as such. They cleared as much as 100 million acres of land by 1850 for agriculture, with no concern for regeneration.

This laissez faire attitude toward the Nation's natural resources continued as the American logging frontier pushed westward to California. In 1816, two scientists named Louis Charles de Chamisso and Ivan Ivanovith Eschscholtz landed at the shores of San Francisco Bay as members of an around-the-world scientific expedition. During their month-long stay, they recorded many of the region's unique botanical wonders, including the California poppy (see "Scientific and Common Names" section) that later was selected as the flower emblem of the state (Mirov 1934). But it was Thomas Nuttall's *North American Sylva* (1849) that added to the Nation's botanical knowledge regarding California trees, and various parts of the Western United States, such as Oregon Territory and the Rocky Mountains.

In 1860, America's laissez faire forestry attitude shifted slightly. In that year, the Agricultural Division of the Patent Office's annual report devoted some 30 pages to the "Forest Trees of North America." As a result of people reading it, tree planting became a popular movement in the prairie states (Smith 1930), and the word "forestry" was defined for the first time in an American dictionary to mean "the art of forming or cultivating trees" (McArdle 1955). Nonetheless, the divisiveness and destruction of the Civil War pushed forestry out of most people's minds. But at the end of war, many civic leaders returned to the idea of "forestry" and a nascent forestry movement began.

In looking at the war's wreckage, some Americans also witnessed the devastation of their forests and concluded that if the rate of deforestation in the Eastern United States continued, the Nation would face a timber famine of historic proportions. Many Americans felt that such an event would not just affect the Nation's economy, but would perhaps influence the future of American civilization. This shift in thinking stemmed largely from the publication of George Perkins Marsh's *Man and Nature: Or, Physical Geography as Modified by Human Action* (1864) (fig. 1).

Marsh's work outlined the history of the destruction of Europe's forests by the late 1700s, and how Europeans had responded to their crisis by developing forestry as a science in order to meet wood shortages (Lewis 2005). He clearly synthesized the ideas and philosophies of contemporary thinkers of his day (Williams 2004), and his conservationist ethic reflected the widespread values of these naturalists. In time, his thoughts regarding environmental degradation resonated with more and more Americans (Hall 2004, Judd 2004).



Courtesy of Library of Congress,
Matthew B. Brady, photographer

Figure 1—George Perkins Marsh, author of *Man and Nature* and considered to be America's first environmentalist.

If Marsh's *Man and Nature* was the catalyst for raising concern about the adverse effects of farm clearing, Reverend Frederic Starr's *American Forests, Their Destruction and Preservation* (Starr 1866) rang the fire bell for many 19th century Americans. Appearing in the 1865 Commissioner of Agriculture's annual report, Starr's article pointedly predicted a "national famine of wood" (Dana 1956). Even though few read Starr's report, use of the term 'famine' was apt, for wood in its various forms was among the most widespread and essential materials for domestic use and industry at the time (MacCleery 1993).

The shaping of California forestry policies regarding conservation and preservation measures was inextricably involved with, and often ran parallel to, those on a national level. And like those states east of the Mississippi River, California had miners, lumbermen, stockmen, and railroaders who wanted the bounties of nature open to them and who were unconcerned about either conservation of natural resources or management and protection of forested public lands. The plundering of California's public domain resources after the Civil War was the natural outcome, but as many in the Eastern United States had realized before them, the general public and some California state officials eventually began to recognize that their state's timber was not unlimited. For instance, the California Board of Agricultural Transactions addressed the problem in their 1868–1869 annual report. One section on "Tree and Forest Culture" read,

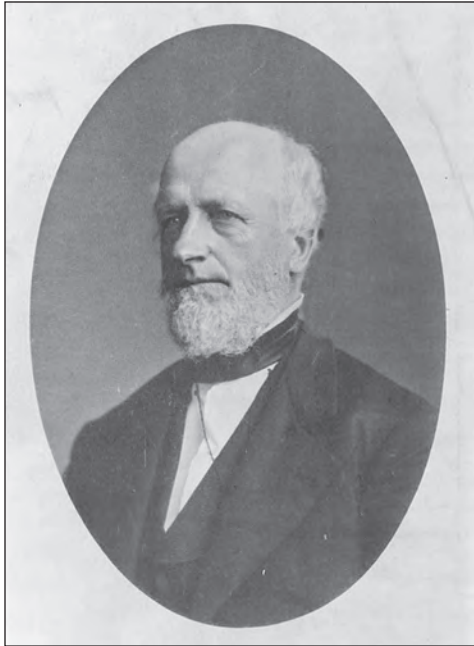
We have thoughtlessly come to regard our supply of these materials...as inexhaustible. The facts are quite different...California is far from being a well timbered state...It is now about twenty years since the consumption of timber and lumber commenced in California, and yet we have the opinion of good judges...that at least one-third of all our accessible timber of value is already consumed and destroyed! [Clar 1973: 71].

Despite the urgency of the statement, the California legislature responded with the passage of only a “mild” state law encouraging the production of trees, while the rapid, reckless, and wasteful cutting of trees continued in California and elsewhere. As lumbermen pushed fast and hard into the forests of Michigan, Wisconsin, and Minnesota to meet the Nation’s insatiable demands for wood, and as warnings of a timber shortage were voiced by men in and out of government mounted, many, like Reverend Starr, began advocating a “program of government-sponsored research on the management of forests and planting of trees” (McArdle 1955) to mitigate the sustained and disturbing rate of America’s timber consumption.

Franklin B. Hough, Nathaniel H. Egleston, and Forest Cultural Compilations, 1873–1886

In 1873, as expressions of the Nation’s concern mounted, Franklin B. Hough (fig. 2), a physician, historian, statistician, poet, and naturalist from Lowville, New York, distilled them into a paper that he presented before the American Association for the Advancement of Sciences (AAAS)¹ annual meeting in Portland, Maine. Entitled “The Duty of Governments in the Preservation of Forests,” Hough’s paper, which drew heavily from Marsh’s *Man and Nature*, convinced AAAS members to urge Congress and various state legislatures to take urgent action against unbridled exploitation of the Nation’s timbered regions. The AAAS memorial promoted conservative forest policy along with the cultivation of timber and asked for appropriate legislation to create a commission of forestry “to study and report on the amount and distribution of woodlands, the influence of forests upon climate, and on European forestry methods” (Steen 2004). Three years later, on August 15, 1876, Congress passed an appropriation act authorizing the Agricultural Department a “staggering” sum of \$2,000, to hire a “man of approved attainments” to pursue investigations and inquiries into the protection, production, and utilization of timber. Fifteen days later, Commissioner of Agriculture Frederick Watts chose Dr. Hough to discharge this duty—thus beginning an uninterrupted forestry

¹ The AAAS was organized in 1849 for the purpose of promoting progress in all the fields of science.



Courtesy of Library of Congress

Figure 2—Franklin B. Hough. Congress ordered 25,000 copies of his report on forestry (1877). Later, Hough became first Chief of the U.S. Division of Forestry in the Agriculture Department (1881–1883).

investigative (research) program in the Department of Agriculture that exists to this day (Dana 1956, Lewis 2005, Smith 1930, Storey 1975).

Despite limited funding, Dr. Hough took his duties seriously and produced three sizeable American forestry reports. Hough's first volume, published in December 1877, spanned a breadth of subjects, but it was largely a compendium of collected information from various published sources, along with replies to his inquiries about forestry legislation, conditions, and practices in North America. Hough's inquiries sent to leading experts on the influences of forests on climate, and measures for the preservation and restoration or planting of forests asked for information regarding European conditions along with data on European schools of forestry (Storey 1975). Among America's natural and physical scientists Hough contacted were Asa Gray,² compiler of the landmark *Manual of Botany*, Harvard botanist George B. Emerson,³ and California state geologist Josiah D. Whitney⁴

² Asa Gray (1810–1888), one of America's leading botanists, is often credited with bringing Darwinism to America and as being the father of American botany. Interestingly, in California, Gray often traveled with early ecologist John Muir. Gray even named several plants after Muir, who helped him collect specimens (see Fernald 1950).

³ George Emerson, an important member of the AAAS, in 1849 published his influential *Report on the Trees and Shrubs of Massachusetts*.

⁴ Josiah D. Whitney wrote *The Yosemite Book* (Whitney 1869), which called attention to the scenery of California and furnished a reliable guide for the time to some of its most interesting features, such as Yosemite Valley, the High Sierra, and the geographical range of the redwoods in California.

(Robbins 1985). Hough's 632-page first volume *Report Upon Forestry* (Hough 1877) so impressed government officials that they authorized the printing of 25,000 copies of the document, making it an instant classic (Williams 2000).

In 1880, Hough, presented his second report to Congress. Two years later, he submitted his third and last volume of his lengthy three-volume set—*Report Upon Forestry*.⁵ Again these volumes were compilations of facts and figures from various publications, as well as letters and other reports outlining techniques of planting and cultivation of various forest tree species. The second volume (1880) focused mostly on export/import statistics with lesser sections on timber on public lands, as well as recent state and territorial legislation relating to forestry (Dana 1956). In the same year, Harvard professor Charles S. Sargent⁶ commanded wide general interest in forestry when his “Report on the Forests of North America” (Sargent 1884) appeared in the *Tenth United States Census*—giving rise to a very general discussion in the press on forests and their complex relations to the welfare and development of the country (Smith 1930).

Hough's third volume, which came out in 1882, continued his examination of various aspects of forestry and forest products. Interestingly, the third volume titled one section “Experimental Stations for Forest Culture.” This section was undoubtedly influenced by a trip that Hough took to Europe the previous year to study forestry conditions, and paid for with a \$1,000 federal appropriation (Robbins 1985, Rodgers 1968, Steen 2004), a measure of the growing interest in U.S. forest culture. In the section on experimental stations, Hough suggested that the federal government create four such stations in America—possibly associated with state agricultural colleges⁷—with one to be located in southern California. The proposed California experimental station, according to Hough, would study the introduction of nonnative species into the area, such as the eucalyptus (a tall evergreen tree mainly active in Australia that provides good timber, resin, and an oil with medicinal properties), the cork oak (a Mediterranean evergreen oak tree whose thick bark

⁵ In addition to his official reports, Hough wrote a book entitled *The Elements of Forestry* (Hough 1882), which became the first American textbook on the subject (Dana 1956).

⁶ Charles Sargent (1841–1927) launched *Garden and Forest* (1888–1897), an important 19th century horticultural journal. Sargent often used its pages to crusade for politically charged issues such as the conservation of the Nation's forests and forest-policy reform. He was the founding director of the Arnold Arboretum of Harvard University, a post he held for close to 50 years.

⁷ Land grant universities were established in each state under the Morrill Act of 1862 and were the “incubators” for the emergence of forestry research at universities. Then, in 1887, Congress passed the Hatch Act, which established the present system of agricultural experiment stations at land grant universities. Forestry research was considered one of the agricultural sciences, but station directors rarely allocated funds to forestry matters until after 1962 and the passage of the McIntire-Stennis Cooperative Forestry Research Act (Skok 1999).

was a source of cork), the cinchona (a Southern American evergreen tree or shrub whose bark was used to produce quinine and some other drugs), and the acacia (a tropical or subtropical shrub or tree) (Dana 1956, Storey 1975).⁸

Despite the increased interest in forest management and preservation among scientists and business and community leaders, for several decades nothing came of Hough's experiment station idea on a federal level. In the meantime, Congress favored Hough's work by temporarily establishing a Division of Forestry in the Agriculture Department. Its mission was to advise farmers and agriculturalists that wished to know more about trees and shrubbery. Hough was made the Chief of this new division (Lewis 2005, Williams 2000). In the end, Hough's 5-year administration (1876–1882) and his publications provided the “first descriptive statistics showing the extent, content, and problems of America's forests, their potential as a basis for commerce, and much more” (Bruce 1999).

Even though Hough's reports stimulated the emerging American forestry movement, in 1883, Hough lost political favor with Commissioner of Agriculture George B. Loring, and was replaced by Nathaniel H. Egleston, a political appointee (Lewis 2005). Egleston, a former Congregational minister, had little experience in forestry, and according to most historians, was largely ineffective. Even so, Egleston did make some interesting recommendations, urging that the federal government establish or support forestry schools nationwide. He also reiterated the need for federal forest experiment stations throughout the country, including “that peculiar region, the Pacific.” But during Egleston's 3-year administration (1883–1886), federal forestry research largely lost all sense of purpose or vitality. Egleston's 1884 *Report on Forestry* was uneven and added little to the cause of forestry, even though Division of Forestry agents, including Franklin B. Hough, wrote most of the report, which generally covered a variety of subjects like tree planting, timber culture, forest conditions, and utilization of forest products (Dana 1956, Storey 1975).

As Egleston floundered, the commitment to resource conservation in California grew. In 1883, the California legislature authorized the Lake Bigler [Tahoe] Forestry Commission to address a public outcry over the denudation of Lake Tahoe's forested shores. Although the Bigler Commission failed to convince a reticent California legislature to set aside Lake Tahoe Basin as a national or state park, the uproar over wasteful cutting led to one very positive step—an 1885 statute creating

⁸ At this time, southern California civic and business leaders became alarmed by the severe erosion of the surface soils of mountain slopes as well as flash floods caused by indiscriminate cutting of timber and overgrazing of livestock in the region. They proposed reforestation the area to protect southern California watersheds for metropolitan domestic needs and soon thereafter lobbied the federal government to take action (Godfrey 2005).

a state Board of Forestry with a dual mission of education and research. Political interest groups—such as farmers, urbanites, and reformers who had tired of federal inertia in regulating forestry and grazing practices and the management of critical mountain watersheds—pushed the idea through the California legislature. The newly established California Board of Forestry (CBF) was the first of its kind in the Nation⁹ and will be discussed elsewhere (Godfrey 2005, Steen 2004).

Bernhard E. Fernow and the “Science of Forestry,” 1886–98

While a budding forestry movement got underway in California, in Washington, D.C., on March 15, 1886, Bernhard E. Fernow (fig. 3),¹⁰ a German-trained forester, succeeded Eggleston.

Shortly thereafter, the Division of Forestry became a permanent part of the Agriculture Department, when Congress gave it statutory recognition on June 30, 1886. Fernow faced many organizational limitations when he took over the post of Chief of the Division of Forestry. First, and most importantly, during his administration (1886–1898), the “new” Division of Forestry continued to lack adequate funding for staff or programs. Second, the Division had no interested community of supporters. Although it was nominally under the Agriculture Department, it drew little or no backing from farmer organizations. And third, the Division had no forests to manage. The first federal forest reserves would not be created until 1891,¹¹ but even then, the Nation’s forest reserves were placed under the control of the Interior Department’s General Land Office (GLO). They would not be transferred to the Agriculture Department until 1905. Therefore, from the onset, Fernow was

⁹ At this time, California and Colorado were the only states to have a board or a commissioner charged with executive duties beyond an advisory capacity. However, the forest commissioner of Colorado was not given any resources to execute his official duties, whereas the CBF had ample means to assert its authority (Fenrow 1892).

¹⁰ Bernhard E. Fernow trained at the famous forest academy at Mueden, Germany. After coming to America in 1876, he led the newly formed American Forestry Association. He later became dean of the New York State College of Forestry at Cornell (1898–1903), professor of forestry at State College of Pennsylvania (1907), and faculty dean of forestry at the University of Toronto (1907–19). During his lifetime, he was also editor of the *Journal of Forestry*.

¹¹ By 1892, California had four forest reserves—the San Gabriel (Los Angeles and San Bernardino Counties), Sierra (Mono, Mariposa, Fresno, Tulare, Inyo, and Kern Counties), San Bernardino (San Bernardino County), and Trabuco Cañon (Orange County). The primary object of these reservations was to insure favorable water conditions in these regions, which depend for their fertility upon irrigation (Fenrow 1892).



Courtesy of Library of Congress, Eckstein's Verlag
Berlin-Charlottenburg, photographers

Figure 3—Bernhard E. Fernow, third chief of the U.S. Division of Forestry (1886–1898) and considered by many as the father of American forestry research.

a forester without adequate financial support, patronage, or any forests to manage. Even so, his appointment was a watershed moment in American forestry science, because Fernow believed that “forestry was, like agriculture, an art and a potential science,” and he moved the division from a compiler of forest cultural observations, which it had been under Hough and Egelston, to one of forestry science and research. During his tenure, Fernow set up scientific research programs and initiated cooperative forestry projects with the states, giving stability and guidance to the fledgling organization (Robbins 1985, Rodgers 1968, Steen 2004, Storey 1975, Williams 2000). Professionalism at last came to the Division of Forestry.

During Fernow’s 12-year tenure, American forestry research made several notable advances, and his 1887 *Report Upon Forestry* outlined his vision of the future for the federal agency. Using three very European research-derived components, Fernow’s programs were practical, economical, and based upon applied scientific principles. His program’s first component was forest biology, or the consideration of the growing crop, including timber and forest pathology, or as he described it, the life history of species in their individual or aggregate life. The second component involved timber physics, which, according to Fernow, was the consideration of the grown crop. This second element included the anatomy, chemical physiology, and physical properties of wood, as well as influences that determined physical properties and diseases and faults of timber. Fernow’s third and final component was soil

**Professionalism at last
came to the Division of
Forestry.**

physics, or, in his words, the consideration of conditions for growing a crop (Dana 1956, Rodgers 1968). Following these three lines of thought, he distinguished himself and moved the Division beyond the mere compilation of scientific knowledge that had occurred in the 10 years under Hough and Eggleston (Smith 1930).

Although Fernow strongly stressed to his researchers the need for thoroughgoing investigations involving basic forestry science as well as research on technological problems associated with wood utilization, his attention was given to subjects of a more immediate application. Many practicable projects illustrate the diversity of work conducted by both the small staff of the division at this time, and a nationwide network of others interested in forestry. For example, during Fernow's administration, George B. Sudworth,¹² botanist of the Division, prepared his memorable work *Nomenclature of the Arborescent Flora of the United States* (Sudworth 1897). Sudworth's volume was the Nation's first checklist of common and botanical names. It contained 500 forest species and established a Linnaean¹³ tradition of classification in forestry science for decades to come. Alabamian Charles Mohr, agent for the division, published notable bulletins dealing with the pines of the Southeastern United States and the turpentine industry; Californian Abbott Kinney¹⁴ wrote about the forests of Los Angeles, San Bernardino, and San Diego Counties and the connection between watersheds and forestry; and Frederick V. Coville¹⁵ published a study on sheep grazing and forest growth as a result of grazing controversies in Oregon. As if these contributions were not enough, in

¹² George B. Sudworth came to the Division of Forestry as a botanist shortly after Fernow's appointment. He contributed some of the most enduring work of the division and remained in federal forest work longer than any employee of the division. He was highly respected by Fernow and promoted by Gifford Pinchot to head his Special Investigations Section (Rodgers 1968). A monumental amplification of his work—*Checklist of the Forest Trees of the United States* (Sudworth 1927)—was published shortly after his death in 1927 (Smith 1930).

¹³ In 1735, Swedish naturalist and physician Carolus Linnaeus in his botanical work *Systema Naturae* devised this system that classified plants and animals under two names, one referring to the genus, and one to the species.

¹⁴ Abbott Kinney was a remarkable Californian who was deeply involved in southern California's forestry/watershed movement. He was president of the state forestry society and several water and forest organizations, as well as an influential publisher, representative of southern California viewpoints. Kinney was chairman of the CBF (1884–1887), President of the Southern California Academy of Sciences (1890–1900), president of the Southern California Pomological Society (1882–1892), president of the Southern California Forest and Water Society (1896–1909), as well as vice-president of the American Forestry Association for California. He founded the City of Ocean Park, California (1894), and died in 1920 in Venice, California, a community that he had developed as one his many business ventures (Clar 1959, Rodgers 1968).

¹⁵ Frederick Vernon Colville authored many important papers on botany for the U.S. Department of Agriculture. In 1893, he became the curator of the U.S. Herbarium, and in 1929, became acting director of the National Arboretum.

collaboration with others, Fernow wrote seminal works on “forest influences,” or the relationship of climate, water, and other influences on forests—a field that retained its identity until the middle of the 20th century (Rodgers 1968, Steen 1998, Steen 2004, Storey 1975).

Finally, for the first time, wood products and timber physics became the subject of scientific inquiry. In 1891, Fernow found funding to push test work on timber, and a year later, sought appropriations to establish a test laboratory at San Francisco and another in Washington for this original work in addition to the laboratory located in St. Louis. Fernow and others in the Division realized that a crucial part of the forest conservation question was better economic use of the Nation’s forest products. Appeals were made by them to the wood consumer to employ more rational and economical use of forest products. Additionally, he believed that once eastern wood consumers used up their home supply of timber, they would, out of necessity, turn to Pacific coast timber. Therefore, he felt it was the duty of government to determine the mechanical strength and other qualities of this timber, which was unknown at the time (Fernow 1892).

Fernow’s proposed San Francisco laboratory never materialized. Nonetheless, the Timber Physics Section under Filibert Roth¹⁶ conducted many early critical pioneer studies in this area. These studies emphasized the wasteful use of American timber, and Roth’s study of wood structure and properties entitled *The Work in Timber Physics in the Division of Forestry, 1877–1898* (Roth 1899) soon became a classic. Fernow saw timber physics as the “science of wood,” but it was Roth whose actual laboratory methods and practices paved the way for wood products science. Furthermore, Fernow and Roth’s joint work on wood decay represented the origins of the study of American forest pathology.¹⁷ But because these studies were more in the nature of “pure” science than “applied” science, they were not considered germane enough to be funded by Congress. In 1897, despite last-ditch efforts by Fernow to save it, timber physics research was discontinued altogether, probably at the height of its usefulness. At this point, many did not fully see the value of general scientific research work with wood and were unprepared to support such research with federal funding (Fernow 1897, Godfrey 1990, Rodgers 1968).

Once eastern wood consumers used up their home supply of timber, they would, out of necessity, turn to Pacific coast timber.

¹⁶ German-born Filibert Roth eventually became America’s first great student of timber technology (Rodgers 1968).

¹⁷ In fact, Emilio Pepe Michael Meinecke, one of America’s first great forest pathologists, who later worked closely with California District 5, believed that Fernow and Roth’s work was the first genuine attempt at scientific study of the subject in this country (Rodgers 1968).

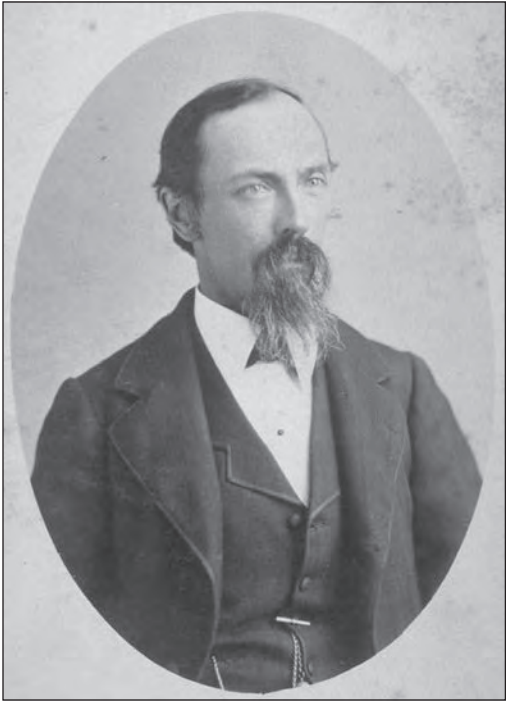
Fernow was also very interested in forestry conditions in states like California, and he often communicated with Eugene W. Hilgard¹⁸ (fig. 4), California's leading professor of agriculture, on the subject. Hilgard on many occasions had publicly warned of the dangers of fires and wasteful lumber practices in California.

Besides writing Professor Hilgard, Fernow religiously read the reports of the CBF, giving Fernow the theoretical knowledge he needed regarding the effect of these practices and events on California's developing fruit industry. That industry depended on the surrounding mountain watersheds, where the forests faced depletion from poor practices and overuse. Having never been to California, however, Fernow had no practical knowledge of the situation, so he could do little in the way of remedying conditions there beyond reporting on them. Circumstances changed in 1889, when Fernow traveled to the West, a trip that included a limited visit to California, where he quickly passed through the redwood regions of the state and into the Sierra Nevada Mountains, with a side trip to the Mariposa "grove" and Yosemite (fig. 5). Fernow's California visit however did include discussing watershed issues with California's leading watershed conservationist, Abbot Kinney. Conversations with Kinney and other conservationists gave him an understanding of the influence of forest vegetation on water supply in that part of the country (Rodgers 1968).

In summary, over the years, Fernow expanded the division's activities and established a scientific basis for federal forestry. His annual reports made it evident that the agency and its programs provided a valuable service. But in 1898, weary of the political nature of his job and the politics of the forestry movement, Fernow resigned his position to become the dean of Cornell's School of Forestry—the first in the United States.¹⁹ In his final annual report, the division's "scientific" staff

¹⁸ Eugene Woldemar Hilgard received his Ph.D. from the University of Heidelberg (1853). In 1872, after studying at Columbia University and the University of Michigan, he moved to a professorship in soils at the University of California at Berkeley, staying there until his death in 1916. He also served as the director of the California Agricultural Experimental Station (1888–1904). Hilgard made his early reputation as state geologist for Mississippi (1855–1870), but he is credited with the concept of soil layers (later called soil horizons) and his visionary work gave birth to modern soil science (Gessel and Harrison 1999). Hilgard repeatedly warned California and the Nation about the effects on agriculture and horticulture of forest depletion through wasteful lumber practices and fires. In 1890, Hilgard, along with other AAAS members, urged President Harrison and Congress to withdraw all public lands from sale or entry, an effort that eventually led to the passage of the 1891 Forest Reserves Act (Rodgers 1968).

¹⁹ Shortly after leaving office, Fernow published his *Report Upon the Forestry Investigations of the U.S. Department of Agriculture, 1877–1898*, (Fernow 1899) which summarized his administration's accomplishments, and made a strong case for the Agricultural Department's involvement in forestry. He suggested the transfer of the forest reserves from the GLO to the care of the Division of Forestry in the Agricultural Department (Steen 1998, Storey 1975). He believed that such a transfer would not only bring "all of the forest interests of the country under one administrative head, but would tend to maintain the most important purpose of the reservations, their use as sources of supply for the irrigation of the agricultural lands of the States in which they are situated" (USDA Division of Forestry 1897).



Bancroft Library, University
of California, Berkeley

Figure 4—Eugene W. Hilgard, California's leading professor of agriculture and the first to offer forestry instruction in California as part of his coursework.



U.S. Forest Service, Pacific Southwest Research Station

Figure 5—California redwoods stretch from Crescent City in northern California to the Big Sur Coast in the south and have inspired humankind since the dawn of time.

included the chief and assistant chief, one dendrologist, one timber expert, two statisticians, one field agent, along with five clerks and a messenger. He recommended an increase of appropriations to \$50,000 to expand the lines of work that he had inaugurated, but Congress denied his request (Fernow 1897). Fernow's leadership marked the beginning of forestry as a government science, and his reports, according to historian James G. Lewis, "played a pivotal role in publicizing the cause of scientific forestry" (Lewis 2005: 16–18, 22). However, Fernow left seeing the need for much additional research. Unwilling to become a politician, he was unable to secure sufficient appropriations needed to accomplish the work (Storey 1975). Although at an early date in his administration he favored the establishment of experiment stations and from his European training knew what they might achieve, he also was never able to find the funding, or support for federal experiment stations (Rodgers 1968). These tasks he would leave to his successor—Gifford Pinchot.

The Beginnings of California Forestry— Leading the Nation, 1885–1992

As noted earlier, in 1885—the year before Bernhard E. Fernow took over the Division of Forestry—the state of California had created a statutory Board of Forestry, the first in the Nation. One purpose of the BF was to halt the destruction of the state's timber resources. Timber devastation in the state was so great at this date, that in 1887 the board supported a movement to have all public forest lands withdrawn from sale and placed in the custody of the army until a commission could be formed to determine what forest regions should be permanently retained under a national plan of forest management. Soon thereafter key federal legislation passed (1891 Forest Reserves Act), placing critical California forests and watersheds into federal forest reserves—the San Gabriel Forest Reserve (part of today's Angeles National Forest) being the first. Setting aside federal forest reserves promised not just watershed protection, but also fire suppression and judicious cutting—goals that many Californians supported (Godfrey 2005, Rodgers 1968).

In April 1885, the first appointed CBF met in the Academy of Sciences at San Francisco and included noted botanist Albert Kellogg.²⁰ Eventually led by the energetic and zealous southern Californian Abbott Kinney, its most notable chairman, the CBF embarked on experimental studies of the requirements of various timber

²⁰ Albert Kellogg was a charter member of the Academy of Sciences who wrote and illustrated many articles on native flora. By the time of his death in 1887, he was the leading botanical authority of California (Clar 1959).

trees for regeneration purposes and other matters of forest culture. It openly sought to educate the public about California's forest conditions and address the conservation of California's natural heritage (Godfrey 2005). But before they could embark upon these two goals, CBF commissioners needed information on state forest conditions, as well as geographical and vegetative knowledge of particular regions. As there was no such thing as a trained American forester in the country at the time, the CBF approached the problem in a piecemeal way. First, it assigned the task of inventorying California's redwood region to Hubert Vischer and a report on forests of the Sierra Nevada region to Luther Wagoner. Additionally, board members such as Abbott Kinney contributed details on the Los Angeles, San Bernardino, and San Diego County forests. Other interested citizens contributed smaller studies of local forest conditions and prepared generalized vegetation maps of their regions of the state. Finally, as part of the forest inventory, CBF transmitted to each county an ambitious questionnaire directed toward obtaining knowledge on (1) areas that had been cut and products harvested, (2) areas that had been destroyed by fire, (3) the means employed to prevent such destruction, (4) what type of regrowth was appearing, (5) possibilities for success in planting various tree species, and (6) changes in weather owing to deforestation. Regrettably, only a fourth of the counties responded to the CBF questionnaire (Clar 1959).

In 3½ months on California's north coast, civil engineer Hubert Vischer compiled an amazing amount of general and statistical information (as reported in Clar 1959) about the geography, climate, and distribution of flora in California's redwood areas, as well as data regarding the harvesting of forest products and the issue of "light burning"²¹ (discussed in the next chapter). Vischer estimated that throughout the region, only about 28 percent of raw material felled actually came out as a commercial product, although some local operators questioned and objected to his calculations. Mining engineer Luther Wagoner's report on Sierra Nevada region (as reported in Clar 1959) was shorter than Vischer's, and unfortunately offered little useful or accurate information regarding Amador, Calaveras, Tuolumne, and Mariposa County forests. Wagoner concluded his report by stating that in the Sierra area the board should begin its reforestation plans by planting hickory, ash, and other needed hardwoods. Nonetheless, the CBF was enthusiastic about forest regeneration—especially the planting of hardwoods and eucalyptus in the southern portion of the state. For instance, in the CBF's first biennial report (1885–1886),

²¹ Light burning is the theory and historical practice in California of using fire to rid the forest of needles, small dry branches, brush, weeds, and reproduction in order to prevent future intense fires; to improve the pasture; to make travel through the woods easier, or to drive out game.

there appeared in the appendix a report by the Southern Pacific Railroad Company regarding the results of its experimental planting of some 45,000 eucalyptus trees, to be used for ties, along its rights-of-way in Alameda County²² (Clar 1959). Besides Vischer and Wagoner's reports, the distinguished California botanist John G. Lemmon²³ and his wife, artist Sara Plummer Lemmon, contributed an illustrated dendrological study on the native trees of California and the Pacific slope (Lemmon and Lemmon 1902). Finally, there was also a serious discussion by popular California writer and poet Joaquin Miller and San Francisco Mayor Adolph Sutro on establishing the last Saturday of January as Arbor Day²⁴ for California (Clar 1959, Pratt 1931, Rodgers 1968).

More important than establishing an Arbor Day, the CBF made regeneration and experimental planting a top priority. They studied the development of state nurseries and experimental farms for reforestation, and the question became which new species could be successfully introduced into the state's various climatic regions? For several reasons, southern Californians were very interested in establishing conifer plantations. First, they wanted to produce shelter trees for the grasslands, and second, they wanted to replace the chaparral-covered mountains with verdant evergreens—for at the time, many people accepted the belief that conifers improved climate and assured increased natural water production. However, with great stands of "virgin" pine forests in the Sierras and elsewhere, there was little inducement in California for scientific studies leading to the regeneration of coniferous timber species. On the other hand, northern Californians were attracted to the idea of hardwood plantations. Hardwoods were considered a good economic commodity, especially for fuelwood, which was in great demand. Finally, a growing urban population, both in northern and southern California, wanted nurseries and plantations to produce shade and ornamental trees for parks and planting along roadways (Clar 1959).

²² Because of the costs of laying and replacing ties, railroads, particularly in the West, were among the first to experiment with tree plantings. "Railroad forestry," as it was called, began in 1870 when the Kansas Pacific Railroad initiated the first experimental plantings. Railroads also sought knowledge regarding the adaptability of various tree species to differing soils and climates (Rodgers 1968).

²³ In 1886, John Gill Lemmon was appointed California's first state forester, and later produced an intensive study of the cone-bearing tree species of California.

²⁴ Despite their enthusiastic support for the idea, the governor at the time vetoed a measure seeking it. An Arbor Day was not enacted in California for another 23 years. Nebraska established the Nation's first official Arbor Day in 1872 (Clar 1959).

To meet citizen demand for experimental nurseries,²⁵ the CBF adopted a resolution to introduce and raise California tree stock by establishing experimental stations in the north, central, and southern parts of the state—an idea that Franklin B. Hough had suggested on a national scale 3 years earlier in his third *Report on Forestry* (Hough 1882). Although the idea for experiment stations in California was not revolutionary—indeed, they were common in European countries by this date—establishing “state-run” stations in America was innovative and exceptional for its time. Following adoption of the resolution, the CBF managed to set up two “experimental forest stations” with its modest budget appropriated monies²⁶ and appointed board member William S. Lyon as the stations’ superintendent. The Santa Monica Station, started in December 1887, was sited on six acres of land in Old Canyon, and the Chico Station was placed on 29 to 37 acres along Chico Creek in February 1888. Other planting stations were eventually established later at Merced, Hesperia, Livermore, and San Jacinto. These early forest experiment stations were perhaps the first and only ones of their kind in the United States at the time (Clar 1959). Although California’s early experiment stations tested introducible forest species on a small scale, eventually extensive groves of eucalyptus and acacias from experiment station stock were planted in barren and special areas throughout southern California. Catalpa, locust, and similar tree species were distributed as well (Godfrey 2005, Pratt 1931, Rodgers 1968). In conjunction with the planting stations, the CBF issued three or four bulletins that referred Californians to available planting stock that could be had at the state-run nurseries, as well as how to plant particular trees (Clar 1959).²⁷ Besides encouraging the planting of exotic species throughout the state, the CBF also published the first forest map of the entire state. In fact, mapping California’s forests at this early date was one of the most important acts of the Forestry Board. The CBF map showed the amount and kind of timber standing in different counties as well as each species’ commercial uses and value. To create this map, State Engineer William Hammond Hall made his unpublished base maps available to the board, and the final native vegetation maps were of inestimable value during a joint federal-state forest study conducted between 1903 and

²⁵ Tree planting and arboriculture for regional distribution and industrial uses was one of the dominant national themes of the day, and California certainly followed this trend.

²⁶ With its modest budget of \$15,000, the CBF was also supposed to prevent forest fires, prosecute depredators, aid forest planters, and make a forest map of the state (Rodgers 1968).

²⁷ Naturally, such action put the board in direct conflict with the private nursery industry, which protested. In spite of this, the board justified its existence to legislators by pointing out that they were experimenting with the rarer varieties of trees not grown in quantities by private nurseries. This point seemed to satisfy most of the objections. In fact, private nursery demands for board planting stock soon exceeded anything the board anticipated. Thereafter, the Santa Monica and Chico Stations grew to meet these demands (Clar 1959).

1907. The board's map work also served as the foundation for the state forester's first published forest type map for California (1911) (Clar 1959.).

On the education level, the CBF distinguished itself as well. In keeping with the times, CBF members believed that the California university system should teach forestry science and conservation. Starting in the late 1870s, the University of California had provided limited forestry instruction to its students. As early as 1876, Berkeley's College of Agriculture and Mechanics reported that its college farm grew experimental crops, illustrating the state's capabilities for special crops, such as forests. Additionally, since 1882, Berkeley professor Eugene Hilgard offered forestry instruction as part of other coursework, and also experiment station work (Rodgers 1968). Although California's education system had already begun to differentiate itself by its support for forestry science, it was the board's awareness that the scarcity of trained men was a "practical difficulty confronting the advancement of forestry in California" that began a movement to establish a forestry school in California. To achieve this end, the CBF tried to persuade the University of California to inaugurate such a school, stating that "If this school is carried on as it has been planned [by the board and various supporters], it will be of great value, and will be the one complete forest school in the United States. We hope that the University of California at Berkeley will advance the great interest of forestry in the same way."²⁸ Although this early effort failed, the board continued to press the point. For instance, in the CBF's fourth biennial report for 1891–1892 (CBF 1892), board member and statistician Fred M. Campbell continued to stress the need for western men trained in forestry—who, Campbell suggested, might go on to educate citizens to seek better forestry practices elsewhere as well. He urged the University of California to establish a Chair of Forestry, and even recommended that the board memorialize Leland Stanford²⁹ by providing for a professor of forestry at Stanford University.³⁰ Meanwhile, Abbott Kinney, CBF's very active and influential chairman, began an intermittent lecture series at the University of Southern California (USC) on general forestry as it applied to southern California's mountains. Kinney boasted that his lectures constituted a forestry school, and led a group of men connected with USC in a plan to establish a school of forestry in the forests of Tulare

²⁸ Remarkably, the board's statement preceded the establishment of the first collegiate forest school in the United States at Cornell University in New York (1898) by a dozen years.

²⁹ Leland Stanford was one of the "big four" (the others being Charles Crocker, Mark Hopkins, and Collis P. Huntington) who built the Central, Pacific, and Northern Pacific Railroads. In 1891, he opened Stanford University to perpetuate the memory of his only son, who died of typhoid at the age of 15.

³⁰ Apparently, enthusiasm for the idea of a School of Forestry at Stanford mounted after Gifford Pinchot visited the school in 1903, but financial losses caused by the 1906 San Francisco earthquake ended all hope of starting such a program (Clar 1959).

County (Clar 1959, Rodgers 1968). In the end, California schools, such as Berkeley, Stanford, or USC, were just not adequately funded or staffed at this early date to educate and train professional foresters. However, that event would not be too far in the offing.

Failure of California Forestry Movement, 1893–1903

In the interim, the forestry research atmosphere in California waned, and then lost most public support and influence with the legislature. Then, in 1893, lawmakers unexpectedly abolished the state Board of Forestry. There appear to be several reasons why California's Board of Forestry died in its frail youth. Bernard Fernow in his final report for the Division of Forestry and his *Brief History of Forestry* (1909) blamed the event on political complications and graft, which he felt undid the board's early work. Fernow harshly deplored the "political decrepitude," which he felt had set back progress in California, a state that had very early on recognized the advantages of a forestry organization (Clar 1959, Rodgers 1968). Others believed the board's dissolution was an economic necessity during a time of a serious business depression. Basically, the cost of the experiment stations could no longer be borne by the state of California. The nurseries at Merced, Hesperia, Livermore, and San Jacinto were abandoned as early as 1890 because of the lack of maintenance funds. Still others alleged that by 1893, new board members had drifted from the California forestry movement's larger aims to create, organize, and direct public sentiment toward real forest conservation and scientific forest use. According to the press at the time, members of the board were "apparently without the slightest convictions, knowledge, or taste in forestry." By 1893, the movement, which campaigned to prevent forest waste, established state forests, and undertook a forest survey of the entire state, had settled down to the care of a small arboretum on Chico Creek and another one in Santa Monica Canyon, from which many thousands of young acacias and eucalyptus were annually distributed throughout southern California.³¹ Finally, some believed that the board's demise could be attributed

New board members had drifted from the California forestry movement's larger aims to create, organize, and direct public sentiment toward real forest conservation and scientific forest use.

³¹ When state appropriations ceased altogether, the University of California took over the two small remaining stations and added them to their system of farm stations. As late as 1896, the experiment stations at Santa Monica and Chico still functioned and another station was established on the slopes of Mount Hamilton to discover what hardwoods grew best on the Coast Range (Rodgers 1968). The Chico Station, which was presented to the state of California for the planting and testing of tree seeds and tree growth, was said to be in very bad condition. There were only eight acres on which 4,000 trees were growing in plantation form as well as a few nursery beds. Furthermore, at this time, California disposed of the bulk of her state forest possessions by the sale of its school lands at a low price of \$1.25 per acre (Clar 1959, Pratt 1931). Unfortunately, the Santa Monica Station burned down in 1905, and all of its field notes on important indigenous and exotic acacias growing in the United States were lost (Pinchot 1905).

to the fact that this period of experimentation was before its time. It did not have enough citizen and industry support to sustain itself (Clar 1959).

With the dissolution of the CBF, the state entered into a decade of official indifference to forest lands. The years 1893 to 1903 marked a period of state government inertia, a decade during which lumbermen from the Lake states and Southern pineries flocked to California to invest in timberlands and when California disposed of its school lands at ridiculously low prices. Although it was a period during which land fraud flourished, it was also a decade during which many of today's national forests were set aside as reserves thanks in part to California forest conservationists, such as Abbott Kinney and others, who united and did not give up on their ideas. They moved forward by founding several key groups, such as the California Society for Conserving Waters and Protecting Forests (CSCWPF). This important organization focused on the status of water and forest conditions in California and advocated the establishment of federal forest reserves to protect watersheds from fires, devastating lumber practices, and erosion caused by overgrazing (Clar 1959).

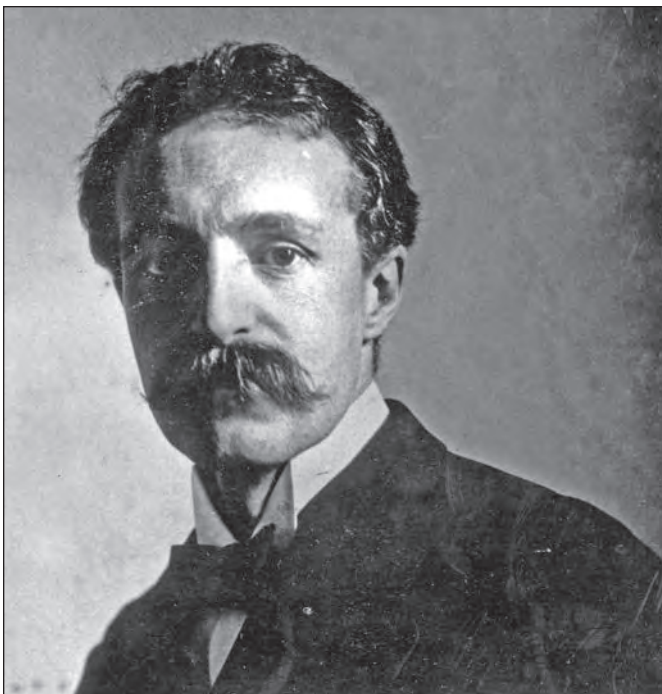
Fortunately, during this decade, federal forestry efforts filled the vacuum left by CBF's demise. Under the 1891 Forest Reserve Act, California acquired its first federal forest reserve—the San Gabriel Forest Reserve (1892). Thereafter, the federal government set aside additional forest reserves in California. After the first reserve, came the Sierra (1893), Trabuco Canyon (1893), San Bernardino (1893), Stanislaus (1897), and San Jacinto (1897) Forest Reserves. Following the passage of the Organic Act on June 4, 1897, which provided the main statutory basis for management of forest reserves by the GLO, other forest reserves were set aside in California. They included the Pine Mountain and Zaca Lake (1898), Tahoe (1899), and Santa Inez (1899) Forest Reserves. Finally, in 1903, the Santa Barbara Forest Reserve (a combination of the Pine Mountain, Zaca Lake, and Santa Inez Forest Reserves) was created. Much of the push for creating and expanding federal forest reserves in California prior to 1898 came from local citizen groups like the CSCWPF, who asked for federal protection from forest watershed destruction caused by mining, lumbering, and livestock interests, or by uncontrolled fires and erosion attributed to the denudation of nearby forests. After 1898, leaders from other influential state groups, such as the California Water and Forest Association, California State Board of Trade, and the Sierra Club supported the push (Godfrey 2005).³² During this push for federal forest reserves, forestry research in California for the most part was left aside.

³² Shocked by the demise of the California Board of Forestry, Kinney and others turned to the federal government and supported the establishment of federal forest reserves.

Gifford Pinchot and the New Era in the Science of Forestry, 1898–1904

Meanwhile, in the post-Fernow years, forestry research in Washington, D.C., also appeared moribund. As noted previously, on July 1, 1898, Bernard Fernow resigned as head of the Division of Forestry. With Fernow's sudden departure, Assistant Chief of the Division, Charles A. Keffer, was left behind to write the division's annual report with little help because other staff members had quickly severed their connections with the division as well. In the first half of 1898 Division of Forestry's report (Pinchot 1898), Keffer summarized the division's state of affairs and research work over the past year in two very somber pages. He briefly described the conclusion of all timber physics investigations, the completion of a few biological studies on various species, and a few other programs. The second half of the report, written by Gifford Pinchot (fig. 6), Fernow's successor, was also only two pages long. Entitled "Plans for the Ensuing Year," it provided a more optimistic view.

Under America's first native-born professional forester, a fresh era in forestry research had begun (Pinchot 1898). With Pinchot, the Division of Forestry found the leader it needed. Where Bernard Fernow struggled with small appropriations,



U.S. Forest Service

Figure 6—Gifford Pinchot took charge of the U.S. Division of Forestry in 1898. Although not particularly research-minded, Pinchot ushered in a new era in the science of forestry as first Chief of the Forest Service (1905–1910).

political red tape, and difficulties with Congress, the young, aggressive Pinchot succeeded because he was a consummate politician who had gifted capabilities as both an administrator and organizer. Emphasizing the economic side of forestry, he ably acquired the needed appropriations from President William McKinley's administration to fund Division of Forestry investigations.³³ Almost immediately, the funds annually allowed to forestry were doubled and more, and personnel increased as a result (Rodgers 1968). For instance, the division staff grew from 61 during Fernow's tenure to 123 a year later under Pinchot (Pinchot 1900). By March 2, 1901, the Division of Forestry had been elevated to full Bureau status, and Pinchot had obtained appropriations to make and continue investigations on forestry, forest reserves, forest fires, and lumbering. The Bureau of Forestry was now called upon to give practical assistance and advice in the management of national, state, and private forests on close to 50 million acres (Pinchot 1901, Rodgers 1968, Storey 1975).

Upon taking the position of the Nation's "forester," Pinchot was critical of his predecessor. The Yale graduate, who had once spent a year in France and Germany studying forestry and had gained practical forestry experience while managing George Vanderbilt's estate in Asheville, North Carolina, thought that Fernow had overemphasized technical and theoretical aspects of forestry. Pinchot—who was not particularly research-minded and had terminated his formal forestry education in Europe before "gaining a thorough knowledge of the sciences underlying forestry"—wished to move forestry research toward "practical" solutions. In 1899, with this in mind, he established a Special Investigations Section, initially headed by George B. Sudworth. Its first mission was to find ways to reduce the number of destructive forest fires and to obtain and develop a body of knowledge that would allow orderly use of the resources of the forest reserves, and later the national forests (Lewis 2005, Pinchot 1900, Steen 2004, Storey 1975).

Around the time that the Division of Forestry became the Bureau of Forestry, there was strong local sentiment in California toward natural reseeding of the burned mountain slopes in southern California. Many Californians hoped to use seeds from surviving trees to accomplish this reforestation goal, or to experiment with direct seed planting of western yellow pine, Torrey pine, and Monterey pine in denuded areas. Pinchot's Bureau saw little direct value in this effort, but felt that a protective cover of trees would make it possible for the later introduction of more

³³ It is important to note that from 1898 onward, Pinchot changed forestry rhetoric from "research" to "investigations" in order to reflect the practical nature of the work and make it more appealing to industry. Ironically, after 1905, western cartoonists referred to Pinchot as "Professor," an epithet he vigorously deflected because he wished to counter strong western opposition to his policies by emphasizing his practical approach to forest management (Steen 1998).

useful timbers. Fire work also included a unique study of the effect of forest cover on the flow of streams in southern California, conducted with the cooperation of the Arrowhead Reservoir Company of San Bernardino. This study was without parallel for its day and included observations of precipitation, run-off, evaporation, and temperature. Strong hopes were entertained for its valuable results from the comparison of the runoff from various types of cover, and research continued into 1903. Working with lumbermen, the division conducted studies related to important commercial trees in the state, such as redwoods, sugar pines, and western yellow pine. In conjunction with this effort, in 1900, the division prepared a short account of the “Big Trees of California” for the Senate Committee on Public Lands, which was fully illustrated with maps, tables, and photographs of Fresno and Tulare Counties by Stanford University’s first botany professor, W.R. Dudley, a collaborator with the division. This work continued until 1902. A number of sequoia groves, hitherto unrecorded, were also examined and mapped in the course of a cooperative investigation of the northern part of the Sierra Forest Reserve with the U.S. Geological Survey (USGS). Special attention was also given to the kind, quality, distribution, and stand of trees in the Sierra Forest Reserve, including the effects of lumbering, fire, and sheep grazing. By 1902, a general study was also underway in northern California with a view toward its protection against fire, overcutting, and overgrazing (Pinchot 1900, 1901, 1902, 1903).

In 1903, a major change occurred in the research program of the Bureau of Forestry that had a direct effect on California forestry investigations. That year, a Forest Products Division was organized in the Washington office (WO) with two sections: wood preservation and timber testing. Soon thereafter, research on forest products became an integral part of the Forestry Bureau’s program. The Division of Forest Products was headed by Hermann Von Schrenk,³⁴ who specialized in the study of various methods of wood preservation. In this field, the division cooperated with major timber users like railroads and pole companies to comprehensively test preservatives on timber under climatic conditions found nationwide. When compared to research conducted by a single railroad, the division’s preservation experiments demonstrated the effectiveness of inquiries by a central federal laboratory and resulted in lessening the adverse effects of these businesses on a shrinking timber supply. Preservation testing would also be a mainstay of research in California, particularly regarding marine borers.

³⁴ Prior to his appointment in 1903, Herman Von Schrenk headed the Mississippi Valley Laboratory located in St. Louis, Missouri. Schrenk’s early work as a pathologist aimed at development of effective wood preservatives, particularly to meet the needs of the railroads in preservation of crossties (Rodgers 1968).

The Division of Forest Products undertook projects in another important area—timber testing, which more directly involved California forestry research. Timber testing or timber physics had begun in the United States under Fernow in 1891, but had been discontinued in 1896 largely because Fernow’s program related principally to testing southern pine. Pinchot revived this field of forest investigation in September 1902, and thereafter instituted a systematic testing of other American timbers. These tests focused on the direct practical value to engineers and to others interested in the utilization of timber (Pinchot 1902, 1903). Assistant Forester Frederick E. Olmsted³⁵ initially was placed in charge of timber testing for the new Division of Forest Products (Pinchot 1903). One of Olmsted’s initial tasks was the publication of *Tests on the Physical Properties of Timber*, (Olmstead 1902), in which he outlined the timber-testing work conducted in Europe, the work accomplished in the United States under the Division of Forestry (1876–1901), and the new investigations planned by the Bureau of Forestry (Rodgers 1968). Thereafter, the Pinchot administration conducted a series of studies on the principal structural timbers currently found in the marketplace (Godfrey 1990). To meet this task, Pinchot established four timber-testing laboratories nationwide—one of which was located at Berkeley.³⁶ Under a cooperative agreement with the Bureau of Forestry, Loren Hunt established and operated the Berkeley timber testing laboratory in April 1903. Its initial purpose was to determine the mechanical and structural properties of Douglas-fir and western hemlock, the first step in a series of investigations of Pacific coast timbers, and the first federal forestry research in California.³⁷ Later, the Berkeley facility was used to study western yellow pine or ponderosa pine as a structural timber and for telephone and telegraph poles and railroad ties, and the commercial possibilities of eucalyptus (blue and red gum) in southern California (Clar 1959, Pinchot 1905). They also investigated the Pacific coast tanbark industry, with important results (Clar 1959, Pinchot 1905). In California, the region of principal supply and work included the collection of data on the commercial range of the species, the effect of cutting and bark peeling on the tree’s reproduction, the

³⁵ Interestingly, Frederick E. Olmsted was a charter member of the Society of American Foresters (1900), later headed California Inspection District 5, and thereafter became the first Forester of California District 5 (1908–1911) (Godfrey 2005).

³⁶ The other timber-testing laboratories were at Yale University, New Haven, Connecticut; Purdue University, Lafayette, Indiana; and USDA, Washington, D.C. (Pinchot 1904).

³⁷ Pinchot hoped to establish a fourth laboratory in Seattle, which would allow the Berkeley facility to work on determining the mechanical properties of redwood (Pinchot 1909).

tannin content of various types of bark, and the relationship of the consumption of bark and methods of cutting to future supplies (Pinchot 1903).

In the end, the Pinchot administration's early timber testing program demonstrated that wood exhibited a remarkable increase of strength when dried to a certain moisture content—the so-called “fiber saturation” point of wood. This discovery and others later set standards for private industry. Unlike earlier research conducted by the Division of Forestry under Fernow, these Forestry Bureau projects emphasized “applied” science over “pure” science, and studies of this nature were funded without question because they addressed specific industry problems and produced immediate practical results. Furthermore, the Bureau of Forestry cooperated with wood users directly in their studies, eventually setting precedents for interaction between government, industry, and universities on wood research problems (Godfrey 1990).

In 1904, Gifford Pinchot expanded forestry research even further when he established the Section of Silvics, or silviculture, in order to “contribute to ordered and scientific knowledge of our forests” (Robbins 1985). Silviculture has been defined as the “art and science of controlling the establishment, growth, composition, health, and quality of forests and woodlands to meet the diverse needs and values of landowners and society on a sustainable basis.” Specific silvicultural techniques to improve forests came to America from Europe, where theories of fundamental biological and social sciences for managing forests had merged into silvicultural science and research practices. Silviculture comprised individual activities or operations done at discrete, short times in order to alter a stand's structure and development. Silviculturalists hoped that by coordinating specific operations systematically over time—namely thinning, regeneration, and other techniques—they could achieve a desired long-term change in a stand's structure and development. North American silvicultural studies appeared in American universities soon after Fernow left office and started teaching at Cornell University (Boyce and Oliver 1999). Eventually, the rise of silvicultural studies dramatically influenced Forest Service research policy and practices.

Additional Cooperative Research Within the Department of Agriculture

The Bureau of Forestry, and its predecessor, the Division of Forestry, did not conduct all federal government scientific research on topics related to forestry by itself. For instance, in cooperation with the Bureau of Chemistry, the Forestry Bureau began studies of tannin and resin-bearing trees in connection with the

The Pinchot administration's early timber testing program demonstrated that wood exhibited a remarkable increase of strength when dried to a certain moisture content—the so-called “fiber saturation” point of wood.

wasteful harvesting “box” method used by naval stores industry.³⁸ Pinchot also commissioned cooperative “practical” work with the same bureau to determine the tanbark, resin, and gum yield of 50 or so American and Philippine trees. Finally, using Bureau of Forestry funds, the Bureau of Chemistry created a dendro-chemical laboratory to test various species of southern pine to determine the effect of moisture on the strength of these woods (Godfrey 1990, Storey 1975). Another USDA agency that Pinchot worked with was the Bureau of Entomology (BE),³⁹ which conducted investigations in forest entomology. The life histories and depredations of forest insects were studied in the Nation’s principal timber. In California, they included the study of tree yuccas in southern California, and redwoods and tanbark oaks elsewhere. There were also cooperative planting projects with the War Department, such as when the Bureau of Forestry consulted on plans for the Presidio Military Reservation in San Francisco. There the Bureau and the War Department worked together to thin the stand planted between 1888 and 1895 and to plant an additional area of just over 100 acres.

The bureau also worked directly with other California cities. For example, an extensive planting plan was laid out by the Forestry Bureau for Griffith Park in Hollywood, near Los Angeles. To promote reforestation of the watersheds and to extend the range of experimental planting, over 8,500 trees were given to Los Angeles. More importantly in southern California, the bureau began at this time an urgent program to reestablish forests on the GLO-controlled San Gabriel Forest Reserve, particularly on Brown Mountain, the western extremity of the reserve. It had been heavily damaged by fire and was bare of timber and scantily covered with brush. To meet this need, the bureau constructed a seedbed in Pasadena, where there was ample water. Seed planting included mostly knobcone, sugar, gray and western yellow pine, with a sprinkling of incense-cedar, and Coulter and Torrey pine. However, the bureau soon decided that San Gabriel Reserve needed a nursery nearer to where the planting was to be done, and thereafter established one on an 80-acre site at Henninger Flats. Some 30,000 trees were transplanted from

³⁸ This method inflicted a severe wound on the tree, but Forest Products Division studies resulted in the “cup and gutter” method, which did not injure the tree and proved economically feasible to the industry.

³⁹ In 1854, the Office of Entomology was created in the Agricultural Section of the Patent Office. Later, a Division of Entomology was established in the Department of Agriculture in 1863, and confirmed by statute in 1878. It was redesignated the Bureau of Entomology (BE) in 1904, a name it maintained until 1934. In addition to its many duties and functions, which included studying and controlling insects in cooperation with the states to prevent plant diseases, the BE studied ways for combating insect damage in America’s forests, and issued extensive reports on the ravages of forest insects. The Bureau of Forestry, and later Forest Service, enjoyed an extensive cooperative relationship with the BE that lasted for decades (Smith 1930).

the Pasadena seedbed to the Henninger Flats nursery, and field germination tests were conducted (Pinchot, 1903, 1904, 1905). Finally, in view of the extremely high value of water near Santa Barbara and the denuded conditions of drainage basins in the vicinity, reforestation work was begun on the Santa Barbara Forest Reserve. Fire had killed the larger and younger growth. After a fire, dry winters, grazing, and lumbering took their toll, presenting a gloomy outlook for increasing coniferous woodlands in the area anytime soon. Nonetheless, the bureau established a nursery just outside of Santa Barbara to supply at least an effort (Guthrie 1904a, 1904b; Pinchot 1905).

But perhaps the greatest cooperative efforts performed by Pinchot's Bureau of Forestry came when the agency dealt directly with the various government forestry boards. For example, in 1901, the Hawaii territorial government sought assistance from the bureau inspecting the Hawaiian Islands forest situation. Prior to that date, Hawaii's forested lands had suffered years of destruction by commercial exploitation of its resources (sandalwood, koa, ohia, tree fern), by demand for fuelwood, by extensive cattle ranching operations, by the sugar industry, by fires, and by feral cattle, goats, and sheep. Pinchot sent assistant forester E.M. Griffith to Hawaii, who immediately recommended a policy of forest protection and natural rehabilitation of watershed cover to minimize loss of forest cover, thus avoiding the consequent need for expensive and slow artificial reforestation. Griffith also recommended establishing a Hawaiian forestry organization to carry out protection and reforestation work (Nelson 1989). Two years later, the legislature of Hawaii passed a bill creating a Board of Agriculture and Forestry to control Territorial forest lands and to administer forest affairs in the islands. Upon the Hawaii Board's request, in 1903, Pinchot detailed William L. Hall⁴⁰ to examine further the conditions and needs of the Hawaiian forests. Hall's report eventually advocated preservation, protection, and rehabilitation of large forest-land areas, and it suggested that forest policy first concentrate on protecting watershed resources by establishing forest reserves, and practically ignored any potential for local commercial timber development. Throughout the early 1900s, the bureau, and later the Forest Service, continued to assist the Territory of Hawaii in implementing this forest policy. Despite this early interest in additional assistance, Forest Service research in Hawaii was sporadic until 1926 and the establishment of the California Experiment Station⁴¹ (Nelson 1989, Pinchot 1904).

⁴⁰ William L. Hall was in charge of forest extension for the Bureau of Forestry.

⁴¹ Hawaii Bureau of Forestry and Forest Service agents, like professional forester Ralph S. Hosmer (1903–15), did test the adaptability of many introduced timber species to sites in Hawaii and determined the technical qualities of the wood of many native tree species. But Hosmer's successor showed little interest and the work was dropped (Nelson 1989).

Pinchot continued to stress the need for knowledge about the actual conditions in the various forests before wise regulatory or administrative forest policies could be developed.

California-Bureau of Forestry Joint Forest Survey, 1903–1904

Pinchot's Bureau of Forestry was more directly involved in California research needs, than in Hawaii needs. During his first few years in office, Pinchot operated “practically” when it came to forestry research, as evidenced by his support for investigations regarding wood products utilization or silviculture and by cooperative agreements with other divisions of the Agriculture Department. But like Hough, Eggleston, and Fernow before him, Pinchot continued to stress the need for knowledge about the actual conditions in the various forests before wise regulatory or administrative forest policies could be developed. His agency, which provided technical assistance to the GLO-controlled forest reserves, to state governments, and to industry, busied itself during the McKinley administration by initiating small-scale surveys of forests and forestry conditions nationwide and outside the country in U.S. territories like Hawaii (Clar 1959).

However, once Theodore Roosevelt—a leading Progressive⁴² and a close personal friend of Pinchot—took office upon President McKinley's death in 1901, Pinchot began to restructure the bureau, which became ever more visible in the public eye. Comprising a staff of mature European-educated foresters on the top, and an understory of enthusiastic young graduates from eastern forestry schools, Pinchot's Bureau of Forestry was ready to come out of the shadows. This was no more evident than in California, where the Bureau of Forestry took on its largest forestry survey to date with the help of Governor George Cooper Pardee⁴³ (fig. 7), a native son (Clar 1959). With Pardee's election, California's decade of government indifference to forestry research officially ended.

During his one term in office, Governor Pardee fought off a California legislature antagonistic to the further creation of forest reserves in California. As a result,

⁴² Progressivism may be considered as an aggregate of political causes and philosophies rather than a single movement. However, in certain respects, most of the men and women in the progressive ranks believed that government, whether it be federal, state, or local, ought to be stronger, more active, and more efficient in serving the public welfare against the so-called “interests.” All strata of society in California eventually enlisted in this crusade for “social justice,” resulting in the election of crusading governors, like George Cooper Pardee and later Hiram Johnson (Godfrey 2005).

⁴³ Pardee was a Progressive in the vein of Theodore Roosevelt, and a conservationist who covered many forestry issues in his 1903 inaugural address—making him known as the “father of natural resource conservation in California.”



Bancroft Library, University of California, Berkeley

Figure 7—California Governor George Cooper Pardee (1903–1907). He ordered a Joint State and Federal Commission to inspect and survey California’s forests, and created a board of forestry to monitor and supervise logging, land usage, and forest fires in California.

the federal government set aside two new forest reserves—the Warner Mountains and Modoc Forest Reserves (1904), the northeastern-most of California’s forest reserves. Overall, between 1892 and 1904, the federal government had created in California a remarkable 12 forest reserves with more than 9.4 million acres of “reserved” forested lands. This was close to one-tenth of the entire state. But more importantly for forestry research in California, on March 16, 1903, the California legislature approved and Governor Pardee signed an act that provided for a comprehensive study of California’s forests. Furthermore, this act authorized the state of California to enter into an agreement with the Bureau of Forestry with two primary purposes: to study the forest resources of the state and their proper conservation, and to formulate a proper state forestry policy (Pinchot 1904). This simple language resulted in a landmark agreement between the state of California and Bureau of Forestry to conduct a joint survey regarding six mutual areas of forestry interest: preventing loss by forest fire; improvement of forests following logging; reforesting parts of southern California; regulating grazing; producing a vegetation type map; and developing a plan to administer forest lands. Expenses for the survey were borne equally by the state and federal governments (Godfrey 2005).

Shortly after Pardee’s election, Gifford Pinchot arrived in San Francisco to sign the historic federal-state joint survey agreement for a technical investigation of California’s forest situation. Prior to its signing, Pinchot delivered the last in a series of forestry lectures at Berkeley, and then attended a banquet given by a select group of Bay area scholars. Guests included the presidents of the University of California and Stanford University. Following this fanfare, two of his young professionals,

Rule-of-thumb guesses by early range managers eventually were replaced by knowledge rooted in tests, experiments, and analysis of detailed knowledge of rangelands.

William Churchill Hodge, Jr.,⁴⁴ and Albert F. Potter⁴⁵ initiated an arduous four-year survey, which began on July 1, 1903⁴⁶ (Clar 1959).

Although William or “Bill” Hodge and his assistants were responsible for southern California, they set up their center of operations in San Francisco. All the same, they immediately set out to study problems occurring in southern California’s forest reserves. According to Hodge’s first report, the survey attacked five major problems: state cooperation, reserve boundaries, fire protection, forest replacement studies, and cooperative planting of eucalyptus. The great hope when the survey began in southern California was to develop a method of securing “high forests” on chaparral slopes. Many southern Californians were optimistic that the bureau could replace dense native mountainside chaparral with conifers or some other tall exotic species. To this end, L.C. Miller and his crew, along with W.J. Gardner, worked on studying chaparral and watersheds, as well as forest reproduction. Growth and site studies embraced plantations in the San Joaquin Valley as well as

⁴⁴ William or “Bill” Hodge started out his career in forestry in the summer of 1899 by first working for the old Division of Forestry as a student assistant. In 1903, at the age of 27, Hodge received his Master of Forestry degree from Yale and was immediately assigned to the California survey. Although considered by his peers as talented and of unusual intelligence and conservative judgment, he was also seen as a dreamer who could not long apply himself to monotonous or burdensome tasks (Clar 1959).

⁴⁵ Albert F. “Bert” Potter was not a trained forester but a local boy who made good. Potter was born on November 14, 1859, in Ione, California, near the Sierra foothills. Son of a Sacramento merchant during the California Gold Rush, Albert, at the age of 24, moved to eastern Arizona for health reasons where he established a cattle ranch. His years as a cattleman exposed him to the consequences of unregulated rangelands and large landowners. In Arizona, Potter met Pinchot, who enticed him into the Bureau of Forestry. Potter, according to Pinchot, was the “cornerstone” of Pinchot’s grazing control policy. In 1905, when the Bureau of Forestry was transformed into the new United States Forest Service, Gifford Pinchot appointed Albert Potter as his grazing expert to handle grazing matters on the forest reserves. Thereafter, Potter chose W.C. Clos, a westerner with a background in animal husbandry and botany, for his staff. Rule-of-thumb guesses by early range managers eventually were replaced by knowledge rooted in tests, experiments, and analysis of detailed knowledge of rangelands. However, true range management science had to wait until the Forest Service assumed full responsibility for grazing research. But for the time being, the Bureau of Forestry made cooperative agreements with the Bureau of Plant Industry for joint studies and experiments with limited results (Rowley 1985). When Pinchot was dismissed in 1910, Potter was the leading candidate for the top job, but reportedly stepped aside in favor of Henry S. Graves (Clar 1959). Potter had initially joined the Forest Service as an Inspector of Grazing and went on to become Assistant Forester (Chief of Grazing) in 1907 and Associate Forester (Chief of Grazing) in 1910, a post he held until William Barnes replaced him in 1916. Potter retired from the Forest Service in 1920 (Prevedel and Johnson 2005).

⁴⁶ Hodge and Potter were assisted by other young men in the field—many of whom had attained or were working for degrees from either Cornell or Yale Forestry Schools, and many of whom were thereafter destined to spend their careers with the Forest Service in California. They included young foresters like Wallace I. Hutchinson and Robert W. “Bummer” Ayers, who started their careers working on this survey and eventually became District/Region 5 officers. Both men retired in 1930 as the Forest Service celebrated a quarter-century of progress (Godfrey 2005).

southern California. But before long, these early scientific foresters began to realize that brush cover was very important to conserving moisture in the absence of tree cover. For instance, in 1904, one assistant forest expert wrote regarding the relative merits of conifers and chaparral that he found a “fine humus of leaves and litter, and in many cases, a green moss,” which he believed was “equal to, if not superior to a coniferous growth” (Guthrie 1904b: 10). Furthermore, these young foresters concluded that fires had caused the chaparral to extend beyond its normal range. Artificial regeneration of a “high” or conifer forest would be very slow and difficult, and even impossible in their opinion, unless fire could be eliminated. Nonetheless, it would be a decade or longer before the federal agency would give up on “reclaiming” the chaparral (Clar 1959, Guthrie 1904b, Pinchot 1904). In the end, these forest investigations resulted in the first completed reports on fire conditions in the San Bernardino, San Gabriel, Santa Barbara, San Jacinto, and Trabuco Canyon forest reserves; in Monterey County, on the western slope of the southern Sierras; and in the Lake Tahoe region (Pinchot 1905).

Albert Potter, who was responsible for northern and central California, set up headquarters in Sacramento. Unlike Hodge, Potter’s crew was more directly involved with the grazing and lumber industries. One special study by them on the effect of grazing on forest lands led immediately to grazing regulations within the forest reserves. But generally speaking, Potter and his assistants were mostly concerned with fire control work conducted cooperatively with the state of California and two progressive lumber companies—the Diamond Match Company (Butte County) and McCloud Company (Siskiyou County). The Diamond Match study stressed and embraced in its investigations a fire plan, the establishment of call boxes, and what some have called the first forest fire lookout in California, and probably in the Nation, at Bald Mountain. Another probable first was the employment of special crews who were constantly ready for fire duty. Two “fire wardens” also rode the trails throughout the summer. The McCloud study focused on developing a systematic plan of fire protection for lands owned by the company. It looked at yield estimate and management costs for a system of fire protection consisting of firebreaks, fire patrols, signage, and tool caches. The final report satisfied the owners that protection was affordable and practicable. The McCloud study’s fire management analysis was reported as *The Control of Forest Fires at McCloud, California* by Albert W. Cooper and Paul D. Kelleter (1907), and was one of the first of its kind nationwide (Clar 1959).

The above describes only a limited amount of the work conducted in north, central, and southern California under the survey. When completed, the survey included 17 comprehensive scientific reports on various subjects, and 45 special

Ultimately, the joint survey recognized that the forest conditions in California were deplorable and that watersheds were being damaged yearly by fire, widespread overgrazing, and land clearing.

papers. Unfortunately, this large body of scientific literature on California's forests has never been compiled into one study under one cover, and regrettably, much of it is unpublished and the manuscripts are either deeply buried in national and state archives, or are lost. Important titles of reports range from Edward T. Allen's⁴⁷ *National Forest Reserves for the State of California* (in Clar 1959), to Hodge's *A Report on a Forest Policy for the State of California* (Hodge 1959) and his *Forest Conditions in the Sierras* (in clar 1959), to Ralph S. Hosmer's⁴⁸ *Forest Conditions in Southern California* (in Clar 1959). Each document broke new ground. For instance, Albert Cooper's *Sugar Pine and Western Yellow Pine in California* (Cooper 1906) went beyond John G. Lemmon's earlier dendrological reports. It was a treatise on the botanical and silvicultural features of the two valuable lumber species, and additionally discussed the economics of lumbering and forest management and the relationship and effect of fire on their production (Clar 1959, Godfrey 2005).

Ultimately, the joint survey recognized that the forest conditions in California were deplorable and that watersheds were being damaged yearly by fire, widespread overgrazing, and land clearing. Timber management was nonexistent and exploitive, and heedless logging had badly deteriorated the forests to the point where some open stands lacked the ability to reproduce. Regarding fire control, the survey pointed out that postsettlement, human-caused fires were increasing owing to general carelessness and an indifference to fire. Most important of all, the joint survey's conclusions led to the passage of a series of laws by the California legislature, the most important being the Forest Protection Act of 1905, which provided

⁴⁷ Edward Tyson Allen was among the charter founders of the Society of American Foresters in 1900, and in 1905 he served as a Forest Service inspector and thereafter was appointed California's first State Forester (Rodgers 1968). Allen had to leave office the following year for personal reasons (Thorton 1994).

⁴⁸ In 1894, Ralph Sheldon Hosmer received his Bachelor of Agricultural Science from Harvard and thereafter served in the USDA Division of Soils (1896–1898) but transferred to the Division of Forestry where he was a field assistant to Gifford Pinchot and then Chief of the Forest Replacement Section until 1903. During the interim, he became one of the charter members of the Society of American Foresters (1900) and was admitted to the first class of the Yale Forest School, obtaining his Master of Forestry in 1902. In January 1904, on Pinchot's recommendation, he became Territorial Forester of Hawaii. Hosmer recognized that the most important resource of Hawaiian forests was water for irrigation of agricultural lands. He also realized that the two greatest hazards to maintaining adequate forest cover on the watersheds were grazing and fire. He proposed and enacted a system of forest reserves, which at the time embraced approximately one-fourth of the total area of the islands. He also advocated extending the forest area by planting and began large-scale test planting of exotic trees to determine those best suited for such extension. Because of his contribution to forestry in Hawaii, a grove of timber on the slopes of Mount Haleakala in the Hawaiian National Park was set aside to memorialize him as being the "father of Hawaiian forestry" (Journal of Forestry 1957).

for the protection and management of the forests within the state and reconstituted the state Board of Forestry along with a technical administrative force consisting of a State Forester and two assistants. Robert W. Cermak, a leading California Forest Service historian, called the California Forest Protection Act a “milestone in the progress of forest conservation in California” (Clar 1959 in Cermak 2005). Passage of the Forest Protection Act ended California’s decade of official indifference to forestry. With its passage, the state of California entered an era of modern forestry, and a state-level interest in the well-being of its natural resources materialized (Clar 1959, Godfrey 2005, Pinchot 1905).

The Dream of California Forestry Education Continues, 1899–1904

Alongside the growth of federal forest reserves in California and the return of state-level interest in forestry came a parallel interest in educating foresters. As detailed above, the idea of forestry education in California was rooted deeply in the past, going as far back as 1876. Men like Berkeley Professor Eugene Hilgard had provided forestry instruction to some students, and others, like watershed conservationist Abbott Kinney, lectured on the subject. However, their activities did not amount to a formal forestry school curriculum. Starting in 1899, interest in forestry education on the university level in California was picked up again, this time by Benjamin Ide Wheeler, President of the University of California. In his inauguration speech, President Wheeler spoke about the need to expand university studies, and he dwelt at great length upon the rising profession of forestry. His speech was no doubt inspired by and urged on by early advocates of forest education, such as Professors Willis Linn Jepson and E.J. Wickson of the Botany Department, and by Julia Lemmon of the California Federation of Women’s Clubs (Clar 1959). Although nothing came of Wheeler’s words, the early seeds for California forestry education were nurtured along.

Three years later, former Chief of Division of Forestry Bernhard Fernow came to California, and his visit planted the idea that someday California would have its own forestry school. In 1902, Fernow delivered a course of lectures during the summer session at the Idyllwild health resort in the San Jacinto Mountains. The success of Fernow’s appearance inspired Professor Jepson to inaugurate an annual summer forestry lecture event at the resort, starting in mid-summer 1903. The primary object of the lecture series was to “correct the sentimental views which were so prevalent and to bring an understanding of the economic principles underlying the science of forestry” (Clar 1959, Rodgers 1968). At this initial event, Jepson spoke on the life histories of a number of California species, and Ralph Hosmer from the

“The University of California is ready and anxious to undertake instruction in Forestry. There is frequent inquiry from students who wish to devote themselves to the work. The demand too for trained foresters is making itself heard.”

Bureau of Forestry covered his current investigation regarding the forest resources of southern California under the California-federal joint forest survey project. Even Gifford Pinchot at one time was listed as a summer lecturer (Rodgers 1968). This lecture series, as well as the continuing work of the joint California-federal forest survey which had begun in July, may have inspired legislative action on behalf of establishing a California forestry school. By late 1903, two funding bills were introduced in the California legislature for appropriations to establish and support a school of forestry at the University of California at Berkeley. The bills failed to receive favorable action, but nevertheless, University President Wheeler and Professor Wickson continued to carry the torch of forestry education. In an article entitled “Forestry in the University” published after the demise of the bills, Wheeler stated: “The University of California is ready and anxious to undertake instruction in Forestry. There is frequent inquiry from students who wish to devote themselves to the work. The demand too for trained foresters is making itself heard” (Clar 1959). The demand for foresters greatly increased after February 1, 1905—the day that Congress transferred the Nation’s forest reserves from the Department of the Interior to the Department of Agriculture and the Bureau of Forestry became the U.S. Forest Service. With this transfer there was also a need for a larger research effort to provide the technical information needed to manage the many resources of these lands so that they could provide goods and services on a sustained basis.

Rise of Forestry Science in America and California

In summary, early scientific interest in America’s forests began in the late 1700s and in California’s forests in the 1810s. However, the development and growth of federal forest research did not occur until 1876, when national fears of an impending timber famine led the Department of Agriculture to study forestry conditions in the United States. This action was 15 years prior to the establishment of “forest reserves” from the public domain, and 21 years before provision was made for protecting and using these reserves, later called “national forests.” During the ensuing years, the role of forestry science increased in importance as its adherents struggled to define it and its terminology, while trying to develop useful science. Under the various administrations of the Division of Forestry—Hough, Eggleston, and Fernow—and Pinchot’s Bureau of Forestry, forest cultural data were compiled and interpreted. Investigations were then made nationwide, gradually increasing in scale in the fields of forest regeneration, dendrology and silviculture, forest products, forest influences, forest fire control, and forest insects and diseases.

In California, a forestry science movement emerged after 1883. By this date, Californians statewide protested the denudation and mismanagement of critical mountain and other watersheds. This public outcry caused the legislature to establish a California Board of Forestry to compile scientific information regarding the condition of the state's forests through research and investigations, to study the use of state nurseries and experimental farms for reforestation purposes, and to educate the public regarding forestry science and conservation through the California university system. The statewide mood supporting forestry research waned after the legislature dissolved the CBF in 1893. A decade later, interest in forestry research in California revived as leadership on the federal, state, university, and industry levels endorsed cooperative research projects, an event notably reflected by the State of California-Bureau of Forestry joint forest survey begun in 1903. From this point forward, a new forestry research period began in California, with the U.S. Forest Service taking the lead.

This Page Left Blank Intentionally

Chapter 2: 1905–1925, Forest Service Research in California

Before February 1, 1905, the Forest Service—then the Bureau of Forestry—was without executive duties. Instead, it was engaged in research aimed at promoting the best use of all forests and forest products throughout the United States by collecting and disseminating both technical and scientific information on American forests and the forestry movement. The Agricultural Department had been doing this more or less effectively since 1876, but after 1905, when the Interior Department transferred control of the national forests to the Forest Service, the role of research took secondary place in Gifford Pinchot's administration. Whatever research that was accomplished was not of the same quality as in the past, and would not be, until the Forest Service recovered its central role in forestry research in the country. "The great task of placing the national forests under administration so completely absorbed the thought and activities of Forest Service personnel that research was very largely ignored" (Pinchot 1908, Storey 1975).

From 1905 to 1925, national forest research went through three basic development periods. During the early years, 1905 to 1914, forest research was largely haphazard and unstructured; nationwide, forest research received smaller and smaller parts of the total Forest Service appropriations.¹ However, starting around 1909, officials in the Forest Service began to reemphasize research and worked to better coordinate research programs, which led to the formative years of the Forest Service's research program from 1915 to 1919. This initial promise of progress was temporarily interrupted by the outbreak of World War I. However, following this era came a maturing period, 1920 to 1925, and forestry research grew into a fully developed national program by mid-1925 and led to the funding of the California Forest Experiment Station—what is now known as the Pacific Southwest (PSW) Research Station.

The Early Years, National Forest Research, 1905–1914

In the early years, from 1905 to 1908, Forest Service research had no clear conception of major objectives, or for that matter, a body of manpower trained in scientific techniques. All forest officers from national forest superintendents and rangers to technical field men considered themselves researchers. Each felt the urge to set out upon some investigative study or another; indeed, not to do so was seen as cause

¹ For example, general investigations, including state and private cooperation, amounted to only about 6.8 percent of Forest Service expenditures for fiscal years 1908 and 1909 (Pinchot 1908, 1909).

to suspect the “genuineness of their conversion to the faith.” Without a scientific education or guidance, and sometimes even without the knowledge of their supervisors, they often produced voluminous reports regarding their personal silvical observations. Under such circumstances, many of the required annual silviculture reports “degenerated into meaningless wordiness” (Hill 1931). Some semblance of coordination in research appeared when permanent sample plots were laid out on many national forests. Using these plots, Forest Service personnel aimed to secure accurate data through experiments on such matters as the recovering of denuded areas, thinning and reproduction cutting, sowing and planting, the introduction of new species, and the best effects of different methods of cutting. However, many of these early studies lacked working plans or were not carried out properly by supervisors, rangers, or technical field men. Additionally, measurements on many of these early experimental plots were begun but never completed, and there was little coordination on research standards. Personnel and scientific interests changed frequently. In later years, Forest Service researchers expended much energy in trying to get something of value from the incomplete, intermittent, and poor records left behind by these early “earnest” scientists (Storey 1975).

Significant change in the Forest Service’s research organization came on May 6, 1908, when Raphael Zon (fig. 8),² head of the Division of Special Investigations in Washington, proposed the creation of forest experiment stations (Pinchot 1909, Storey 1975, Williams 2000). This idea to decentralize research was promptly approved, and during the summer of 1908, the Forest Service established the Fort Valley Experiment Station on the Coconino National Forest near Flagstaff, Arizona, with G.A. Pearson in charge.³ Similar stations soon followed. They included the Fremont Experiment Station (1909) in Colorado, directed by Carlos G. Bates,⁴ and the Priest River Experiment Station, in Idaho (1911), directed by Donald B. Brewster.⁵ The Forest Service soon added research stations to other

² Raphael Zon graduated from Cornell’s first forestry school class (1901) under guidance of Bernard Fernow. With a Forest Engineer degree in hand, on July 1, 1901, Gifford Pinchot appointed this Russian immigrant, who also had collegiate work in Russia, Belgium, and England, as a student assistant at the munificent annual salary of \$300. In January 1, 1902, Zon was permanently hired as an assistant forest expert. Advancement came quickly for Zon, who was strongly research minded. By 1905, Zon headed the Division of Investigations and thereafter laid the foundation for Forest Service silvicultural investigative work and exercised a major influence on forestry research during his long years of service (Clapp 1956, Rodgers 1968, Storey 1975).

³ For a history of this station, see Gaines and Shaw 1958 and Olberding 2000.

⁴ The Fremont Experiment Station was located near Manitou Springs, Colorado, in a pleasant mountain valley on the east slope of Pikes Peak. For a brief history of the Fremont Experiment Station, see Price 1976.

⁵ For a recent history of the Priest River Experiment Station see Graham 2004. Experiment stations in California will be discussed in detail later in this chapter.



U.S. Forest Service, Forest History Society

Figure 8—Raphael Zon directed the Division of Special Investigations (Research) (1902–1909). He was the first to propose the creation of forest experiment stations to decentralize research. Zon also pioneered studies of the relationship of forests to streams and flooding.

states, including California, Washington, and Utah. All of these early Forest Service research stations were very small and had limited facilities. Nonetheless, they investigated important silvicultural problems that could only be answered satisfactorily by long years of ongoing research in their states or districts. Their research activities supplemented the research carried out by the administrative men within each state or district (Storey 1975), such as California District 5 (Godfrey 2005).

Starting in 1909, the Forest Service set nationwide research priorities and goals. As noted in the previous chapter, in 1891, Bernhard Fernow started forest products research in the form of a “timber physics” program, but this research was discontinued in 1897. In 1903, Gifford Pinchot reestablished forest products research, which utilized four timber-testing laboratories nationwide. It soon became evident that better coordination, laboratory supplies, and equipment could be provided if products research was consolidated into one centralized laboratory. Therefore, in 1909, the Forest Service announced that it would build a laboratory at the University of Wisconsin-Madison under the direction of McGarvey Cline.⁶ A year later, the

⁶ As early as 1907, bills were introduced into Congress to establish a centralized wood-testing laboratory in America. The idea for a new laboratory was moribund until McGarvey Cline, head of the Section of Wood Uses within the Forest Service’s Branch of Forest Products, proposed that a cooperative agreement with a high-grade technical school be undertaken to establish a national laboratory. Seven universities enthusiastically received Cline’s idea and they competed for the new forest products research facility. The University of Wisconsin received the highest scores in a ranking among them and on June 4, 1910, the Forest Products Laboratory opened there with Cline as its first director (1910–1912) (Godfrey 1990).

Forest Service dedicated the Forest Products Laboratory (FPL). Initially the FPL was organized into eight sections: wood preservation, timber tests, wood chemistry, wood technology, engineering, wood pathology, wood distillation, and pulp and paper (Storey 1975), and was considered a “forward step in forest conservation, a symbol of optimistic faith of the day, and part of the larger Progressive movement aimed at bettering modern society through rational planning based on science and technology” (Godfrey 1990).

The search for order in national forest research continued in January 1912 under Forest Service Order 41, which established a Central Investigative Committee (CIC) in Washington, D.C. Chaired by Raphael Zon, head of the silviculture branch, the other CIC members consisted of the heads of the grazing and forest products branches, James T. Jardine and Howard Weiss, respectively. The CIC was charged with setting up a plan for organizing national Forest Service investigative work.

Along with the CIC, district investigative committees (DICs) were created. They consisted of one representative of each of the major lines of investigation conducted at the district level (silviculture, grazing, and products) and one supervisor who had technical training. The creation of the CIC and DICs was an improvement over prior conditions, but only marginally (Storey 1975).

Meanwhile, the newly formed Forest Service continued to cooperate with other federal agencies on range and forest insect research as the agency had done in previous years. In 1905, following the transfer of the forest reserves to the Forest Service, the agency became directly concerned with problems associated with range use, protection, and rehabilitation. Initially, there were limited cooperative agreements with the Bureau of Plant Industry (BPI)⁷ for joint studies and experiments to discover under what conditions and in what localities it would be possible to secure natural reproduction of valuable forage grasses and plants, and how and where to plant new seed successfully (Pinchot 1907). But in 1908, a Branch of Grazing was created within the Forest Service, and the agency soon began conducting its own

⁷ To handle grazing developments throughout the Nation, Congress established the Division of Botany (1868), and then the Bureau of Animal Husbandry (1884). By 1895, however, deterioration of ranges in California and other Western States caused by the introduction of great numbers of sheep, which rapaciously consumed limited range resources, had become critical. Congress responded to these range problems by creating the Division of Agrostology, whose mission centered on studying major questions related to rotation, range reseeding, and grazing. In 1901, the Divisions of Botany and Agrostology were combined into the Bureau of Plant Industry, which aimed to rectify range problems by applying scientific principles to the study of forage plants, reseeding, and grazing impacts on public rangeland. But because its new director, W.J. Spillman, was interested more in crop agriculture than in range stock problems, federal range work was actually curtailed. There appears to have been little cooperative work on range matters between the Bureau of Plant Industry and Bureau of Forestry at this early date (Rowley 1985, 1999).

applied range science⁸ projects, exploring areas such as handling livestock, planting seed, studying poisonous plants, and exterminating animals injurious to rangeland. Two individuals, agricultural scientist James T. Jardine⁹ and plant ecologist Arthur W. Sampson¹⁰ (fig. 9)¹⁰, conducted reseeding studies, and reports on growth habits and requirements of important range plants to furnish important information for determining grazing capacity on Western ranges (Pinchot 1908, Storey 1975). Meanwhile, in 1910, the Forest Service moved closer to establishing its own range research program when the Office of Range and Forage Plant Investigations was set up in the Branch of Grazing. James Jardine was placed in charge. This step marked the beginning of a formal recognition of range research within the Forest Service as an important field of investigation. Subsequently, in 1911, district range research offices were established in the Pacific Northwest, and the Intermountain, Rocky Mountain, and Southwest regions. The primary work of these offices was to conduct range reconnaissance surveys, although limited studies of the relation of grazing to erosion and floods were conducted as well (Storey 1975).

⁸ Actually, the development of western range science may have begun in California, for in 1883, William H. Brewer published his influential essay “Pasture and Forage Plants” (Brewer 1883). Brewer’s article was the first publication in the Nation to actually identify the taxonomic distinctions between western versus eastern rangeland. In his study, Brewer used the valleys and lower ranges of the western Sierra in identifying and classifying California’s vegetation conditions. Interestingly, at that time, Brewer also recognized the area’s growing overgrazing problem. Brewer’s California observations may have foretold the catastrophic stock losses caused by overstocked ranges and depleted native grasses that occurred on the southern plains in the winter of 1885–1886, on the northern plains in 1886–1887, and in the Great Basin during the winter of 1889–1890 (Rowley 1999). With no regulation of grazing, mountain meadows were severely overgrazed by cattle and sheep, with some ranges in California completely denuded of vegetation and trampled out by 1890 (Godfrey 2005).

⁹ Born in Idaho, James Tertius Jardine graduated from Utah State Agriculture College in 1905 with a bachelor’s degree and soon joined the Forest Service as a special agent. In 1910, Jardine was made “inspector of grazing” in charge of national forest range investigations and surveys. From 1920 to 1931, he served as the Director of the Oregon Agricultural Experiment Station in Corvallis.

¹⁰ Arthur W. Sampson joined the Forest Service in 1907 as an assistant plant ecologist and was hired to work with Jardine on urgent range problems in the mountains of eastern Oregon. Their work furnished essential information for determining ways and means of using the forage consistent with the growth requirements of local vegetation. In 1911, Sampson’s work led him to California, where he worked with William A. Dayton on the relation of grazing to timber production on the Shasta National Forest (Sampson 1913). Thereafter, he became the first director of the Great Basin Experiment Station, a post he held from 1912 to 1922. Sampson was one of the first Forest Service researchers to study grazing and watershed problems. In 1922, he accepted a position as associate professor of forestry at Berkeley, where he introduced courses in range management, and taught at that institution until his death in 1940 (Cassamajor 1965).



U.S. Forest Service, Pacific Southwest Research Station

Figure 9—Arthur W. Sampson, pioneer range scientist in the Forest Service (1907–1922) and noted University of California grazing expert who introduced courses in range management at the Berkeley campus.

Besides cooperating with BPI on range research, starting in 1907 the Forest Service began working with the bureau's newly established Washington, D.C., forest pathology laboratory on forest disease research.¹¹ The BPI's D.C. laboratory gave major attention to nursery diseases—especially those afflicting conifers because of the Forest Service's efforts to reforest denuded areas in western forests—but was essentially responsible for all disease research, except for research on wood preservatives, which fell to the Forest Service. Additionally, by 1908, the laboratory began a survey of forest diseases in the West, and in 1910, the Forest Service reached an agreement with BPI to assign pathologists to each of the western forest districts. By that year, BPI pathologists focused their early studies on subjects like dwarf mistletoes (see "Scientific and Common Names" section) of western

¹¹ Forest disease research began in 1899 under Hermann von Schrenk, whose work led to the creation of the Mississippi Valley Laboratory at the Shaw School of Botany, Washington University, St. Louis, Missouri. The Bureau of Forestry and its successor, the Forest Service, worked with the St. Louis laboratory until 1907, when a disagreement occurred between the Forest Service and the Mississippi Valley Laboratory over areas of responsibility in different areas of pathology. The dispute led to the establishment of a new laboratory of pathology within the Bureau of Plant Industry in Washington, D.C. (Storey 1975).

conifers and heart rots of Pacific coast firs. In 1912, white pine blister rust (fig. 10)¹² assumed epidemic proportions and thereafter came under the watchful eyes of western pathologists (Storey 1975).

Finally, the Forest Service also continued work on insect research projects with the Bureau of Entomology's (BE) Office of Forest Insect Investigation, which had been created in 1902. During the period 1905 to 1914, BE's forest insect effort focused first on assessing important insect problems nationwide, and then on developing both control and research programs, especially in the Nation's western forests. By 1905, BE had developed a regional approach to the study of forest insects, and California fell into the Pacific coast region. The first control work in California began in 1910, and for the next several years, a major part of the effort of the forest insect group was controlling outbreaks of bark beetles there (Storey 1975).

Early Development and Growth of Forest Research in California and the Pacific Islands, 1905–1914

The year 1905 was a legacy year in California conservation history. In that year, not only did the General Land Office (GLO) forest reserves in California come under the control of the newly established Forest Service, but new forest reserves were carved out of public land in the state.¹³ At this time, the Forest Service had no "formal" forest research program in California, and would not have one until a few years later. Therefore, from 1905 to 1908, the Forest Service leaned on its own untrained personnel, or on California college professors of botany, for the small amount of formal research that was conducted in forest management, forest extension, forest products, and dendrology.

Important forest management studies conducted by Forest Service personnel included the inspection of timber cutting on District 5 forest reserves; the study of white fir; the formation of working plans for portions of the Sierra Forest Reserve;

¹² Blister rust is not native to North America, and it is generally believed that the rust's original host was Swiss stone pine in northern Asia. The rust made two critical moves into North America through imports of infected nursery stock. Imported pine seedlings brought the fungus to the Northeastern States in 1898, if not earlier. A separate shipment from France brought the fungus to the Pacific coast in 1910 at Vancouver, British Columbia. In the 1920s, the rate of spread picked up momentum, and by 1930, the rust had progressed as far south as the sugar pine stands in northeastern California and as far east as the white pine stands of western Montana (Miller and Kimmey 1958).

¹³ In 1905, they included the Diamond Mountain, Klamath, Lassen Peak, Plumas, Shasta, Trinity, and Yuba Forest Reserves. The Monterey (1906), Pinnacles (1906), San Luis Obispo (1906), and Stony Creek (1907) Forest Reserves soon followed. With the addition of the Stony Creek Reserve, California had the largest number of forest reserves in the country—20. The task of managing the "old" California GLO reserves and the "new" Forest Service reserves was left to forest reserve supervisors and rangers (Godfrey 2005).



U.S. Forest Service, Pacific Southwest Research Station

Figure 10—Blister rust is probably the most destructive disease of pines in the United States, and the Forest Service works diligently to control blister rust in America's forests.

and the examination of proposed cuttings on the Santa Barbara Forest Reserve. Forest extension projects comprised the study of state forest land; the preparation of planting plans with various landowners; and nursery and planting work on the Santa Barbara Forest Reserve. Forest products research and dendrology projects research were left largely to a cooperative field program with various universities and individuals who were drafted to conduct this research by the collaborator method. Dendrology projects included the study of the new and little-known eucalypts for the United States; the investigation of tanbark oaks of the Pacific coast; special studies of little-known California trees like the four-leaf pine, Torrey pine, and Bishop pine; and the examination of native and exotic acacias. Forest products research continued to look into the strength of various woods, through cooperation with the University of California at Berkeley. Studies carried out in Los Angeles centered on wood preservation. Forest Service personnel such as Robert Ayers¹⁴ ran experiments in the preservative treatment of fence posts with creosote in open tanks and experimented in seasoning and treating telephone and other poles for electric wires in close cooperation with southern California electric companies (Hill 1931).

The California research situation changed somewhat in December 1908 when Gifford Pinchot reorganized the Forest Service into districts and transferred a good part of his clerical staff from Washington to district offices, which became

¹⁴ Robert W. Ayres joined the Forest Service in 1902 and retired in 1943. By the time of his retirement, he had served under every district and regional forester of the California region and typified old-time forest officers (Godfrey 2005).

small replicas of the Washington office (WO) with the same branch organization. California and a small portion of Nevada was designated as District Office 5, and Frederick E. Olmsted¹⁵ was placed in charge of District 5's small staff, located in San Francisco. Any formal forest research conducted within District 5 by the Forest Service was left to the branch chiefs, and the superintendents, rangers, and technical field men under them. George M. Homans¹⁶ led the silviculture branch with the practical and blunt New Englander T.D. Woodbury¹⁷ as his assistant. George Peavey¹⁸ conducted planting work and F.R. Cooper¹⁹ headed investigations. John H. Hatton²⁰ was made chief of grazing, and C. Stowell Smith was made chief of products, a position he held until 1917 (fig. 11). There were assistants and project leaders as well for operations, silviculture, grazing, and products (Hill 1931, Show, n.d.). From this point onward, the development of Forest Service research work in California was given direction by these men and took a productive form.

During the period 1905 to 1914, two district foresters administered California District 5. Frederick Olmsted carried District 5 through its initial years from 1908 to 1911. However, even at this early date, District 5 staff started to complain about

¹⁵ Frederick "Fritz" Erskine Olmsted was a young discipline-minded engineer, who, after attending Yale, entered the U.S. Geological Survey (USGS) as a surveyor, where he met Pinchot. Following his advice, Olmsted attended the Biltmore Forest School and then trained in forestry in Germany and India. In 1900, he returned to America and joined the USDA Division of Forestry. In 1908, Olmsted became California District 5's first district forester, a post he held until June 1911, when he left the Forest Service. Olmsted then worked as a consulting forester, served as president of the Society of American Foresters (1919), and wrote numerous articles promoting effective fire protection and good forest management (Godfrey 2005).

¹⁶ In 1910, George Morris Homans was appointed California's third State Forester, following E.T. Allen (1905) and George B. Lull (1906–1909).

¹⁷ T.D. Woodbury joined the Forest Service in 1904 and was a key member of California District 5's timber management program from the 1910s to the 1930s, where he was in charge of the Branch of Timber Management, and after 1935, the Division of Forest Management. According to Woodbury, the policy of national forest management in California was very simple: "It consisted in selling mature timber wherever the operator wants it unless some reasons were known why the sale should not be made." In other words, silviculture and timber sales took precedence over all other forest management areas and responsibilities. During World War I, Woodbury was made Assistant District 5 Forester when Coert DuBois was furloughed to the war effort and later Assistant Regional Forester until his retirement in September 1941 (Godfrey 2005).

¹⁸ George W. Peavey left the Forest Service soon thereafter to become the first Dean of the Forest School at Corvallis, Oregon, and then President of Oregon State University (Godfrey 2005).

¹⁹ No information could be located regarding F.R. Cooper.

²⁰ Hatton later transferred to another Forest Service district. His successors were M.B. Elliott and later C.E. Rachford; both had worked as cowboys before joining the agency (Show, n.d.).



U.S. Forest Service, Pacific Southwest Region

Figure 11—District 5 officers. left to right: T.D. Woodbury, Forest Management; L.A. Barrett, Lands; Paul G. Redington, District Forester; Frank E. Bonner, District Engineer; S.B. Show, Research; J.W. Nelson, Grazing; Dr. E.P. Meinecke, Pathology; W.I. Hutchinson, Public Relations; A.W. Smith, Finance and Accounts; R.L. Deering, Operations.

the level of useable information and scientific fact regarding California forestry. For instance, at the 1910 supervisor's meeting for District 5, old-time forest examiner Louis Margolin succinctly summarized the history and current state of Forest Service forestry research in this way.

When the old Division of Forestry was first organized it was a purely technical office engaged in two different lines of work. Its chief task was propaganda—the spreading of the gospel of Forestry amon[g] an uninterested nation. The second task was of a scientific character, and some of our most valuable publication[s] date from that period...

When the transfer of the Forest Reserves from the Interior Department to the Department of Agriculture occurred on February 1, 1905, a great change took place in the policy of the old Division of Forestry. From an insignificant scientific office it developed into a great administrative

Bureau.... As a consequence the scientific force of the Bureau was greatly reduced and was overshadowed in every way by the men in administrative positions. Scientific work was at a discount and the best men fought shy of it. This state of affairs was entirely justifiable at that time, but as order is now being brought out of chaos a change is taking place [USDA FS 1910: 36].

Under Olmsted, District 5 undertook to do something about this situation. Men like Olmsted saw that science played an important role in timber, forest products, and forest influences, and he supported the classic fields of European forestry on which investigations had centered since Bureau of Forestry days. Most California research efforts in these early years focused on reforestation research, especially the reclamation of brushfields in southern California through nursery and planting programs. Besides reforestation, District 5 personnel also recognized the value of research in other important areas such as forest products, although Olmsted considered it “more or less separate and distinct from the Forest Service” (USDA FS 1910). Nonetheless, research accomplishments under Olmsted were limited prior to his resignation in June 1911.

With District Forester Olmsted’s departure, Coert DuBois became District 5’s second district forester, and served from 1911 to 1919. During DuBois’ administration, research efforts in California increased in some research areas, and changed directions in others.²¹ Much like his predecessor, District Forester DuBois saw products research as a service only to lumbermen and he believed it had no place in a district organization whose main business was the running of public forests. He maintained that if lumbermen wanted products research, they should establish and finance it themselves, and argued that such work should be confined to the FPL (Hill 1931). On the other hand, DuBois did believe in research in silviculture, forest pathology, entomology, range management, and especially fire protection and control.

²¹ Starting in 1911 and under the direction of District Forester Olmsted, District 5 supervisors were required to prepare silvicultural work plans for their forests based upon a 17-page questionnaire that asked for past, present, and future information regarding all classes of forest business, as well as timber management on their forests. Although these plans were supported by a mass of related data, in one supervisor’s opinion, they were mostly made to give the files a “scientific aroma.” In 1914, DuBois suspended the effort (Godfrey 2005).

California Forest Service Research Program, 1905–1914

Silviculture Studies

During the first decades of the 20th century, silvicultural studies covered a broad spectrum of research topics. District 5 carried out a number of such studies during the period 1905 to 1914, to resolve forest management problems through scientific investigations. For instance, there were minor studies regarding the different methods of cutting, the influence of forests on streamflow, the breeding of trees, and the differences in the growth owing to seed source.²² Forest economics and marketing studies were made in cooperation with the state of California on white fir and other important commercial trees of the Sierras. Cooperative state forest studies also included a commercial tree study of the redwood and the completion of a series of studies on California's forests (Pinchot 1906, 1907, 1909). But without question, in these early years, forest regeneration studies dominated silvicultural research in California, particularly in southern California. Southern Californians, such as Theodore P. Lukens²³ and George B. Lull,²⁴ agitated for this reforestation research, and planting investigations were the order of the day.

To meet reforestation needs, between 1905 and 1908 District 5 expanded the capacity of the Henninger Flats nursery in southern California, building sleeping quarters, a tool house, and increased working equipment there. By the end of the

²² The policy of the Forest Service at this time was to reestablish by artificial means, as rapidly as possible, areas of forests that would not within a reasonable time be reforested naturally. Seeding was seen as a viable means to this end, and a large amount of experimental work in seeding and planting was done to determine the best methods. As early as 1909, various comparative methods of seeding and planting were being investigated on the Angeles, Cleveland, and Santa Barbara National Forests (Pinchot 1909).

²³ Theodore Parker Lukens was a Pasadena civic and business leader and citrus grower who actively crusaded for watershed protection in southern California. Starting in the 1880s, Lukens pushed for regeneration of California's forests by planting efforts and believed that the burned-over southern California mountainsides could be covered with timber and the watershed protected. He and others like Abbot Kinney were conservationists for pragmatic reasons—they wished to conserve watersheds for nearby metropolitan areas' domestic and commercial needs. Lukens' perseverance with reforestation eventually earned him the sobriquet "father of California forestry" (Godfrey 2005).

²⁴ George B. Lull joined the Bureau of Forestry shortly after graduating from Cornell and was one of Gifford Pinchot's youthful assistants. He worked on the California-Bureau of Forestry Joint Forest Survey (1903–1905), where the boy from the East became deeply impressed with the eucalyptus tree (Clar 1959). In 1906, Lull became California's second State Forester—an office he held until 1909. Lull devoted much energy toward fire protection, but his administration is best known for his support for the planting of eucalyptus for future hardwood timber supplies. He mistakenly believed that the eucalyptus industry would one day be a more fruitful source of revenue to the state of California than the orange industry (Pratt 1931).

year, nursery rows at Henninger Flats contained approximately 387,000 two-year-old trees, which were set out in the mountains to fill in spaces in previous plantings. Small experimental plantations were also set out at 500-foot intervals all the way to the summit of Mount Wilson, where the famous observatory now stands. Besides these actions, the Henninger Flats nursery supplied 30,000 trees for planting on the Santa Barbara Reserve. An additional 3,100 ended up at Griffith Park,²⁵ and almost 12,000 were given to individuals to plant on watersheds for experimental purposes. While improvements were being made at Henninger Flats, District 5 established nursery and planting programs elsewhere on California forest reserves. Meanwhile, in the spring of 1905, a new nursery was built at Marcos Pass on the Santa Barbara Forest Reserve, where the beds were seeded with knobcone, Jeffrey, and gray pine (Pinchot 1906), and the next year, District 5 made extensive preliminary examinations for reserve planting plans in northern California on the Modoc and Warner Mountains. By the following year, planting efforts took place on the San Bernardino National Forest²⁶ with 42,000 trees planted. Forest rangers on the San Luis Obispo and the Monterey National Forests experimented with planting as well, setting out 5,100 and 4,700 trees, respectively, on these forests. All of these work projects tested the value of different kinds of trees and planting situations while training the field force in planting methods (Pinchot 1906, 1907).

Reforestation efforts also spilled over to one special investigation that involved extensive cooperation with the state of California. This extension project included a study of forest planting for watershed protection and wood supply in California's agricultural regions; an important investigation of the relation of forest cover to streamflow for water power and irrigation companies; and completion of a report submitted to the California State Board of Forestry on the location and extent of state forest lands with Forest Service recommendations for legislation (Pinchot 1906). Soon everybody in the state seemed to be forest extension minded—even in northern California, where planting or seeding was thought necessary to assist natural reproduction in the reclamation of areas deforested by fires (Pinchot 1909). Furthermore, by 1909, cooperative experiments in nursery and planting were also expanded to Hawaii, when Ralph S. Hosmer (fig. 12), the Territorial Forester for

²⁵ Griffith Park, one the biggest state parks in California, is situated in the eastern part of the Santa Monica Mountains, and covers 4,000 acres. In the park are the Los Angeles Zoo and the Griffith Observatory. The park bears the name of its founder Griffith J. Griffith, who donated the greater part of the park land to the city in 1896.

²⁶ On March 4, 1907, all forest reserves were renamed national forests.



Courtesy of Forest History Society, Durham, NC

Figure 12—Ralph Sheldon Hosmer, Hawaii's first Territorial Forester for the newly established Division of Forestry in Hawaii. He helped establish forest reserves throughout the islands.

Tree-planting rangers, their backs aching from the grueling labor, knew well before their superiors did, that the reforestation work was futile in this part of California.

Hawaii²⁷ conducted experiments to determine which trees were best adapted to regional use there. Cooperative experiments with state institutions and with the support of the Territorial Legislature in Hawaii soon centered mostly on nursery and planting work (Pinchot 1909).

Notwithstanding the above accomplishments in Hawaii, there were major problems with reforestation in southern California at the onset, for despite their investment in money, time, and labor, District 5's determined efforts to convert indigenous chaparral into forest land desired by southern California residents fell far short. Unlike the rest of the Nation, where the expense of growing and planting was within reason (\$0.81 per thousand 1-year-old seedlings), in southern California, the average cost of setting trees out on the chaparral-covered watersheds of reserves such as the San Gabriel and Santa Barbara Forest Reserves was much higher (\$17.22 per thousand 1-year-old seedlings), and difficult besides. Tree-planting rangers, their backs aching from the grueling labor, knew well before their superiors did,

²⁷ In 1894, Ralph Sheldon Hosmer received his Bachelor of Agricultural Science from Harvard and thereafter served in the USDA Division of Soils (1896–1898) but transferred to the Division of Forestry where he was a field assistant to Gifford Pinchot and then Chief of the Forest Replacement Section until 1903. During the interim, he became one of the charter members of the Society of American Foresters (1900) and was admitted to the first class of the Yale Forest School, obtaining his Master of Forestry in 1902. In January 1904, on Pinchot's recommendation, he became, for a decade, Territorial Forester of Hawaii. Hosmer recognized that the most important resource of Hawaiian forests was water for irrigation of agricultural lands. He also realized that the two greatest hazards to maintaining adequate forest cover on the watersheds were grazing and fire. He proposed and enacted a system of forest reserves, which at the time embraced approximately one-fourth of the total area of the islands. He also advocated extending the forest area by planting and began large-scale test planting of exotic trees to determine those best suited for such extension. Because of his contribution to forestry in Hawaii, a grove of timber on the slopes of Mount Haleakala in the Hawaiian National Park was set aside to memorialize him as being the “father of Hawaiian forestry” (Journal of Forestry 1957). For a history of the early years of forestry in Hawaii, see Cox 1991.

that the reforestation work was futile in this part of California. Each season, they watched a large percentage of recently planted pine seedlings be eaten by rabbits, birds, wood rats, and other rodents. What trees survived these assaults withered under the heat and drought conditions of southern California. For instance, the San Gabriel nursery lost more than 90 percent of its trees planted in 1906, and wild animals destroyed nearly 50 percent of those planted the next year. A full 95 percent of those trees planted in the brush were seriously injured. In 1907, the Santa Barbara nursery lost 66 percent of their plantings because of late summer dry weather. To combat these setbacks, the Forest Service tried to give greater care to choosing planting sites and to perfecting its field planting techniques. To this end, the Henninger Flats and Marcos Pass nurseries were closed in 1907, and the Pasadena nursery, which had been in operation for 4 years, was moved to Lytle Creek, because this location on the renamed Angeles National Forest offered a more reliable source of water. By the next year, the 75,000-acre Lytle Creek nursery had an annual productive capacity of 500,000 trees and had some 65,000 trees ready for planting (Pinchot 1906, 1907, 1908, 1909). In spite of these actions, attrition of young trees continued to frustrate the efforts to reforest critical watersheds. For instance, at the 1910 supervisors meeting, Angeles National Forest Supervisor R.H. Charlton noted that 50 percent of the 54,000 conifers he planted only 6 weeks before were now dead. Hearing this statement, another supervisor admonished him, stating that the “brush cover is the [emphasis in original] cover in southern California. Go and ask the people who have lived there for years and they will tell you that brush cover is the best cover.... Water is the main question down there” (USDA FS 1910). District 5’s reforestation problems appeared hopeless. Anxious to find a solution, the Forest Service turned to the eucalyptus tree, a tall Australian evergreen species, as the answer to their prayers.

Experimentation with eucalyptus began in 1906, when the Forest Service in cooperation with the State Forester explored the silvical characteristics and methods of propagation of eucalyptus. Initially, this study was undertaken because of a newly appreciated value of eucalyptus for posts, telephone poles, pilings, and railroad ties based on timber testing by the University of California at Berkeley. These experiments aroused great interest among consumers of structural timber in California because initial testing promised to bring to California a new usable species that would help promote a more conservative utilization of the native timber supply (Pinchot 1906, 1907). Therefore, this cooperative project began limited experimental planting of the species, with 4,000 acres of eucalypts put out in 1907 (Pinchot 1907). A year later, the Forest Service issued a revised circular on eucalyptus describing the trees’ characteristics, and distributed 30,000 copies of the circular in California (Pinchot 1908). Additionally, during the winter of 1908–1909,

District 5 planted nearly 45 acres of eucalyptus in its nurseries, which grew rapidly and even withstood an exceptional drought that year. At this point, Forest Service officials naturally concluded that eucalyptus forest (fig. 13) might protect southern California land at least as well as chaparral, and provide added value as timber for the public (Pinchot 1909). By 1910, many in the Forest Service thought there was even a good possibility of successfully replacing southern California brushland with eucalyptus at a reasonable cost (Pinchot, FS 1910).

Southern Californians themselves became ever more interested in the fast-growing evergreen as well. Bolstered by private studies, and now by Forest Service scientific studies, the general public came to believe that the aromatic tree, which



Forest History Society

Figure 13—Eucalyptus were imported into California as early as the 1860s. Many plantations were established on the bare hills of southern California at the turn of the century because of the tree's reputation for fast growth and hardwood production.

also produced an oil with medicinal properties, could yield as much as 100,000 board feet in 10 years. Before long, extravagant claims by speculators led to a “Eucalyptus Gold Rush” in California, where overnight more than 50 eucalyptus-growing companies were incorporated. An investment boom resulted in exorbitant stock sales, and before long these companies represented stock valued at several million dollars. Concomitant with the stock fever came a land rush fueled by outlandish real estate promotions of eucalyptus plantations. The Forest Service was not immune from eucalyptus fever either. Based on its own initial, but limited information, District 5 immediately started nurseries on southern forests geared to fill eucalyptus demands. New nurseries were built at Oak Grove (Cleveland National Forest), Los Preitos (Santa Barbara National Forest), Cerro Alto (San Louis Obispo National Forest), and Merrick Canyon (Angeles National Forest). But the miracle was not to be. The proverbial eucalyptus bubble burst when additional tests and studies by District 5’s Office of Products proved that the yield and return on the eucalyptus species did not meet the exaggerated expectations that earlier studies found regarding both growth rate and timber quality. Furthermore, young growth—which constituted the present stands in California—could not be commercially converted into high-grade lumber because of kiln drying concerns. To warn the public, Assistant District Forester T.D. Woodbury published Circular No. 210, *Yield and Return of Blue Gum in California* (1912). With this new research knowledge, the Forest Service almost immediately abandoned their eucalyptus nurseries. Nonetheless, eucalyptus fever lasted in California for several more years. When it finally died out, it left behind many penniless investors (Ayres 1958; Brown 1945, 1945b; Graves 1910, 1913; Pinchot 1909; USDA FS 1910, 1912, 1913).

The surge of reforestation on California’s national forests came to an end as well because of the eucalyptus bust. Even though District 5 contracted with the War Department for the afforestation of Angel Island, Fort Barry, Mare Island, and, later on, Yerba Buena in northern California, by 1911, Forest Service employees had become disillusioned with reforestation efforts. The almost complete failure of direct seeding both in northern and southern California had become more and more evident, except on the Shasta National Forest in northern California. Here the Pilgrim Creek nursery²⁸ continued to generate real interest in nursery and planting

Before long, extravagant claims by speculators led to a “Eucalyptus Gold Rush” in California, where overnight more than 50 eucalyptus-growing companies were incorporated.

²⁸ The Pilgrim Creek nursery was established in 1910. By 1913, it had 338,000 seedlings and transplants on hand, but was one of the smallest national forest nurseries at the time (Graves 1913, 1914, 1915, 1916). The bulk of trees cultivated here were Austrian pine (40 percent), yellow pine (23 percent) or sugar pine (14 percent), which were to be used on the Shasta National Forest, and stock was made available for establishing experimental plantations on other forests in the northern portion of District 5. The Pilgrim Creek nursery also propagated stock of eastern hardwoods for experimental planting at low elevations on forests bordering the Sacramento Valley (USDA FS 1910, 1912).

research among foresters (Show, n.d.). But on the whole, planting failures in southern California were found to be nearly universal. In 1912, because of drought, frost, rodents, and birds, and because past failures with planting and artificial seeding on a large scale were so persistent, District 5 postponed further reforestation work in southern California until methods that promised success could be developed. In a “doleful” report written by Assistant Chief of Silviculture T.D. Woodbury and Forest Assistant Edward Munns, forest extension work in southern California was declared a “foolish” failure. Despite the Forest Service’s failure, Woodbury’s report suggested that planting should continue as a research matter, and recommended that the Feather River Experiment Station, which had been established on the Plumas National Forest in 1912, take up the subject of reforestation work with the aim of restoring burned areas in the main forest belts in northern California (Ayres 1941; 1945a, 1945b; Buck 1974; Munns 1913). In 1913 in southern California, the closed Converse Flats nursery on the Angeles National Forest was converted into the Converse Experiment Station—California’s second experiment station. Under the direction of the energetic Edward N. Munns,²⁹ the station’s designated mission was to study southern California watersheds, which were heavily used for municipal supply, including wherever extension of forest growth would better both the regularity and the purity of streams (Graves 1912, 1913, 1914).

Besides the Forest Service’s obsession with its planting and nursery reforestation programs, and the intense effort and expense put into the promotion of eucalyptus as the answer to the tree planter’s prayers—at least in southern California—starting in 1909, District 5 conducted a number of other silvicultural studies. The aim of these investigations was to resolve forest management problems through the collection of data for growth and volume tables for leading commercial species in the Sierras³⁰ through the establishment of permanent sample plots laid out on many

²⁹ Edward Norfolk Munns joined the Forest Service in 1912 as a regular employee after undergraduate work at the Bradley Polytechnic Institute of Illinois, and obtaining a Master of Forestry degree from the University of Michigan. His first assignment was as a forest assistant on the Angeles National Forest, comprising the critical watersheds of southern California. There, the study of the effects of fire and other forms of cover depletion on water erosion and flooding influenced his entire career. In 1913, he was made head of the Converse Experiment Station. With the closure of the station during World War I, Munns did some war work and then returned to District 5 after the war to conduct a logging and cutting methods study for the state of California. Eventually, Munns went to Washington, D.C., and served as Chief of the Office of Experiment Stations (1925–1928), where his influence was great and unique. In 1937, his extensive knowledge regarding watershed management led to his selection as chief of the Division of Forest Influences when it was established that year (Show, n.d.; Watts 1951).

³⁰ S.W. Allen, Gerald Kennedy, and Frederick Thomas, out of Sonora, California, conducted these studies (Hill 1931).

forests.³¹ These plots were designed to secure accurate data through experiments concerning such matters as recovering denuded areas, the introduction of new species, and the best effects of different methods of cutting (Hill 1931; Pinchot 1906, 1907, 1909).

Although growth and volume studies began under District 5 Forester Olmsted, they did not become fully established throughout the district until 1911, when Coert DuBois took over. In that year, DuBois directed Forest Assistant R.S. Maddox to set aside a 24-acre plot on the Plumas National Forest in order to study growth and reproduction, following logging in mixed conifers by the Feather River Lumber Company in 1910. In July 1912, at the urging of Forester Henry S. Graves³² and Raphael Zon, chief of the Division of Silvics in Washington, D.C., DuBois established the Feather River Experiment Station on the Plumas National Forest in northern California to oversee this experiment. The station was to give chief attention to the problems most typical of the region and most urgent in District 5, including the study of sugar and yellow pine forests and the reforestation of the brushfields on California's northern national forests. In 1912, the vast brushfields on a number of national forests of northern California totaled roughly 1.5 million acres. Additionally, District 5 studied the possibility of reforesting the extensive bear clover or tarweed areas in the central and southern Sierras, which had been created largely by repeated forest fires. They believed that planting or seeding would ultimately play a large part in reclaiming deforested areas and assisting natural reproduction in northern California (Graves 1910, 1912; Show, n.d.; USDA FS 1912). DuBois' actions became one of the most significant events for scientific forestry in California.

The Feather River Experiment Station was located 4 miles north of Quincy, California, and was the fourth experiment station established in the Nation. DuBois

³¹ As early as 1906, a plot had been established on the Stanislaus Forest Reserve. These plots were maintained from 1906 to 1909, with the purpose of studying growth of residual stands, establishment and growth of regeneration, and decay of logging slash (Fowells 1978).

³² Henry Solon Graves started his career by first studying forestry in Europe before being appointed assistant chief of the Division of Forestry in 1898 under Gifford Pinchot. In 1900, he resigned that post to become director of the Yale University School of Forestry, where he taught many of District 5's foresters. In 1910, he became the second Chief of the Forest Service and served until 1920. One of his many contributions during his tenure was to strengthen the foundations of forestry by putting them on a more scientific basis when the Forest Products Laboratory (1910), the Central Investigative Committee (1912), and the Research Branch of the Forest Service (1915) were organized and established during his tenure (Clepper 1971).

The establishment of Feather River under H.A. Greenamyre lifted the burden of making everyone with a forest school diploma in District 5 into a scientist.

picked H.A. Greenamyre³³ to direct the station, but Acting Director D.K. Noyes (1914–1915) soon replaced him. However, during the station’s first year of operation, Greenamyre put in a small nursery and constructed a residence and barn, which got the station underway (Fowells 1983). The station was placed under the administrative control of District Forester DuBois, who was located in San Francisco. However, District 5’s Central Investigative Committee devised the Feather River Station’s research program.³⁴ This situation created a dual authority over the station and its research program that caused many problems in the early years of the station’s operation. Although the Feather River Experiment Station supplemented rather than replaced research activities conducted by District 5 administrative staff, there appeared to be concerns and disputes between station and District 5 personnel (Fowells 1983). Nonetheless, the establishment of Feather River under H.A. Greenamyre lifted the burden of making everyone with a forest school diploma in District 5 into a scientist (Show, n.d.). Besides, the average forest assistant was “not naturally inclined to do any more scientific work than he could help” and even preferred administrative work to scientific studies (USDA FS 1912).

From the onset, the Feather River Experiment Station was designated primarily to serve national forest needs in northern California and parts of Nevada. The station’s initial scope of work defined three areas for research emphasis: forest problems, which included silvical volume and growth and stand studies; forest influences, which included mostly meteorological observations; and artificial reforestation, which included nursery practices, test planting, and seed sowing (USDA FS 1912). At the time of the station’s establishment, the forest was old-growth mixed conifer of medium site quality. To determine the best practices for converting old-growth stands to managed forests, eight permanent plots, each 6.4 acres, were established in the drainage of Massack Creek. In 1913 and 1914, two plots were cut at 10 percent, two at 20 percent, two at 30 percent, and two at 40 percent of volume. Following logging, some reproduction plots were put in. From their initial cutting to just after World War II, a veritable who’s who of District 5 researchers regularly participated in reexamining and collecting important data from these plots³⁵

³³ Not much is known knowing Greenamyre. However, Stuart Bevier, or “S.B.” Show, the indefatigable and outspoken leader of District/Region 5 from 1926 to 1946 stated in his memoirs that Greenamyre was a “bad choice” but gave no explanation for his opinion (Show, n.d.). One reason he may have grated on Show was that upon taking his position, Greenamyre injudiciously criticized the past scientific work of forest assistants, stating that “in some cases the basic principles have not been sound” and that though a mass of information had been gathered by them, their data had not been correlated and applied (USDA FS 1912).

³⁴ The actual membership and annual programs of District 5’s CIC are unknown because of gaps in the historical record.

³⁵ They included R.S. Maddox and R.W. Taylor (1914 and 1915), Duncan Dunning (1917), Dunning and S.B. Show, E.N. Munns, and J.A. Kittredge (1920), Howard Siggins (1925), Dunning, U.A. Clements, and A.L. Hormay (1926), A.A. Hassel (1930), P.G. Haddock and P. Burris (field assistant) (1941), and R.F. Nelson (1946) (Fowells 1983).

(Fowells 1983). The Feather River Station also conducted planting and nursery studies. Following the development of the little nursery by Greenamyre in 1912, T.C. Zschotte put in a seed spotting study in an area near Meadow Valley the next year. A year later, Greenamyre, along with G.H. Wiggins and D.K. Noyes, also started a study of various tree species in an experimental area of the Bear Creek drainage. Here, they measured soil temperatures, soil moisture content, and evaporation³⁶ (Fowells 1983).

Forest Products Research

Whereas silvical studies, discussed above, aimed at increasing the productive power of the forest, forest products studies were designed to improve economy in the use of what the forest creates. At this date, the Forest Service sought to promote economy of use, first, through learning and making known the actual situation as to demand and supply of forest products, and second, through investigations to discover how forest products might be put to better service. As a result of forest product scientific studies, the Forest Service was increasingly able to give advice concerning methods of handling, seasoning, manufacturing, and utilizing woods, as well as the extraction and manufacturing of forest products and many similar matters (Pinchot 1908, 1909). In California, forest products studies were not a major emphasis of District 5's research program largely because of the prejudices of District Foresters Olmsted and DuBois. Nonetheless, some such studies did take place under the direction of C. Stowell Smith, District 5's chief of products.

Prior to 1908, Forest Service forest products research had focused on timber testing in cooperation with the University of California at Berkeley. This testing aimed at learning whether certain species, such as eucalyptus, redwood, red fir, and tanbark oak, could be used in place of such structural timbers as hickory and oak (Pinchot 1906, 1907). By 1908–1909, timber testing at Berkeley found California tanbark oak suitable for use as a substitute for eastern hardwoods, and that a number of species of eucalyptus might be used in place of hickory and oak, although this conclusion was later proved to be wrong. Additionally, cooperative testing was conducted on redwood with the California Redwood Association (CRA) to determine its value as a structural wood (Pinchot 1908, 1909). District 5's staff of five Office of Products technicians concentrated their work on other problems. These included seasoning of various kinds of lumber and the determination of their best uses; investigations into the value of different barks for tanning purposes; the

³⁶ These early planting and nursery studies were followed until 1922, when S.B. Show summarized them in USDA Circular 92 (Fowells 1983, Show 1930).

Smith would rig up an old tank and fill it up with hot creosote. He would then grab nearby ranchers by the neck, bring them to his operation and say: “Come here with your fence posts: stick `em into the tank; I know what’s good for you.”

quality of paper or cardboard yielded by different pulpwoods; the amount and kind of products that could be extracted from California woods through distillation; the heating value of different species and the relative durability of different woods when exposed to influences of decay and other destructive agencies, such as marine wood borers³⁷ in salt water (USDA FS 1910).

At the same time, Smith’s District 5 Office of Products spent a great deal of time and money investigating the efficiency of various preservatives and methods of application. As a result, Smith carried on a vigorous campaign to educate and induce wood users to adopt methods that had already been proved practicable³⁸ (USDA FS 1910). In 1908, a number of electric light and power companies took Smith’s advice. In cooperation with the Forest Service, they erected a number of experimental open-tank plants at Fresno and Los Angeles at which several thousand western yellow pine and red cedar poles, used for telephone and power poles, were treated. Many of these poles were placed in an experimental line between Los Angeles and Whittier, California, to test the relative merits of the different preservatives (mostly creosote and zinc chloride) and methods of treatment. This cooperative work continued the following year when the investigative work with five electric light, railway, and power companies in southern California worked out methods of handling and preserving western yellow pine and redcedar poles, together with designs for a commercial pole-treating plant (Pinchot 1908, 1909; USDA FS 1910).

Meanwhile, the Forest Products Branch within the WO underwent a slow re-organization, which affected California research. At first, various sections were renamed or combined to solve administrative problems (Pinchot 1907). However, by 1908, it became clear that the Forest Service needed a more centralized organization to be efficient. To consolidate the timber testing work and bring it into close cooperation with the wood chemistry and wood preservation sections, the Yale and Purdue testing laboratories were discontinued. This action left the laboratories at the Universities of Colorado, California, and Washington to work on problems directly concerned with the utilization of products of the national forests. After

³⁷ Marine borers are organisms that make their home in immersed timber or stone. They can be divided into two classes: mollusks and crustaceans. The former burrow into the interior of the wood, and from the surface their attacks are not very apparent, whereas the latter eat inward from the surface, destroying one layer of wood at a time. By this early date, these marine pests had done incalculable damage to harbor pilings in San Francisco and San Diego Bays, and in other coastal areas of the country (USDA FS 1910).

³⁸ One story goes that Smith would rig up an old tank and fill it up with hot creosote. He would then grab nearby ranchers by the neck, bring them to his operation and say: “Come here with your fence posts: stick `em into the tank; I know what’s good for you” (USDA FS 1910).

1910, and the establishment of the FPL in Madison, Wisconsin, the investigative work and research methods of these remaining university laboratories were to be closely correlated with the FPL (Pinchot 1908, 1909). Other forest products research work was also gradually centralized under the direction of the FPL, leaving the California Office of Forest Products very little research to do. C. Stowell Smith and his staff still ventured into a variety of areas, such as conducting experiments in turpentine western yellow pine because there was such a high national demand for naval stores products (Graves 1912), or studying the practicability of obtaining hardwood distillates, wood alcohol, acetate of lime, and charcoal from California black oak (Graves 1914). But, for the most part, District 5's Office of Products was relegated to wood preservation projects in cooperation with the FPL. These projects constituted the bulk of the program for several years to come.³⁹

Fire Research

Beyond silvicultural studies and forest products research, District 5 spent research time on fire protection and control research, which by 1915 had evolved into a systematic study of fire in the California region. First, there were the easy years prior to the creation of District 5 when fire seasons were mild. Nonetheless, starting in 1906, the Forest Service worked closely with the state of California to develop fire-protection plans. These plans aimed to prevent fires from starting by means of patrols along carefully laid out routes, by locating telephone and tool stations at key places for the patrols, and by building broad firelines. In 1907, this cooperative effort led to the building of a permanent fireline on the San Bernardino National Forest. Two years later, the state of California commissioned forest rangers in the state as fire wardens, and in that same year, the value of firelines was shown in southern California, where one fireline stopped a serious fire without human help, and another prevented a dangerous valley fire from extending into the mountains. Burned areas in California were greatly reduced in these years by this thinly spread out line of protection improvements, along with a few rangers and fireguards (Pinchot 1906, 1907). "Light burning," or the intentional burning of forests to improve grazing, became a major issue at this time as well. Some proposed that all forests "should be burned over every year or two in order to prevent the accumulation of vegetable litter on the ground." Nonetheless, at this time, the Forest Service took the

³⁹ Cooperatively engaged with various companies, the FPL designed wood preservation plants and set standards for the physical and chemical requirements of wood preservation, using the data obtained earlier by District 5. The laboratory eventually determined that wood-treating plants used 1-1/2 times as much zinc chloride, and 10 to 20 times as much creosote as necessary to prevent decay. These kinds of findings put the preservation industry on a sounder scientific basis than it had been before (Godfrey 1990).

position that although there were a “few open forests of mature timber where the ground might be burned over annually or periodically by a light fire under complete control without injury to the forest,” there was only an “exceedingly limited area” in the mountains where this could be safely done and at great expense (Graves 1910).

Then came the disastrous 1910 fire season, when 2.5 million acres on western national forests burned. In Idaho, the “Milestone Blaze,” dubbed so for its effect on the public conscience, killed 85 people, 72 of whom were firefighters. California was not struck as hard during the 1910 fire season, compared to the disaster that befell the northern Rockies, but by the end of the summer, 278 fires had burned thousands of acres of California national forest land. People had caused two-thirds of them, either accidentally or deliberately (Cermak 2005, Godfrey 2005).

Fire research in California grew out of this devastating fire season, for in the wake of that fateful summer, District 5 officials produced an unprecedented wave of innovation in fire control. This ingenious rush of ideas included adapting automobiles, motorcycles, and even balloons and fixed-wing aircraft for fire patrols. Beyond these technological developments and others, district personnel conducted some of the earliest fire research studies in the state and perhaps the country. For instance, in 1911, Roy Headley, District 5’s Chief of Operations, produced the first fire case study in California when he analyzed the Waterman Canyon Fire on the San Bernardino National Forest, “taking into account fire suppression costs and fire damage” (Cermak 2005). A year later, Richard H. Boerker,⁴⁰ a ranger from the Lassen National Forest, thoroughly discussed the issue of light burning versus forest management in northern California in an article for *Forestry Quarterly* (1912). In that year, a large number of fires were deliberately set in northern California. These were not started by vandals or criminals, but were set according to the theory of light burning practiced by certain influential timbermen of the state (Graves 1912). After reviewing the known data and using a rather complicated mathematical formula based on measuring the relationship of yield, thinning, value of the soil, capitalized value of the annual expenses, age of the stand destroyed, a 100-year rotation factor, and interest rates, Boerker concluded that “fire should be used only after careful consideration of both the advantages and disadvantages which its use carries with it.” In short, only “where the fire danger was great; where there is no young growth; where the fire can be controlled; with fire-resistant species; and where the injury to the soil is justified by advantages of protection” (Boerker 1912).

⁴⁰ Richard H. Boerker later wrote an early popular history of America’s national forests entitled *Our National Forests: A Short Popular Account of the Work of the United States Forest Service on the National Forests* (1918).

District Forester DuBois (fig. 14) urged his supervisors in the same direction as these studies. Other fire studies soon followed. Paul G. Redington⁴¹ of the Sierra National Forest, Robert W. Ayers of the Stanislaus National Forest, and R.H. Charlton, from the Angeles National Forest provided several contributions in fire prevention studies. Supervisors E.W. Kelley of the Eldorado National Forest and W.P. Rider from the Klamath National Forest studied fire organization, David P. Godwin, from the California National Forest, analyzed fire detection, and J.D. Coffman of the Trinity National Forest provided data on fire causes. The results of this work by District 5 supervisors, and other work,⁴² were reported to DuBois at the 1913 forest supervisors' meeting in San Francisco. Thereafter, DuBois read their work and distilled it into his path-breaking monograph *Systematic Fire Protection in the California Forests* (DuBois 1914)—probably the “most influential single document in United States forest fire control history” (Cermak 2005). Furthermore, the 1910 fire season had stimulated DuBois to begin the application of science to a new field—fire science research. *Systematic Fire Protection* was a rational and orderly analysis of the fire problem and a brilliant and imaginative postulation of a science of fire control that called for a determined program to get private ownership to carry its share of the load (Show, n.d.).

Along with this major achievement, District Forester DuBois believed that District 5 should make the methodical study of fire a priority. Contrary to the thought of most foresters of his day, DuBois concluded that science could contribute to the solution of the problem. Accordingly, DuBois made fire research a major line of investigation for the Converse Experiment Station, along with erosion control, streamflow studies, and silviculture (Watts 1951). Meanwhile, District 5 cooperated with other USDA agencies to address other District 5 forestry problems, such as forest pathology and entomology research.

DuBois read their work and distilled it into his path-breaking monograph *Systematic Fire Protection in the California Forests* (DuBois 1914)—probably the “most influential single document in United States forest fire control history.”

⁴¹ In 1919, Paul G. Redington became District 5's third district forester and served in that post until 1926. Redington had joined the Forest Service in 1904 after graduating from Dartmouth and Yale Forestry School. Redington rose rapidly in the ranks of the Forest Service. He served for 5 years as supervisor for the Sierra National Forest, but then left the agency, taking a job as city manager for Albuquerque, New Mexico. When he returned to the Forest Service as district forester, his management style differed greatly from the dictatorial style of his predecessors Olmsted and DuBois. Instead, Redington's style depended on finding good men and then listening to them (Godfrey 2005).

⁴² During the same time, District 5 officials conducted studies to determine the actual damage done by fires and the recovery of environments such as chaparral from fire (USDA FS 1912).



U.S. Forest Service

Figure 14—Coert DuBois. California District 5's second District Forester. Under his administration, research efforts increased especially in fire protection and control. He also established the Feather River Experiment Station—the fourth station in the Nation.

Forest Pathology and Entomology Research

Research in the area of forest pathology took off in California shortly before District 5 Forester Olmsted resigned in June 1911. This progress can be credited to consulting pathologist E.P. Meinecke (fig. 15), who was assigned by BPI to District 5 in 1910. Meinecke “recognized the vast problem of converting ragged, irregular, defective, over mature, stagnant and only partly merchantable forests into productive and managed stands” (Show, n.d.).

The energetic Meinecke immediately got to work by lecturing the first gathering of District 5 supervisors. He warned his attentive audience that the most dangerous enemies of the forest besides fire were insects, mistletoes, and fungi. He then went into great detail educating them regarding these threats (USDA FS 1910). Shortly after coming to California, Meinecke had a clear vision of forest pathology as something radically broader than mycology, or the study of fungi. The perspective was to be not the fungus itself, but the tree attacked by the fungus and the effect of such attacks upon the forest complex (Hill 1931). By 1912, Meinecke had



U.S. Forest Service, Pacific Southwest Research Station

Figure 15—E.P. Meinecke, leading forest pathologist in the United States and author of *Forest Tree Diseases Common in California and Nevada*.

conducted a pathological survey of the Mono, Tahoe, Eldorado, Stanislaus, Sierra, Lassen, Klamath, and Shasta National Forests, and prepared a small field manual entitled *Forest Tree Diseases Common in California and Nevada* (Meinecke 1914) for the use of forest officers (Graves 1912). In 1913, Meinecke and others studied the diseases of white fir and incense-cedar in California, species peculiarly subject to defect from wood-destroying fungi. To help rid the forest of this menace by removing diseased trees, they advocated the creation of special requirements, called “sanitation clauses,” for timber sales (Graves 1913). A year later, nearly all timber-sale contracts in California carried this sanitation clause requiring the cutting of snags and diseased trees.⁴³ A study on the Shasta National Forest at that time had determined that the economic operation of this clause showed a substantial gain

⁴³ In 1910, District 5 originated the first forest sanitation clause in the Forest Service. By 1912, the entire Forest Service had adopted it. The clause offered three advantages to the Forest Service. One, it removed a serious fire menace. Two, sample marking eliminated friction between the purchaser and the Forest Service and put timber contracts on a strictly business basis. And three, the merchantable timber contained in diseased and malformed trees was saved and the Forest Service got paid for it (USDA FS 1912).

At the 1910 supervisors meeting, Miller pointed out to his superiors that the amount of damage caused by insects in District 5's national forests had never been carefully estimated.

in the amount of merchantable timber yielded by the cutting, not to mention the improved condition of the forest (Graves 1914). Meinecke would become a major force in bringing about the period of organized and effective disease research in California, especially after the publication of his *Forest Pathology in Forest Regulation* (Meinecke 1916).⁴⁴ In this latter publication, he argued persuasively that forest pathology should be an integral element of forest management (Hill 1931).

Safekeeping of the national forests included not just protection against disease but also control of insect infestations. In October 1910,⁴⁵ John M. Miller (fig. 16) of the Sierra National Forest, who had trained in entomology at Stanford, became the first Forest Service entomologist in the West. At the 1910 supervisors meeting, Miller pointed out to his superiors that the amount of damage caused by insects in District 5's national forests had never been carefully estimated. After this statement, he set out to educate the supervisors on the subject by producing that year, his *Study of Insect Infected Timber*—a manual of the insect enemies of California's forests, stating that rangers in the saddle would probably be the first to notice any fresh appearance of insect damage (USDA FS 1910, Wickman 2005).

In 1911, Ranger Miller⁴⁶ was detailed to the BE's Yreka Station⁴⁷ to assist on the control work that was being developed on the Klamath National Forest (Burke 1946; Show, n.d.; USDA FS 1910). In 1912, Miller warned that the forest resources

⁴⁴ In his *Forest Pathology in Forest Regulation*, Meinecke (1916) further developed the concept of forest sanitation in connection with timber sales and the concept of pathological rotation. To him, forest pathology was an integral element of forest regulation and management. He believed that regulated forests of the future must be something fundamentally different from just a reproduction of another such forest as those that had been cut down (Hill 1931).

⁴⁵ The first information on extensive insect depredations in western forests was brought to the attention of the Bureau of Entomology around 1898. However, any control work in the West was not undertaken until circa 1909 Bureau of Entomology, (BE), and that research took place in the Black Hills and parts of Colorado. So, insect control work in California was not far behind (USDA FS 1912). Interestingly, two early attempts to start insect control work in California were made prior to 1909. In 1905, a Santa Barbara Forest Reserve ranger reported bark beetle infestations in the southeastern part of this reserve. His report went to the BE, which made recommendations for control measures by letter, making it the first recorded attempt to control bark beetles in any western area. The next attempt to set up control work in California occurred in 1908. In that year, a surveyor for the Diamond Match Lumber Company noted bark beetle infestations east of Oroville, California, but no action was taken on the matter (Burke 1946, Wickman 2005).

⁴⁶ J.M. Miller later headed the BE's Ashland, Oregon, substation, and also conducted the first forest insect control work in any national park, at Yosemite National Park (Burke 1946, Wickman 2005).

⁴⁷ Apparently, although Miller had official Forest Service orders to survey, collect insects, and make entomological reports, his work was irregular and impinged on the BE Division of Forest Insect Investigations. Miller was transferred to the BE to resolve this conflict (Wickman 2005).



U.S. Forest Service, Pacific Southwest Research Station

Figure 16—1914. John M. Miller (on right), pioneer in Western forest entomology and bark beetle control projects with the Forest Service.

of California were being seriously impaired by insect damage, much of which could be prevented if greater interest had been manifested and the proper precautions taken by those directly responsible for the forest administration (Miller 1912). In the meantime, the BE moved Field Station No. 5 from Yreka to Placerville, a more central location, and placed it under Harry E. Burke,⁴⁸ a former assistant to

⁴⁸ Harry Eugene Burke was educated at Washington State and Stanford Universities and was appointed to the Bureau of Forestry in 1902. In 1903, the BE instituted a regional approach to the study of forest insect problems and the country was divided into four major forest areas, one of which was the Pacific coast. Burke was selected to oversee the Pacific coast because he was from that part of the country and was already familiar with some of the conditions. In 1904, he transferred from the Bureau of Forestry to the BE and designated as head of the region. Burke was placed in charge of Forest Insect Station 5 (Yreka, California, 1911–1912; Placerville, 1911–1916), the Pacific Slope Station (Ashland, Oregon, 1916–1920), the North Fork Station, California (1920–1924), and then in 1924 moved to the Stanford University campus, where the North Fork and several other field stations were consolidated (Burke 1946).

Andrew D. Hopkins⁴⁹ the “Father of Forest Entomology” (Burke 1946, Hill 1931). Burke became a central figure of forest entomology in California during the first two decades of the 20th century (Burke 1946, Wickman 2005). Under his direction, the first cooperative insect control work in District 5, known as the Barkhouse and Craggy Mountain projects,⁵⁰ took place in early 1912 on the Klamath National Forest (Burke 1946, USDA FS 1912). Entomological research in California grew more resolute thereafter. District 5 engaged the BE as a serious source for information to help prevent additional losses from forest insects. Through reconnaissance and expert inspection of the national forests, District 5 officials learned what damage was being done and how to locate incipient attacks where control was most needed. Control operations concentrated on the more accessible and valuable timber stands that were threatened. In 1913, the first prevention of insect depredations through control operations began on California’s national forests (Graves 1913).

By the next year, 10 national forests in District 5 were covered. During this reconnaissance effort, approximately \$10,000 was expended in stamping out attacks of *Dendroctonus brevicomis* (fig. 17) in yellow pine timber on the Stanislaus, Sierra, Trinity, and Klamath National Forests (Graves 1914).

Range Management Studies

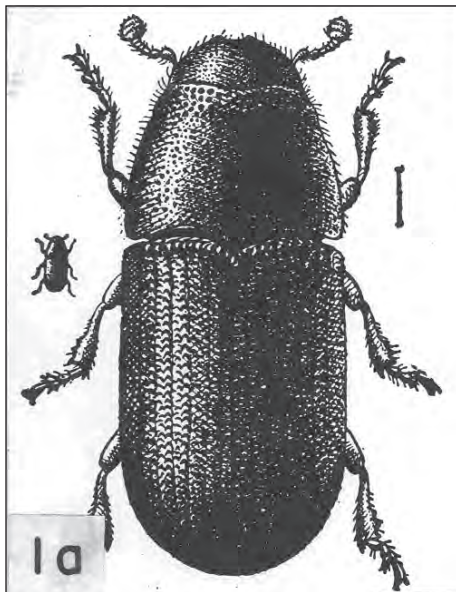
As in the fields of entomology and forest pathology, District 5 relied upon other USDA agencies for range management research. From 1905 to 1914, District 5’s immediate concerns in range management included establishing grazing fees, issuing permits and establishing driveways for sheep,⁵¹ and stopping trespassing on the national forests by stockmen.⁵² The quiet-spoken John Hatton, District 5’s Chief of Grazing, sought to reach these goals (Godfrey 2005), but also looked to improving the health of livestock by eradicating disease from California’s national forest ranges. Toward this end, District 5 worked closely with the Bureau of Animal Husbandry (BAH). Starting in 1905, owners of stock were required to submit their

⁴⁹ Andrew Delmar Hopkins (1857–1948) was the first chief of the Division of Forest Insect Investigations and directed this work in the Bureau of Entomology from 1902 to 1923. He first visited California in 1899 as an entomologist for the West Virginia Experiment Station to collect specimens and make notes, which resulted in his publication *A Preliminary Report of the Insect Enemies in the Northwest* (Hopkins 1899). He then periodically visited the state in 1911 and 1915 as he made the rounds of western field stations (Burke 1946).

⁵⁰ For a detailed description of these projects, see Wickman: 2005.

⁵¹ In 1905, the Forest Service established the first such driveways on the Stanislaus and Sierra Forest Reserves to allow sheep to cross forest reserve lands to reach area of private lands within the Sierra mountains (Pinchot 1905).

⁵² District Forester Olmsted saw grazing on national forests as a “necessary evil,” and Hatton, his Chief of Grazing, saw it as a problem “thrust upon” the Forest Service and simply sought ways to harmonize grazing and silvicultural interests. However, they viewed grazing as secondary to silviculture (USDA FS 1910).



USDA Bureau of Entomology

Figure 17—The western pine beetle aggressively attacks and kills ponderosa pine trees and is most damaging in California.

animals to inspection in districts infected with contagious diseases, and the Bureau of Animal Industry began working with Forest Service officials in California to require dipping of permitted sheep for scab and mange. By 1907, all sheep permitted to graze on the Tahoe, Stanislaus, and Diamond Mountain National Forests⁵³ were being inspected and dipped when found to have been exposed to or infected with scab (Pinchot 1905, 1907).

One particular problem of concern for southern California ranges was Texas-fever tick, which infected almost every portion of the national forests in this region. Together with BAH, District 5 worked diligently to free the ranges from this disease, borne and transmitted by cattle coming up from Mexico. By 1910, their efforts paid off. Texas-fever tick was eradicated on all the southern California national forests, except for the Cleveland National Forest, where it was confined to a small area along the international border. In 1912, a quarantine drift fence was completed, which within a comparatively short time made the Cleveland National Forest free of Texas fever (Pinchot 1908, 1909; Graves 1910, 1912, 1913).

Regarding range conditions, John Hatton wanted to promptly and permanently restore California's "beat up" ranges to their past state of pristine productivity, even though forage conditions seemed adequate at the time (Godfrey 2005). Starting in 1907, the Forest Service recognized the urgent need for investigations to improve the production of forage on ranges that had been overgrazed. In cooperation with BHA, the Forest Service commenced such investigations to discover under what

⁵³ The Diamond Mountain Forest Reserve was proclaimed in 1905, but consolidated with the Plumas National Forest in 1908 by executive order (Godfrey 2005).

With the concurrence of WO grazing inspector James Jardine, District 5 officials decided officially that it was not advisable to conduct intensive reconnaissance on most of the timbered forests of the district, largely because of cost and the uncertain value of such research.

conditions and in what localities it was possible to secure natural reproduction and in what areas planting new seed would succeed (Pinchot 1907). At the 1910 District 5 supervisors meeting, the topic of the range reconnaissance was considered. Sierra National Forest supervisor H.A. Benedict had just completed the first classification of range types and District 5's first range reconnaissance, and presented several colorful type maps to the supervisors illustrating his classification system. Hatton's work very much interested them, especially the scientific phase of the subject (e.g., the identification of different grasses and the determination of their forage value). However, in response, Hatton lamented that in the last year or two, he was unable to get "scientific men assigned to the District for that purpose" (USDA FS 1910). The effect of grazing on reproduction was also taken up at the supervisors meeting. Anecdotal information and general observations surfaced, but no definite experiments were reported upon, although 14 supervisors eagerly stated that they expected to have experiments underway by the next year. Next, supervisors from several national forests (e.g., Eldorado and Tahoe) discussed experimental range improvements conducted in protected areas near ranger stations using a variety of grasses. But their experiments appeared to be small, uncoordinated projects (USDA FS 1910). Despite these range discussions, in 1912, with the concurrence of WO grazing inspector James Jardine, District 5 officials decided officially that it was not advisable to conduct intensive reconnaissance on most of the timbered forests of the district, largely because of cost and the uncertain value of such research (USDA FS 1912). About the only range experimentation that took place in District 5 prior to 1915 occurred on the Lassen National Forest in 1909 to aid goat breeders in California, who were unable to obtain range because cattle and sheep owners monopolized the permit process. The 2-year project allowed free ranging of 3,000 head of goats on the forest to reduce the cost of forest planting on burned-over areas grown up to brush (Graves 1913, Pinchot 1909).

In the interim, some science made its way into range affairs on District 5. The initial idea of range management science came from Jardine, but the capable Hatton welcomed it to California. Beginning in 1910, District 5 conducted various small, range management studies. District 5 installed a series of fenced "sample plots," started an herbarium of range plants, and made a frustrating attempt to have forest assistants collect range information along with the silvical notes while on timber reconnaissance projects. For instance, on the Shasta National Forest, a study attempted to determine the effect of grazing on the reproduction of conifer forests, and worked out a plan of grazing management to secure the maximum use of all resources (Graves 1915; Show, n.d.). On the Inyo National Forest, a 1913–1916 study sought data on the advantages and advisability of more complete stock control by

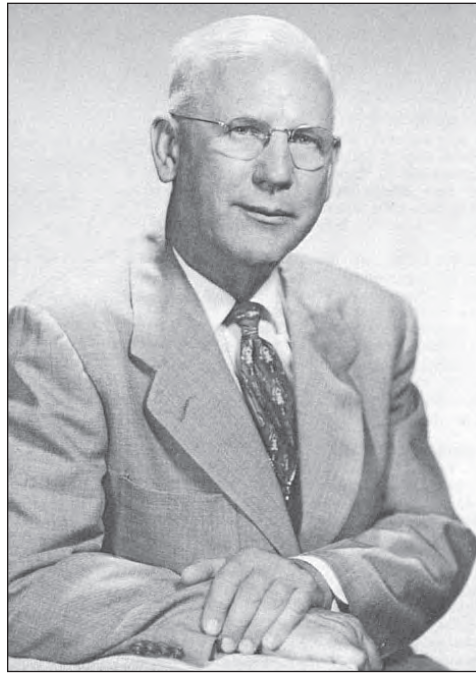
grazing cattle within enclosures as compared to letting them roam free on open forest lands. Another study looked at erosion in small but important mountain meadows of the high Sierras caused by grazing (Graves 1914, 1916). District 5 officials soon embraced the idea that the business of grazing could benefit from scientific study in four areas: determining range capacity, the importance of forage crops, the influence of grazing on reproduction, and its role in protection against fire (USDA FS 1912). However, a district grazing research office was not established in California until 1915 (Storey 1975), most likely because favorable periods of above-normal precipitation (with the exception of the 1912–1913 drought, which severely affected parts of the state) obscured the effect of deleterious overgrazing on California's range.

California University Developments

While District 5 made many contributions to research in silviculture, forest products, range management, forest pathology, entomology, and fire control in California, important forestry developments also occurred on the Berkeley campus. From 1911 to 1914, a group of devoted preforestry student activists led by A. Everett Wieslander⁵⁴ (fig. 18) organized themselves into a forestry club and persistently lobbied the university administration, the Forest Service, the lumber industry, and the state legislature to establish a forestry school at the university. They finally succeeded in 1914 when the university appointed Walter Mulford⁵⁵

⁵⁴ A. Everett Wieslander (1890–1992) was born in Oakland, California, and enrolled at the University of California, Berkeley in 1910 in a preforestry curriculum. He graduated from the university's first forestry school class (1914). From Berkeley, Wieslander went to the University of Michigan where he earned his Master of Forestry degree (1916). After World War I, Wieslander joined the Forest Service, first spending 7 years on the Lassen National Forest, then in 1926 becoming one of the initial staff of the California Forest Experiment Station (Bradshaw and Jensen 1992). As later chapters will indicate, Wieslander had a long and extensive career with the Forest Service's California Forest and Range Experiment Station in Berkeley, which he detailed in his autobiography *California Forester: Mapper of Wildland Vegetation and Soils* (Wieslander 1986).

⁵⁵ In 1899, Walter Mulford received his B.S. (agriculture) and his F.E. (forest engineer) degree in 1901 from the New York State College of Forestry at Cornell. He then established Connecticut's forestry program, becoming the first to hold the title of State Forester in the country. During 1904–1905, he briefly had an assignment with the Bureau of Forestry in the southern Appalachian Mountains, before serving as an assistant in the Yale School of Forestry. After teaching silviculture at the University of Michigan (1911–1914), he became head of the Division of Forestry, University of California, Berkeley and directed the department until 1939, and the School of Forestry until 1946, retiring as dean. In 1948, he planned and supervised the construction of the forestry building on campus, which bears his name—Mulford Hall (Clepper 1971, Rodgers 1968).



University of California, Berkeley

Figure 18—Albert Everett Wieslander, scientist and researcher in the fields of wildland vegetation and soil mapping and forest inventory. He pioneered the use of aerial photographs in those activities as well.

to the faculty, and the first classes of the Division of Forestry, or the forestry school, opened at the University of California, Berkeley. Under Mulford's training, several important foresters and forestry scientists emerged from Berkeley's program of forestry education to serve in the Forest Service.

The founding of Berkeley's Division of Forestry injected a new element and direct opportunity for forestry research in California. Deciding what role the division would play in the field was a difficult one. There were three directions Berkeley professors could take. They could simply duplicate the Forest Service's work in order to verify it; they could apply similar studies to different species or in a different area; or they could pursue fundamental studies of a laboratory character, which the Forest Service had not done to any great extent. In the end, Berkeley and the Forest Service struck a "gentlemen's agreement" under which the school, for the most part, conducted their research in all three areas, but did not directly investigate areas that were thoroughly covered already by Forest Service researchers. For example, in the redwood region, where the Forest Service had done practically nothing because of the absence of national forests therein, the Berkeley school cultivated all lines of silvicultural research with marked success. This research included nursery and planting investigations, testing of a large number of imported species, thinning experiments in mixed redwood second-growth stands, and forest products investigations tied closely with logging and sawmill problems of the redwood industry. In the area of forest management, Berkeley scholar Donald Bruce studied

the cost of logging, transporting, and milling different-sized timber, adding to, and complementing, similar work conducted by W.W. Ashe for the Forest Service since 1909. Finally, in range management, Berkeley's Division of Forestry checked the results of experimental research in range management that came out of the Great Basin Station in Utah, and at the Santa Rita⁵⁶ and Jornada⁵⁷ Range Reserves in the Southwest, as they applied to grazing practices on California's national forests (Hill 1931).

The Formative Years, Forest Service Research Program, 1915–1919

During Gifford Pinchot's administration, as previously noted, forestry research was almost totally set aside in favor of Pinchot's efforts to administer the national forests. The mission of providing scientific information was subsumed under an agency bent on facilitating efficient forest management (Storey 1975). However, in the early years of the Henry S. Graves (fig. 19) administration (1910–1920), research began to regain some of its status and focus as a provider of scientific information within the Forest Service. This transformation started in 1910 with the establishment and instant success of the FPL, followed by the organization of the CIC in Washington, D.C., in 1912. Even though forestry research made continual progress from then on, by 1915, Forest Service research remained uncoordinated and scattered in small units across the Nation. It was also still subordinate to administrative needs. Fortunately, Agriculture Secretary David F. Houston recognized this state of affairs and directed Chief Graves to take steps to correct it (Steen 1998).

On June 1, 1915, Graves created a new and separate Research Branch within the Forest Service that would better correlate various Forest Service studies and investigations while at the same time separate investigative work from administrative work in accordance with Houston's Department of Agriculture policy. A further purpose of Graves' measure was to "give the research work and personnel fullest recognition" and "to develop and strengthen research as a coordinate division of the Service" (Graves 1915: 23). Five basic Forest Service research activities were transferred into the new Branch of Research: silvicultural investigations,

⁵⁶ The Santa Rita Range Reserve was located in southern Arizona and established in 1903 by the Bureau of Plant Industry. As the oldest experimental range in the United States, it represented typical semidesert grass and shrub rangelands in that part of Arizona, as well as southern New Mexico and west Texas (Price 1976).

⁵⁷ The Jornada Range Reserve was established on the Jornada Del Muerto Plain in Dona Ana County, New Mexico, by Executive order in 1912. The range covered close to 200,000 acres. The main objectives of research there centered on how to improve and maintain the range, and how to manage it for sustained use and production of range livestock (Price 1976).



U.S. Forest Service

Figure 19—Henry S. Graves, second Chief of the Forest Service, 1910–1920. Under his administration the Forest Service Research Branch, known earlier as the Office of Silvics, was established (1915).

including the Office of Forest Investigations in Washington, D.C., district and eight experiment stations nationwide; forest products investigations, including the Office of Industrial Investigations in Washington, D.C. and the FPL in Madison, Wisconsin; all economic studies of lumber and other wood-using industries and studies of methods, cost, and efficiency; fire protection studies; and statistical investigations (Graves 1915). Graves named Earle H. Clapp (fig. 20) as the first assistant forester in charge of the branch. His task was to implement and promulgate these Forest Service research efforts.

Earle Hart Clapp attended Cornell University (1902–1903) and joined the Forest Service as a forest assistant in 1905. Initially, Clapp worked in the South-western District, first in charge of forest management (1907–1908), then as associate district forester for District 3, (1908–1911), and finally as forest inspector of silviculture (1911–1915) (Clepper 1971).⁵⁸ In 1915, at the age of 38, Clapp was promoted to head the Branch of Research—a post he would hold for the next 20 years⁵⁹

⁵⁸ Interestingly, Clapp spoke at length on the subject of silviculture at the first District 5 supervisors meeting held in 1910; specifically regarding regeneration work and proper cutting rotation by yield studies (USDA FS 1910).

⁵⁹ Clapp next served as associate chief (1935–1939) and then as acting chief (1939–1943) of the Forest Service. During his lifetime, he authored many governmental and scientific publications, including *A National Program of Forest Research* (Clapp 1926), which provided the basis for the McSweeney-McNary Act of 1928 (discussed in later chapters) (Clepper 1971).



U.S. Forest Service

Figure 20—Earle H. Clapp. Under his direction, research was formalized in 1915 with the creation of the Branch of Research. Clapp later served as the sixth Chief of the Forest Service (1939–1943).

(Clepper 1971). In 1933, Clapp reflected on the moment, stating: “Research was so submerged, in fact, and so out of the thought of the rank and file of Forest Service personnel that its development was practically at a standstill. In organization, administration, finances, and the selection of personnel, and in practically every other particular it was subordinated to the development and administration of the National Forest” (Storey 1975). Earle Clapp eventually became the principal architect of the Forest Service’s nationwide research program, and his views dominated forestry research policy for the next two decades (1915–1935). But in 1915, the new appointee had little or no experience in research programs, and he received no real instructions from Chief Graves. To learn about Forest Service research objectives, methods, and organization, the 38-year-old Clapp took several steps. First, he went out West to acquaint himself with the work of the various experimental stations. Next, he brought field researchers into the WO to steep himself in “research program lore.” Finally, he started attending the annual meetings of the American Association for the Advancement of Science (AAAS) to learn more about the current state of forestry science in America (Steen 1998).

While busy educating himself, Clapp organized the Research Branch into three sections: Forest Investigations, Industrial Investigations, and the FPL, headed by

Research was so submerged, in fact, and so out of the thought of the rank and file of Forest Service personnel that its development was practically at a standstill.

**Reorganization
“strengthened
research as one of the
basic functions of the
Forest Service and
gave it a standing that
it had not previously
possessed.”**

**“Federal practice must
set standards. The
[research] program
must show a balance
between pure science
and applied, between
fundamental research
and that which to a
reasonable degree
will furnish results,
perhaps not wholly
complete and exact,
for immediate practical
application.”**

Raphael Zon, Howard S. Betts,⁶⁰ and Howard F. Weiss,⁶¹ respectively. All research programs, except grazing studies, forest insects, and disease,⁶² whether located in the WO, at the forest and range experiment stations, at the FPL in Madison, or elsewhere, were brought together in this new branch. This reorganization “strengthened research as one of the basic functions of the Forest Service and gave it a standing that it had not previously possessed” (Storey 1975: 17–18). The Forest Service branch of Research thereafter provided a strong central office, and general guidance, coordination, and planning for federal forestry research on a national scale.

In December 1916, in a paper presented to the Society of American Foresters, Earle Clapp gave his views on the state and conditions of Forest Service research. Clapp plainly stated that “but slight attempt, if any, has been made to correlate the efforts of the forest schools, the States, and the Federal Government” prior to 1916, and he called for a national forestry research program to “secure correlation of all the forest research in the United States.” Clapp acknowledged that investigative work since 1905 had become secondary to forest administration, which seemed “to offer the only real career for foresters,” but now, many foresters realized “how little basis they had for their work.” He concluded that they could not carry out their work and answer important questions of policy with the limited number of investigators available for research. “Federal practice,” according to Clapp, “must set standards.” He further stated: “The [research] program must show a balance between pure science and applied, between fundamental research and that which to a reasonable degree will furnish results, perhaps not wholly complete and exact, for immediate practical application.” In his opinion, the results of investigations and

⁶⁰ Graduating from the Stevens Institute of Technology in 1900, Howard S. Betts later directed the New Haven Laboratory at the Yale Forestry School (1902) and then moved to Washington, D.C., and began comprehensive timber testing work for the Forest Service’s laboratory there. Betts was instrumental in selecting the University of Wisconsin as the site of the FPL and drawing up the plans for it (Rodgers 1968).

⁶¹ Howard F. Weiss was FPL’s second director and ran the Madison laboratory from 1912 to 1917 (Godfrey 1990).

⁶² When Forester Graves took office, he retained Albert Potter in the post of Chief of Grazing with the “glamorous and colorful” Will C. Barnes advising him, while keeping agricultural scientist James T. Jardine only in an advisory post. This led to the queer dichotomy of “cowboy management of the range and the early efforts, led by Jardine, to introduce science into range management.” S.B. Show believed that Jardine would have done a better job in the post. According to Show, Potter’s era of “magnificently impressive and bewildering pseudo-science of range survey, with its undigested array of palatability and forage acre factors and all” was “unencumbered by real recognition of ecological sensitivity of many ranges—impolitely, biological illiteracy” (Show, n.d.). In 1915, in Chief Forester Graves’ absence, Albert Potter successfully lobbied Agriculture Secretary Houston to keep range investigations in Washington, D.C., and the district offices under his Grazing Branch (Steen 1998). The BE and Bureau of Plant Industry, both USDA agencies, continued their cooperative roles with the Forest Service.

other research engaged in by the federal government, as well as by private concerns such as state and privately controlled laboratories, consulting engineers, and forestry schools, should be openly discussed and dispersed to all (Clapp 1917).

Thereafter, Zon, Betts, and Weiss wasted no time in developing plans for a national, coordinated federal forest research program. During pre-World War I years, the Forest Investigations Section under Zon continued to conduct silvicultural investigative work, seeking better ways of managing national forests, studying the hundreds of tree species in America and worldwide, and exploring methods of replanting and reseeding forests. Industrial Investigations continued timber testing work, but eventually this section was merged within the FPL program. Under Howard Weiss' direction, the FPL made significant progress in fundamental and applied research in the fields of wood preservation, timber testing, kiln drying, and pulp and paper. Despite these achievements, the laboratory's early research years were plagued with persistent problems that all applied research institutions faced then and even today—adequate research funding, retention of valuable personnel, publishing and disseminating of research results, and securing commercial application of research results (Godfrey 1990).

With the national emergency created by America's entrance into the "Great War," new challenges in wood science came to the attention of the Forest Service. Wood, and products derived from wood, played a major role in the American war effort, and radically affected the Forest Service research program, especially in the area of forest products investigations. These studies largely took place at the Madison laboratory under the leadership of Carlisle P. ("Cap") Winslow.⁶³ By the end of the war, the FPL had conducted research in many areas, but three in particular related to the war effort: kiln drying, packaging, and the design and manufacture of airplanes using light-weight but very strong wood, such as Sitka spruce. Additionally, FPL research on the mechanical properties and production of plywood from various species gave dramatic proof of the strength of this wood fabrication type. The FPL's war work eventually led to the commercial use of plywood after the war (Godfrey 1990).

Naturally, because of the war emergency, forest products research received four times the budget of other types of research. And, as might be expected, forestry research independent of and unrelated to the war effort fell off. In times of crisis like World War I, or when required by policy decisions, justification of funding and research topics was often dictated by demands outside of the Forest Service's main

⁶³ Carlisle P. Winslow became the third director of the FPL in April 1917. Previously, he headed the Office of Preservation in the Branch of Forest Products. Winslow ran the FPL for the next 29 years—the longest time in office of any FPL director (Godfrey 1990).

focus. In the winter of 1917, key researchers in the Forest Service were called into Washington, D.C., to discuss this dilemma. All aspects of research, from nurseries, seeding, and ecology, to fire, pathology, economics, and other research activities came under scrutiny, but the issue of independence of research from administrative goals took center stage and a lively debate ensued.⁶⁴ One problem discussed was that although experiment stations reported directly to Clapp on technical matters, administratively, they were subordinate to district foresters. Many researchers strongly felt that district foresters “coping with pressing demands would be likely to disrupt ongoing research in order to gain specific information.” They believed that all reports should go directly to Washington and not to district foresters. In response, Chief Forester Graves issued a 14-page research policy letter addressing this dysfunction between forest scientists and administrators. Unwilling to tackle the problem directly, his letter instead asked for greater cooperation between the two groups, and insisted that they concentrate all research efforts toward the agency’s broader mission. Graves also bemoaned the inadequate pool of properly trained scientists available for employment by the Branch of Research (Steen 1998).

Whereas the scientist works from facts to policy, often management would rather work from policy to facts.

Stunted Growth of Forest Research in California and the Pacific Islands, 1915–1919

With the creation of the Branch of Research in mid-1915, the WO took direction and control of District 5’s field program and set research priorities for the Feather River and the Converse Experiment Stations in California. This organizational transition and readjustment of policy took time. Essentially, for at least a year, very little new work took place in California, and then America’s entry into World War I curtailed any serious District 5 research work. Because of the war, many research projects were immediately discontinued, and others were greatly reduced. Items that required field investigation by the stations were halted altogether because California’s two experiment stations were closed down during most of the war years.

⁶⁴ As early as the mid-1920s, the Forest Service faced the continual problem of bridging the gap between science and politics in the management of our national forests. Whereas the scientist works from facts to policy, often management would rather work from policy to facts (Anderson 1927). Furthermore, those in research and those with administrative responsibilities often do not have similar goals. Whereas administrators usually want direct quick answers to current forest problems because of outside pressures, researchers often seem tentative in their conclusions, wishing to continue data gathering and analysis of problems (Steen 1998). In recent years, advocacy activities of scientists have become a major topic of concern in natural resource circles.



U.S. Forest Service, Pacific Southwest Region

Figure 21—Stuart B. Show, District/Region 5’s fourth Forester (1926–1946). Show conducted significant studies in fire research in California and co-authored with Edward Kotok *Forest Fires in California*—which examined the origin and behavior of fires and protection theories.

Silviculture Studies

With the inauguration of the Branch of Research, changes came immediately to the Feather River Experiment Station. In 1916, J.A. Mitchell replaced Acting Director Noyes, who had run the station for the previous 2 years. Mitchell conducted the station along the same lines of research as in the past. Stuart Bevier (or “S.B.”) Show⁶⁵ (fig. 21) joined the roster of the station in 1915.

Show, who would later serve as District/Regional Forester for California from 1926 to 1946, worked alone for almost 2 years at the station, keeping up to date the remeasurement of the station’s permanent sample plots (Show, n.d). His experience

⁶⁵ Stuart Bevier Show (rhymes with “now”), or “Bevier” as he preferred to be called, was born in Nebraska in 1886, but his family moved to Palo Alto, California, when he was still a child. His father was the first history professor at the struggling institution known as Leland Stanford Junior University. Show grew into a bright young man who had an orderly and inquisitive mind. In 1905, Show entered Stanford University with no career goals in mind. There, he attended a lecture given by Gifford Pinchot. After the lecture, Show asked him about the Forest Service. Pinchot recommended that Show get a Master’s in Forestry at Yale University if he were interested in joining, which Show did in 1910. Show thereafter joined the Forest Service and was assigned to the Shasta National Forest (Cermak 2005).

“The fruits of the forest research tree were not to ripen, for the most part, until after 1920.”

reflected the difficulties the Forest Service encountered in securing satisfactory labor prior to and during World War I (Graves 1917). To add to matters, in 1917, the Feather River Experiment Station was closed temporarily. With its closure, Mitchell moved on and Show was transferred to the San Francisco office, where he assumed charge of the silvical investigations section of the district office. However, soon thereafter that section was discontinued as well, and Show was reassigned to the Pilgrim Creek nursery on the Shasta National Forest, where he conducted nursery and planting research (Hill 1931; Show, n.d.).

However, the Feather River Experiment Station was not completely abandoned. Instead, the facility was temporarily taken over by the Department of Agriculture’s Office of Pathology (OP). Under the direction of E.P. Meinecke, the station was used to further District 5 investigations over the next 5 years, with the stipulation that key measurements in ongoing sample plot measurements continue. In 1917, Duncan Dunning⁶⁶ (fig. 22), who later headed silvicultural research after the founding of the California Forest and Range Experiment Station, measured key permanent plots. In 1919, an OP crew led by H.G. Lachmund reexamined the station’s harvest cutting plots, with Dunning writing the progress report the following year. Meanwhile, in 1918, the Converse Experiment Station, which was conducting reforestation work in southern California under Edward Munns, was abandoned altogether, falling victim to wartime economy and efficiency measures. With the closure of the Converse Experiment Station, forestry research pertaining to southern California ended altogether for a time (Fowells 1983; Hill 1931; Show, n.d.). “The fruits of the forest research tree,” according to a veteran District 5 researcher, “were not to ripen, for the most part, until after 1920” (Hill 1931).

Research circumstances in Hawaii after 1915 were not much different. In 1915, Charles Judd succeeded Ralph Hosmer as superintendent of Hawaiian territorial forestry. Prior to leaving, Hosmer submitted a progress report to District Forester DuBois summing up his research results pertaining to two projects: experimental tree planting (temperate zone trees, particularly conifers) carried out on the upper levels of the high mountains located on the islands of Maui and Hawaii, and planting eucalyptus in the Nuuanu Valley on the island of Oahu near Honolulu to see which species was best adapted in Hawaii. According to Hosmer, the high mountain

⁶⁶ Duncan Dunning earned his B.S. in 1915 and his M.S. in 1916 at the University of California at Berkeley. In 1916, he joined the Forest Service as an assistant forest ranger on the Shasta National Forest and later that year was reassigned as a forest assistant at the Feather River Experiment Station, a position he held until World War I, when he joined the army (USDA FS 1948).



U.S. Forest Service, Pacific Southwest Research Station

Figure 22—The 1934 University of California Forest School Faculty—California Forest and Range Experimental Station meeting. In 1937, Duncan Dunning (top right) authored the site and crown classification systems used by foresters throughout the West and developed a plan for sustained-yield forestry for the Forest Service.

project was a total failure because of the inability to secure proper care in the raising of seedlings in local nurseries, and because climatic conditions were found to be unfavorable. However, the eucalyptus plantations were without question a success. Trees planted in 1910 were still doing well in 1914. Forest Service funds helped pay for the equipment for these reforestation experiments, and Hosmer believed that by inaugurating this investigation, the Forest Service had rendered a lasting benefit to the Territory of Hawaii (Territory of Hawaii, Division of Forestry 1914).

Unlike Hosmer, whose reports urged management of areas for continuous production forests, Judd ignored any local commercial timber potential. It seems that Judd was closely aligned with Harold Lyon of the Hawaiian Planters Association, an organization that opposed any commercial timber activities that might supplant sugar or pineapple plantation production. Furthermore, cattlemen, who owned most of the land not suited for either sugarcane or pineapple production, wanted forest land cleared for pastureland. Therefore, after 1915, and for years to come, there was

little official interest by the Forest Service, the Hawaiian government, or large private landowners in the silviculture or timber production aspects of forestry. During the decades of Judd's administration, which covered the years 1915 to 1939, forestry policy and programs in Hawaii continued to focus almost exclusively on protecting watershed resources (Nelson 1989d). Growing problems in Hawaii's natural forests stands caused by the spread of noxious nonnative weeds and shrubs were largely ignored.

Forest Products Research

Forest products research in California had been on the decline since 1913, when it was relegated to conducting regional wood preservation projects for the FPL. Four years later, C. Stowell Smith resigned as its head, reducing it to a one-man operation. During the war years, District 5's forest products research was suspended altogether, when all such research was concentrated at the FPL (Hill 1931).

Fire Research

Unlike silviculture and wood products research, fire research in California made progress prior to and during World War I. Aware of the forest management problems brought about by the threat of fires—made even more evident by the disastrous 1910 fire season—District 5 personnel began to analyze fire reports in California for their hidden research meaning. This work began in 1915, when District Forester Coert Dubois assigned S.B. Show to start a fire research program at the Feather River Experiment Station. Undeterred by the immense task before him, Show set up fire research projects at the Feather River Experiment Station that investigated the rate of spread of fires, light burning, and fire damage (Fowells 1983). However, Show struggled to make sense of individual fire reports from California's national forests. Many rangers felt that filling out these reports was a useless exercise in bureaucratic paperwork and could not see their value. As a result, many reports were incomplete or badly organized (Show, n.d.). At the same time Show was pouring over his paperwork, W.H. Gallaher of the Tahoe National Forest prepared a report, "Value of Continuous Fire Protection in California." In his study, Gallaher concluded that from 1905 to 1915, California's national forests had made a rapid recovery from their former rundown condition (from Cermak 2005).

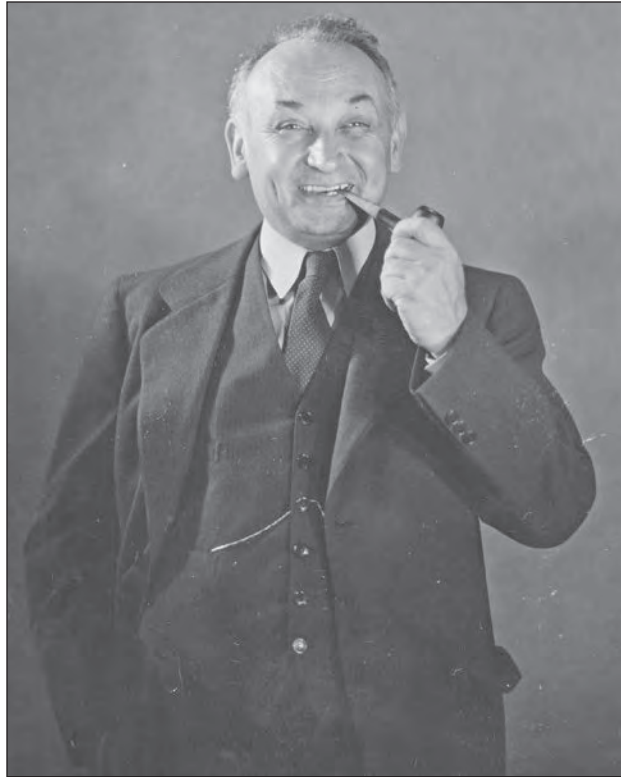
Meanwhile, by the beginning of 1918, Show began to share his fire research work with Eldorado National Forest supervisor Edward I. Kotok⁶⁷ (fig. 23), who in 1926 became the first director of the California Forest Experiment Station (now the PSW Research Station). The two of them had known each other since 1912, when they met while working together on the Shasta National Forest. They soon became fast friends until Show left in 1915 to take charge of the Feather River Experiment Station near Quincy⁶⁸ (Cermak 2005). Despite the distance between them, they continued collaborating on California's fire problems, and in the winter of 1918–1919, Show and Kotok made fire research history when they presented the first of many studies on fire control. After analyzing a particular fire on the Eldorado National Forest, the so-called Ham Station Fire, along with previous fire reports from the Shasta National Forest, they presented their results at a District 5 supervisors conference at Davis, California. Their report electrified the audience. Show and Kotok's analysis showed with astonishing clarity that too few personnel and the fact that it took firefighters too long to reach the location of the fire were responsible for turning these relatively small fires into disasters. Their conference presentation literally sold fire science and research to District 5's field men "as something not remote in the clouds but having a direct relation to their everyday jobs" (Hill 1931).

Their paper also laid the foundation for Show and Kotok's fire research over the next 10 years. Furthermore, their paper may have influenced the California State Board of Forestry to enter into an agreement in 1919 with the federal government under the Weeks Act of 1911. Passed on March 1, 1911, the Weeks Act, among other provisions, authorized Forest Service cooperative efforts with states to provide forest fire protection. This act was designed for the prevention and suppression of forest fires and provided matching funds to states for hiring rangers for those purposes (Pratt 1931). For years, the state of California had failed to take advantage of cooperative federal fire control funds under the act (Cermak 2005), but in 1919,

Their conference presentation literally sold fire science and research to District 5's field men "as something not remote in the clouds but having a direct relation to their everyday jobs".

⁶⁷ Edward I. Kotok was born in 1888 "somewhere between the Crimea and Ukraine." He and his family came to America when he was 7, leaving Russia because of his father's anti-Czarist politics. Edward attended City College of New York and graduated in 1909 with a chemical engineering degree. Kotok, like so many others, was inspired to join the Forest Service after hearing a lecture by Gifford Pinchot. In 1911, he completed a Master of Forestry degree at the University of Michigan, thinking that he would become a chemist at the newly established FPL in nearby Wisconsin. However, in 1911, fate led him to the Shasta National Forest, where he accepted a permanent position in 1911. There, he was put in charge of planting work in northern California. Eventually, he steadily advanced and by 1916, worked his way up to becoming the Eldorado National Forest Supervisor (American Forests and Forest Life 1926; Cermak 2005 Journal of Forestry 1941). Interestingly, as Supervisor for the Eldorado National Forest, Kotok was perhaps the first to initiate road-signing of historic spots, such as the Lincoln Highway (Show 1965).

⁶⁸ By that date, their friendship bond had strengthened further because Show's younger sister Ruth met and married Kotok.



U.S. Forest Service

Figure 23—Edward I. Kotok, first director of California Forest Experiment Station (1926–1940). His major contribution to Forest Service research was his ability to organize and administer research during its formative years of development in California.

the Forest Service provided \$3,500 for four “rangers” salaries. By 1920, the ranger organization expanded with 10 rangers overseeing 10 fire districts (Thorton 1994). By this date, Edward Kotok, who had been moved into the San Francisco District 5 office to take over fire control and cooperative fire duties there, was thereafter appointed as the first Weeks Act “Inspector” for California (Cermak 2005, Hastings 1976). Once again, the two men were brought together. “Over the next ten years, Show and Kotok would collaborate on six of the most important publications in the history of fire control” (Cermak 2005).

Range Management Research

In 1915, responsibility for range research outside the national forests was transferred from the former BPI to the Forest Service, and the Santa Rita and Jornada Range Reserves were transferred to the Forest Service. With these transfers, Department of Agriculture responsibility for range and native pasture research on public and private lands passed to the Forest Service (Price 1976). In the same year, a district range research office was established in California under District 5’s Branch of Grazing. The primary work of this office was to conduct range surveys, using the “range reconnaissance” method of range inventory devised by James T. Jardine. Thereafter, the first range reconnaissance surveys were begun in District 5, starting

with the Trinity National Forest (Graves 1915). “None of this had great consequence,” according to S.B. Show, “but it bespoke the entry of science into another field of national forest management” (Show, n.d.). In addition to range reconnaissance, in the pre-World War I years, observations and demonstration tests to work out practical methods of eliminating livestock loss from poisonous plants occurred in District 5. At the top of District 5’s list was suppression of larkspur, which is highly palatable but extremely poisonous to cattle, and which caused heavy cattle losses on western range states. In cooperation with cattlemen, the Forest Service selected a demonstration area on the Stanislaus National Forest. There, they eradicated the weed on approximately 67 acres by digging it out. Likewise, they conducted similar tests on a smaller scale on the Sierra and Angeles National Forests. In every case, losses from poisoning were reduced to such an extent that the cost of testing was more than justified (Graves 1916, 1917). However, all such research was curtailed during World War I while the Forest Service filled a mandate to “increase the number of stock already authorized by the Secretary for the season of 1917 [and thereafter] wherever this was possible without serious danger of over-grazing and over-stocking the range” (Graves 1917).

Push for Fundamental Scientific Research and Experiment Stations in the West

On November 11, 1918, the European war ended when Germany capitulated. Now the Forest Service research program faced new demands in its post-war years. At the end of the war, Earle Clapp, head of the Branch of Research, felt optimistic about the future of Forest Service research. If forestry research in the United States lacked justification before the war, in his opinion, it was now more important than ever. The role forestry research played in winning the war in Clapp’s opinion had earned it new respect (Clapp 1918, 1919a, 1919b), and thereafter a trend toward basic research characterized this period in forestry research history. Research work in which the results of field observation and experimentation were verified by methods under laboratory control, as practiced by the FPL during the war years, influenced this development. Increasing integration of diverse lines of research was another research trend exhibited at this time as well (Hill 1931).

In July 1919, the American Forestry Association (AFA) crystallized these challenges. In an editorial entitled “Why We Need More Forest Research,” the organization outlined the reasons for a new research effort aimed toward fundamental forestry research. The AFA pointed out how the Forest Service, through its experiment stations, had been successful over the previous decade in “solving the technical problems that arose in marking timber, in working out methods of

The Forest Service must “set itself at once to the task of securing more fundamental facts,” and obtain such data by “long-continued, painstaking, scientific research.”

“Full productiveness of our forests can not be secured without full information regarding the means of controlling growth.”

brush disposal to secure natural reproduction, methods of artificial reforestation, and similar problems.” A renewed research effort was called for by groups such as the AFA following World War I because the United States was facing an economic problem—producing enough wood to meet the future needs of the Nation’s growing population and industries. The AFA thought the federal government ought to take vigorous action to avoid “a very serious shortage of timber with attendant high prices, hardship for consumers, and hindrance to the economic development of the country...” The Forest Service, according to the AFA, must “set itself at once to the task of securing more fundamental facts,” and obtain such data by “long-continued, painstaking, scientific research.” In other words, purely investigative work as opposed to applied science (American Forestry Association 1919). Over the next few years, the AFA reiterated this position and pushed for materially strengthening the Forest Service experiment station system and the initiation of long-term scientific studies of forestry problems. “Full productiveness of our forests,” the editorial stated, “can not be secured without full information regarding the means of controlling growth.” The association bemoaned the “virtual abandonment of the forest experiment stations in the West,” stating that they were “as necessary to forestry as the agricultural stations are to progress in agriculture...” The organization suggested that there should be at least one station in each of the main forest regions of the country (American Forestry Association 1920).

Meanwhile, nationally there was a parallel call for forest research to expand beyond the Forest Service. A clear advocate of American schools of forestry and other institutions taking a larger part in such research was James W. Toumey,⁶⁹ dean of Yale University’s School of Forestry. Toumey opposed centralization of research in the Forest Service, which he characterized as primarily an administrative and executive branch of the government, and declared: “...past experience has shown that those [experiment stations] already in existence are located without reference to forest conditions in the entire country, but with reference to the national forests, which are a small part, and in many respects the least important part, of the forests of the entire country.” Instead, the Yale dean recommended the formation of a central national body that would give direction to forest research being carried

⁶⁹ In the 1890s, James William Toumey taught botany at Michigan State and at the University of Arizona prior to his appointment as superintendent of tree planting in the Division of Forestry in 1899. However, the next year, Toumey was called to Yale University where he became an outstanding authority on dendrology and silviculture. From 1910 to 1922, Toumey served as dean of Yale’s School of Forestry. When he retired from the deanship, he continued to teach and do research at the university (Clepper 1971).

out by the Forest Service and state agencies, as well as educational and private institutions. Moreover, he believed that forestry needed what agriculture needed and obtained a half century ago—a research station in every state in the Union under national support and linked up with an educational institution, preferably with the College of Agriculture or with established forestry departments in other institutions (Toumey 1919).

While this issue was nationally debated, the “gentlemen’s agreement” between the University of California and the District 5, which turned out not to be satisfactory to either party, fell apart. As the fundamental research idea began to germinate nationwide, Berkeley professors grasped its significance and decided to center the school’s future efforts toward such work. Donald Bruce, a professor at Berkeley, went in this direction in the field of mensuration, or the measurement of lengths, areas, and volumes. Traditional methods of calculating volume and growth measurement at this time were crude and open to suspicion. Bruce, starting in 1920, applied the rigid control of statistical mathematics to mensuration, leading to more accuracy in volume tables for the growth of such California species as white fir, red fir, and second-growth redwood. Also at this time, other Berkeley professors, such as Arthur Sampson, who studied the nutrition of forage grasses and other significant topics in grazing research, also produced significant results in fundamental research (Hill 1931). Against this backdrop, the Forest Service research program matured in the early 1920s.

Maturation of the Forest Service’s Research Program, 1920–1925

By the time peace returned to America, many people in the Nation were quite concerned about America’s declining forest resources, much like their grandparents must have felt 50 years earlier, when Franklin B. Hough presented his paper “The Duty of Governments in the Preservation of Forests,” which spawned the birth of America’s forestry movement. In the 1920s, the United States used timber at a rate four times as fast as it was being grown, and the Nation had already consumed or destroyed 60 percent of its original timber wealth. Concurrently, and as a consequence, public interest and involvement in forestry grew in the 1920s as well. This involvement spread to a degree greater than ever before in the country’s history, which was reflected in the Nation’s growing desire to promote wiser and wider use of forest resources. For instance, by 1925, several new organizations had already formed around a conservation theme. They included the Save the Redwoods

Forestry needed what agriculture needed and obtained a half century ago—a research station in every state in the Union under national support and linked up with an educational institution, preferably with the College of Agriculture or with established forestry departments in other institutions.

Only by intensive management on all the forest lands in the United States can timber production be increased sufficiently to meet our requirements. The wolf will not be driven from the door until four times our present growth of wood is secured.

League⁷⁰ (1918) and the Izaak Walton League⁷¹ (1922), both of which joined the Forest Service in the spread of interest in forestry issues (Greeley 1925). In addition, Arthur Capper, newly elected Senator from Kansas, expressed from the Senate floor in 1920 the national apprehension over the consumption and destruction of the Nation's forest heritage when he introduced and engineered the passage of the Capper Resolution.⁷² This Senate resolution directed Agriculture Secretary Henry C. Wallace to report on the extent of forest depletion, lumber prices, exports, and the degree of concentration of forest ownership (Godfrey 2005). And, as in Hough's day, public interest in forest research rose to the point that the federal government stepped in to meet the crisis. The Senate called for increasing timber-growing investigations and the creation of an extensive forest experiment station system. The 1923 Forest Service annual report thereafter declared, "Only by intensive management on all the forest lands in the United States can timber production be increased sufficiently to meet our requirements. The wolf will not be driven from the door until four times our present growth of wood is secured. Forest investigations.... have a very concrete part to perform in the program of national forestry..."⁷³ (Greeley 1921).

⁷⁰ The Save the Redwoods League began in 1917 after prominent California conservationists like John C. Merriam, Madison Grant, and Henry Fairfield saw the widespread destruction of the forests along the northern coast of California after the completion of Highway 101. In the spring of 1918, they formed the league to save primeval redwood forests from destruction. Thereafter, the league worked in close cooperation with federal, state, and other organizations to establish redwood parks in the state of California. By 1925, two-thirds of the timber operators in the redwood region of California were either actually reforesting their lands or investigating its feasibility (Greeley 1925).

⁷¹ The Izaak Walton League was organized in 1922 by a group of Chicago sportsmen. While discussing a common interest—the deteriorating conditions of America's top fishing streams by uncontrolled industrial discharges, raw sewage, and soil erosion, which threatened to destroy many of the Nation's most productive waterways—they decided to create an organization to confront this problem. As a constant reminder of their goals, they named the group after Izaak Walton, the 17th century English angler who wrote the classic *The Compleat Angler*. Their ultimate mission eventually turned to conserving, maintaining, protecting, and restoring the soil, forest, water, and other natural resources of the United States and to educate the public with respect to such resources.

⁷² The 1920s was a time when the use of Congressional power to investigate reached new heights—a trend that continued into the 1930s. During these decades, progressives in Congress effectively wielded this device to expose the inequities in society and corruption in government, much as they had done through the 1912 Pujo Committee investigation of Wall Street prior to World War I and after the war through the Teapot Dome investigation into cabinet-level corruption in 1924 (Godfrey 1985).

⁷³ National aid in the advancement of forestry came when the Clarke-McNary Act passed in 1924. Its chief purpose was to encourage local forestry, and it opened a new era in cooperative work with the states in four areas: encouraging farm forestry and tree planting, protecting state and private forests from fire, resolving forest taxation issues, and increasing forestry extension work (Greeley 1925).

Earle Clapp's Branch of Research prepared the Forest Service's official response to Capper's 1920 resolution. It indicated that there was serious timber depletion in some parts of the country, particularly the "eastern and most populous part of the country which had begun to suffer the pinch of timber scarcity and high lumber prices in consequence of forest depletion" (Greeley 1923). Greeley's lengthy report should have inspired the Nation to invest more into forestry research. Unfortunately, the Forest Service was caught on the wrong side of a controversy involving regulating forest practices on private lands,⁷⁴ which did not help Clapp's research budget needs (Steen 1976, 1998). Appropriations needed to revitalize Forest Service research were not forthcoming. In fact, because of budget difficulties following World War I, FPL staff members were reduced by about half, and the annual budget of the Branch of Research declined in the 1920s, too (Steen 1998). For example, expenditures for research in 1921, which included forest products, silviculture, range and forage plant investigations, experiments in tree planting, scientific management of stock and forage, and recording, digesting, and disseminating the results of scientific technical work, amounted to less than \$370,000, or just under six percent of the Forest Service's annual appropriation (Greeley 1921). This figure was a full percentage point below what it had been a decade earlier. By 1925, this percentage had dropped to 4.24 percent of the overall Forest Service budget (Greeley 1923). Besides these budgetary woes, Clapp confronted another prevalent problem in the postwar period—the availability of technically trained men with adequate research experience. For instance, in 1921, the annual turnover of various groups of scientific and technical personnel ranged somewhere between 14 and 27 percent (Greeley 1921).

Despite inadequate funding and a growing need for forest research scientists, Earle Clapp rebuilt and rebalanced the Branch of Research program goals from their wartime footing as best as he could. Eventually, Clapp pieced together a research program that met the Nation's research demands and one that achieved full independence and recognition of the Branch's authority over Forest Service research matters. Clapp's plan began at the end of 1921, when, in a pamphlet entitled *Forest Experiment Stations* (Clapp 1921), he proposed the creation of at least one forest experiment station in each of the principal timber regions of the country—10 regional experiment stations in all (Steen 1998). This idea met one of Yale Dean Toumey's criticisms and brought out congressional allies who fought for the necessary appropriations to fund individual experimental stations. Sometimes,

Unfortunately, the Forest Service was caught on the wrong side of a controversy involving regulating forest practices on private lands.

⁷⁴ In the 1920s, many people, including those in the Forest Service, worried about the risks of depending on private forests and the forest industry for the Nation's future supplies of timber and wished to institute government controls over private forestry.

Clapp and his supporters won. For instance, in 1921, congressional legislation passed authorizing the creation of two new eastern experiment stations, one in New Orleans, Louisiana, and the other in Ashville, Kentucky. At the same time, the Missoula, Montana, station reopened on a restricted basis (Greeley 1921, Steen 1998). Sometimes, they lost. For example, that same year, California's Senator Hiram Johnson and Representative Henry Z. Osborne introduced a bill backed by the Forest Service to establish a California experiment station to enlarge the small-scale work underway in District 5. The California bill failed to pass that year, even though the AFA endorsed it⁷⁵ (American Forestry Association 1921a, 1921b). However, two years later, two additional stations were added to Clapp's Research Branch. One was located at Amherst, Massachusetts, and the other in St. Paul, Minnesota. In 1924, Clapp increased his arsenal of experiment stations again when the Forest Service opened the Portland, Oregon, experiment station. In the interim, original experiment stations, such as the ones at Fort Valley and Priest River, were systematically converted to experimental forests, probably because they did not meet the regional qualification Clapp sought (Steen 1998). By 1924, the functions of forest experiment stations, as well as the ways and means of disseminating results of their work, had been hammered out at the National Conference on Utilization of Forest Products that Clapp held at the FPL in March of that year. According to Clapp, the meeting's purpose was "to unite the entire research force into a more homogenous organization, and to bring about a closer coordination of the work of the men at the different stations which are more or less isolated from one another" (USDA FS 1924b: 4). Chief Forester William B. Greeley⁷⁶ attended the meeting along with key Washington research and branch staff and representatives from all the forest experiment stations and the district offices (Greeley 1925, USDA FS 1924b).

⁷⁵ In January of 1922, Senator Johnson reintroduced the bill asking for an appropriation of \$40,000, but it failed as well. A year later, the California state legislature passed a resolution urging Congress to authorize the expenditure and make the necessary appropriation, but again their plea fell on deaf ears. Interestingly, two months earlier, the California State Board of Forestry had intended to sponsor a bill asking for a state appropriation of \$10,000 for the establishment and maintenance of a forest experiment station in the state provided that the federal government appropriate a sum of \$25,000 for the same purpose (Clar 1959).

⁷⁶ William Buckhout Greeley received a law degree from the University of California (1901) and a Master of Forestry degree from Yale (1904). He joined the Forest Service working in California and was promoted to supervisor of the Sequoia National Forest (1906). He later served as district forester for the Northern Rocky Mountain Region (1908) and in Washington, D.C., as Chief of Silviculture or Forest Management (1911). Like many in the Forest Service, he served in the 10th Engineers, United States Army Corps of Engineers during World War I. In 1920, he was appointed the Nation's third Chief of the Forest Service and held that position until 1928, when he resigned (Clepper 1971).

At a special session regarding experiment stations, Samuel T. Dana, director of the Northeastern Forest Experiment Station at Amherst, and a stalwart advocate of forest experiment stations since 1909, spelled out the philosophy, the functions, and the duties of forest experiment stations. According to Dana, the mission of federal forest experiment stations was to exercise an active leadership in forest research along three lines in the regions where they were located: conducting research; making the results available to the public in usable form, and seeing that the research is put into practice; and stimulating and coordinating research on the part of other agencies that were, or should be, doing work in the same field. In other words, station research work should include both bringing together and making available existing research, and securing original data. In the selection of specific projects, each station was to give preference to problems of immediate urgency and outstanding importance in its region. Fundamental research was not to be neglected, but would be conducted only when necessary to obtain satisfactory answers to the problems under investigation. Station Director Dana also maintained that research fields should be limited to forest protection, forest production, and forest management and that entomology and forest pathology staff detailed to the various stations by the BE and Plant Industry should continue their work. In Dana's estimation, each station needed to stay in close touch with all investigations in forest products and forest economics in their region, but that should not preclude the station from doing work in those fields. In addition to their own research activities, experiment stations were to keep in touch with other phases of forestry in their regions—such as work conducted by state agencies, educational institutions, and private institutes and industry. Finally, Forest Service research findings were to be circulated promptly to administrative officers and throughout the Forest Service. The general and concerned public was to be informed by means of scientific publications, popular articles, talks, demonstrations, and personal contacts (Dana 1909, 1924).

The mission of federal forest experiment stations was to exercise an active leadership in forest research.

California District 5 Administrative and Research Program, 1920–1925

In 1920, District 5 Forester Paul Redington named S.B. Show head of District 5's research division. Without any experiment stations to oversee, all forestry research efforts took place in District 5's research division. From 1920 to 1925, research work increased exponentially under Show, although there were only a limited number of personnel to conduct research. By 1922, District 5's research division consisted only of S.B. Show (division head and fire research), Duncan Dunning (silviculture), C.L. Hill (wood products) and Miss D.H. Vinther, an administrative assistant (Wilson 1976). In 1925, botanist Howard Siggins joined the research

division to help Dunning with silvicultural studies. At various times, field men were detailed to the division, as well as extra clerical assistance, but for the most part, in these early days, Show, Dunning, and Hill made up the entire operation. Fortunately, some research subjects, such as insect and disease research and grazing management were still handled by other USDA agencies or branches. Despite his limited staffing arrangement, Show worked diligently alongside Earle Clapp and the Washington office. For instance, in November 1924, after Chief Forester Greeley (fig. 24) addressed the Washington section of the Society of American Foresters on the “Importance of Forest Research,” a committee was formed to report its findings on forestry. This committee included contributions from outstanding California men, such as S.B. Show. In 1924, Show, Kotok, and Dunning represented District 5 at the National Conference on Utilization of Forest Products. Show even presented a short paper at the meeting on the correlation of forest products and silvical research (USDA FS 1924).

Research Program, 1920–1925

Silviculture Studies

From 1920 to 1925, Duncan Dunning handled all silvicultural studies within District 5, and enlisted help from others when needed.⁷⁷ However, in 1921, reforestation efforts within District 5 were halted. A decrease in congressional appropriations for planting and sowing from a prewar nationwide total of over \$170,000 to \$125,000, and the high cost of labor after the war, forced the Forest Service to selectively plant in those regions where the greatest success was obtained in the past and where the need for artificial reforestation was the greatest. Planting in California was suspended for a number of years because the region did not meet these criteria (Greeley 1921, 1923).

This attitude began to change following Clapp’s report on the Capper Resolution. With release of the report, District 5’s cutting and marking policy underwent considerable study and reevaluation. For more than 10 years, District 5 had been conducting a detailed study of cutover lands on permanent plots on the Shasta, Lassen, Plumas, Tahoe, Stanislaus, Sierra, and Sequoia National Forests to determine the effects of cutting on the growth of remaining trees and on reproduction. In

⁷⁷ For instance, in 1920, Dunning, Show, Edward Munns, and J.A. Kittredge reexamined the 24-acre permanent plot located within the Feather River Experiment Station on the Plumas National Forest. With the closure of the Converse Experiment Station, Munns did some war work and then returned to District 5 after the war to conduct a logging and cutting methods study for the state of California. Eventually, Munns went to Washington, D.C., and served as Chief of the Office of Experiment Stations (1925–1928) (Show, n.d.; Watts 1951).



U.S. Forest Service

Figure 24—William B. Greeley, third Chief of the Forest Service, 1920–1928. Greeley fostered an extensive system of basic and applied research.

1922, Duncan Dunning published the initial results. He found that there was little correlation between cutting practices and probable growth and reproduction, which depended more on a tree's seed capacity, the relative value of the species, wind firmness, and other factors. Two years later, Dunning's final study was published, confirming his earlier findings (from Ayres 1958). As a result, District 5 marking rules were redesigned to release well-established young growth from light and root competition brought about by early marking practices. According to District 5 assistant district forester T.D. Woodbury:

Now for the first time, we are able to handle cutting operations on the basis of facts obtained on our own region through careful research....[W]e administrative men who are responsible for growing the maximum amount of wood of the best species on our cutover lands can now ascertain... the most productive trees to leave in order to accomplish this objective [Godfrey 2005: 183].

Dunning's study once again stimulated interest in reforestation on District 5. In early 1924, a 10-year program of planting experiments was undertaken under District 5's research branch, with the object of improving the protection and utilization of timber. Woodbury suggested that the Feather River nursery be involved in the project (Godfrey 2005).

Other achievements in silviculture research under Dunning followed once the California Experiment Station was established in mid-1925 (see below). One notable accomplishment was Dunning's invention of an instrument that read the history of trees and forests from annual rings of increment cores taken from living trees (fig. 25). Dunning's instrument accommodated the ordinary Swedish borer and allowed for the measurement of increment cores economically with comparative rapidity, consistent accuracy, and a minimum of fatigue and eyestrain (USDA FS 1924a, Dunning 1925).

Forest Products Research

In 1920, District Forester Redington reinstated wood products research within District 5's research division under the direction of Carey L. Hill.⁷⁸ In the main, Hill trended away from investigating wood preservation problems characteristic of research in the pre-World War I years, even though those problems were still important to the conservation of wood material. For instance, Hill had spent considerable research time on marine pilings preservation. Now, Hill turned to the study of other problems, such as waste and losses in the timber conversion processes. At the 1924 National Conference on Utilization of Forest Products, there was widespread interest in the amount of wood wasted in the forest. At the conference, it was estimated that logging operations left on the ground 20 to 30 percent of the timber, chiefly in the form of so-called "inferior" species, defective logs, high stumps, and large tops. Additionally, sawmill waste was seen as a great opportunity for research (Greeley 1925). Addressing these issues, Hill published several articles in forest economic and products journals discussing the reduction and utilization of logging and sawmill waste, including the manufacture of pulp, paper, rayon, and ethyl alcohol. Hill also undertook cooperative woods and mill studies and made a study concerning air seasoning of lumber in California, and the great savings that could be attained by better processes (Aitro 1977, Hill 1931). Nonetheless, wood products research essentially remained a one-man operation during the early 1920s. Investigations of any California wood species for specific purposes, such as for citrus-fruit boxes, were conducted by the better-equipped laboratory facilities at the FPL (Greeley 1921, 1923).

⁷⁸ In 1941, Cary Leroy Hill died after 36 years of working in California for the Forest Service. In 1903, he attended the University of Michigan forestry school and a year prior to graduation in 1905 with an M.S. in Forestry he joined the Forest Service. With the exception of 3 years (1909–1912), when he taught forest utilization, wood technology, mensuration, and dendrology at his alma mater, he worked in various capacities for the Forest Service. Prior to joining the staff of District 5, he had worked as a forest examiner on the Sierra National Forest and served for a time as chief of the Forest Products Division in Denver (Anonymous 1941).



U.S. Forest Service, Pacific Southwest Region

Figure 25—Person reading the life history of trees and forests from the annual rings of increment cores taken from living trees. The instrument was invented by Duncan Dunning of the California District, U.S. Forest Service, 1925.

Fire Research

While Dunning and Hill attended to their research efforts in silviculture and wood products, Show increasingly directed his energies toward fire research. Show leaned in this direction so much that the lines between administrative research duties for District 5 and his fire research blurred. Quibbling and hairsplitting definitions of what constituted fire research as opposed to administrative work began to appear between him and other District 5 staff—so much so that in 1923, a joint meeting was held between researchers and administration in San Francisco to resolve this bureaucratic conflict. The 14 people who attended discussed their needs and important issues, which included topics such as light burning, fire damage appraisal, analysis of fire reports, tracking lightning storms, fire danger rating, and initial attack speed-up on fires. In the end, a pioneering “investigative committee” was formed to focus special attention on fire research requirements in California (USDA FS 1922, Wilson and Davis 1988).

District 5 went from a “let burn” policy to a new policy of putting out all fires as soon as possible.

In the early 1920s, fire research was certainly one of District 5’s primary concerns, and teamwork by S.B. Show and Edward I. Kotok contributed significantly to analytical research on fire protection in California. But first, fire policy in District 5 needed to change. While District Forester DuBois served during World War I, Roy Headley, his chief of operations, was put in charge of the district. In DuBois’ absence, Headley instituted a nonscientific “let burn” policy for California, which he based on personal opinions and experiences. Using an economic cost ratio of damage versus control, Headley deemed that certain fires ought to be allowed to burn if expenditures were disproportionate to the value of the resources under protection. The policy was dropped when Show demonstrated Headley’s errant judgment in a paper he presented at the 1920 supervisor’s conference in Davis, California. Show analyzed forest fire records for the previous 7 years and found Headley’s theory unworkable, demonstrating that the personal views and experiences of Forest Service personnel with firefighting were not enough to successfully fight fire in a state as diverse as California, and that analytical statistics could improve fire prevention. Based on Show’s results, District Forester Redington reoriented District 5’s fire policy. District 5 went from a “let burn” policy to a new policy of putting out all fires as soon as possible. After Show’s conference paper, District 5 witnessed several important events related to fire control research. First, in 1921, Chief Forester Greeley recognized a growing desire among Californians, and people in other western states, to prevent forest fires and to address an ever worsening fire situation throughout the West. To tackle the problem, Greeley called a national fire conference, the first of its kind. The Mather Conference—named so because it was held at the Army Air Service base at Mather Field, Sacramento—established forest fire control as a national priority (fig. 26). It also endorsed fire



U.S. Forest Service, Pacific Southwest Region

Figure 26—Fire conference at Mather Field, Sacramento, California. Attendees included Forest Service Chief William B. Greeley (second row, seventh from left).

research “as an essential tool in developing an adequate fire control organization.” From this conference, District 5 emerged as a leader in fire control for the Forest Service in many areas (Godfrey 2005).

As a result, the district’s fire research program under Show—with the assistance of Kotok—expanded to fill this responsibility. Often they directed their research to resolving immediate administrative concerns rather than answering fundamental questions. For instance, during the summer of 1921, lightning-caused fires became a major concern within District 5. On the Klamath National Forest that year, a series of storms started 48 fires within 6 days, and on the Trinity National Forest, a single thunderstorm started 70 fires in 1 day, besides causing a number of others on neighboring forests (Greeley 1921). The next year, District 5 gathered an enormous amount of statistical data on lightning storms, seeking a way to predict serious storms. Even with Show and Kotok’s diligence, District 5’s records were incomplete,⁷⁹ largely because not all forests impressed upon their lookouts the necessity for keeping good data. To fill gaps in their patchy statistics, Show gathered material from Districts 1 and 6. Show even spent considerable time working with noted fire researcher Harry T. Gisborne,⁸⁰ director of Priest River Experiment Station, on the subject. In 1923, Show and Kotok published their results, *The Occurrence of Lightning Storms in Relation to Forest Fires in California*, which gave the characteristics and seasonal distribution of fires caused by lightning (Show and Kotok 1923b).

Along with this and similar studies, Show and Kotok tackled the origin and behavior of fires, and continued directing their attention to other fire-related matters, such as methods of fire suppression and prevention of fire damage. In the next few years, they produced a number of significant papers on these topics. First came the 1923 publication of *Forest Fires in California, 1911–1920: An Analytical Study*, as USDA Circular No. 243 (Show and Kotok 1923a). This publication was a methodical study of some 10,500 fires in the 12 California timbered national forests. *Forest Fires in California* examined protection theories (e.g., Headley’s economic theory), and variations of the theories, as well their effects on fire control. It also pointed out certain weaknesses in fire control traceable to organizational flaws and laid the foundation for a set of fire control premises that were explored further

⁷⁹ For the interested researcher, there is a huge amount of raw data available from this study available in Record Group 95, Federal Record Center, San Francisco, California.

⁸⁰ Some consider Harry T. Gisborne the “father of forest fire research” because of his contributions to the development of the fire-danger rating system (Hardy 1983).

Because infested lands were intermingled in various public and private holdings, it required a concerted effort on the part of all parties over several years to clear the lands of beetle-killed trees at the same time.

in later publications by Show and Kotok. The two men realized “that improved fire protection was essential if intensive forest (timber) management was to succeed...” (Cermak 2005). Next, the two authors published *The Role of Fire in the California Pine Forests* as USDA Bulletin 1294 (Show and Kotok 1924). This USDA Bulletin examined direct and secondary fire damage and estimated the seriousness of each form of injury, the immediate loss and indirect cost, and surveyed the effect of losses on the future timber supply and on California’s forest management problem. Both publications pushed District 5 toward better fire control and prevention.

Forest Entomology Research

Although insect control projects had begun on District 5 in 1910, the Bureau of Entomology, or BE, in cooperation with the Forest Service, had not prevented a very serious infestation of tree-killing insects that hit northern California and southern Oregon in 1921. This outbreak affected nearly 1.25 million acres of national forest, Indian reservations, and private holdings, causing \$3 million in damage. Bark beetles were destroying one of the finest bodies of pine timber remaining in the United States. Because infested lands were intermingled in various public and private holdings, it required a concerted effort on the part of all parties over several years to clear the lands of beetle-killed trees at the same time (Greeley 1921, 1923). District 5 worked hard to clear the pest from 225,000 acres of beetle-infested national forest lands, and in 1923 the California legislature passed the Forest Insect Eradication Law, authorizing establishment of zones of infestation (Hastings 1976).

In the interim, popular California author and naturalist Stewart E. White⁸¹ linked insect control work and the topic of “light burning” together and led a vigorous and large-scale propaganda effort in favor of light burning as the answer to the growing destruction of pines near White’s cabin home on the Sierra National Forest. White assumed that insects that attacked nearby forests bred in dead and decaying wood, and like so many others, believed that light burning would remove them. District Forester Redington tried to respond to White by citing principles of

⁸¹ American author and conservationist Stewart Edward White produced many works (novels, histories, short stories) based upon his own life’s experiences in the American West and elsewhere. Born in Grand Rapids, Michigan, and educated at Columbia University (M.A. 1903), he then moved to California. In 1903, he married, honeymooned in the High Sierras, and then settled with his bride in Burlingame, California, south of San Francisco. *The Forest* (1904), *The Mountains* (1904), *Arizona Nights* (1907) were some of his novels that dealt with the outdoors and summer pursuits. White also produced many fiction and nonfiction works on the history of California, such as *Gold* (1913), *The Gray Dawn* (1915), and *The Rose Dawn* (1920). A grove of sequoias on California’s redwood coast was named in his honor following his death in 1946.

forestry science, but to no avail. This situation became one of those times that research was tapped to address an administrative public relations issue. First, S.B. Show debated White in a series of public forums, but the results were inconclusive. Then to appease White and his followers, Redington authorized Project San Joaquin on the Sierra National Forest, where White's cabin was located. This project embraced the front of the sugar pine belt in the forest from North Fork south to the Sequoia National Park area, which for the next few years became the chief entomological activity for District 5. Before it folded in 1924, the project led to a number of important studies regarding how to maintain control of insect attacks, what classes of trees were subject to attacks, and which trees were the most resistant. Thereafter, the San Joaquin Project⁸² was moved to the more serious infestation on the Modoc National Forest in the northern part of the state (Godfrey 2005).

Range Management Research

In the early 1920s, range management science had its problems as well. The first problem centered on the lack of grazing specialists with scientific backgrounds. Prior to World War I, Forest Service grazing research depended on the range expertise of "energetic and resourceful old cowboys" like Albert Potter and C.E. Rachford⁸³ for its scientific opinion. To many of these old range men, "college boys" and their hybrid research seemed a needless expense involving time-consuming procedures and doubtful experiments (Rowley 1985). This "old grazing guard" would have given way in the 1920s to men with scientific background and

The California Forestry Committee unanimously agreed that light or controlled burning was not a practicable method of forest protection in California, an action that dampened the light burning discussion in California for several decades to come.

⁸² Although the San Joaquin Project ended the light burning-insect control issue, it did not convince light burning supporters that the practice had no other forest management advantages. Finally, in hopes of ending the debate once and for all, District 5, in close cooperation with the State Board of Forestry, conducted a light burning experiment at Moffatt Creek on the Klamath National Forest. As far as the actual burn, the effort was considered a failure. The California Forestry Committee, a body comprising representatives of the pine and redwood associations, Southern Pacific Railway, State Forester, Berkeley Forestry School, and the Forest Service, unanimously agreed that light or controlled burning was not a practicable method of forest protection in California, an action that dampened the light burning discussion in California for several decades to come (USDA FS 1922, 1923). Additionally, entomologist J.M. Miller also testified before the California Forestry Committee. He gave a summary of his research on bark beetle relations to wildfire, the biology of bark beetles, and current methods used to control, and "essentially demolished the claims made by White" (Wickman 2005).

⁸³ Interestingly, Christopher E. "Chris" Rachford was a northern Californian who joined the Forest Service in 1905 after being in the sheep business in the Modoc country. He was a ranger for the eastern slope of the Warner Forest Reserve for one season under A.H. Hogue, who oversaw the Modoc and Warner Reserves (1905 to 1907), "wearing out three good horses and almost himself in the process." Rachford succeeded Hogue as forest supervisor. In 1914, Rachford was transferred as Supervisor of the Santa Barbara National Forest. Later, he became Assistant District Forester for California Region 5, but ultimately retired in 1941 as Assistant Chief Forester of the Forest Service (Brown 1945c).

better range investigations if they could have been found. However, the Forest Service was unable to attract the well-trained grazing experts needed to conduct investigations and bring the ranges to their full development and most beneficial use. As a result, in California, grazing investigations were severely reduced in the early 1920s. The only real work of this nature being done within the Forest Service occurred at the Great Basin Experimental Station in Utah, and the Jornada and Santa Rita Range Reserves in New Mexico and Arizona. So instead, every new technical grazing man in District 5 was given a course of practical training under the guidance of “experienced” cowboys like Potter and Rachford. They were men who, according to S.B. Show, “wrote down mystical figures and ratings,”... “unhampered by such impractical ideas as ecology—indeed [they] instructed that heavy grazing was good, since it decreased fire hazard.” Without scientifically trained men in the field, range research at this time in California amounted to rangers and supervisors simply completing their annual grazing report forms, which were derisively known as “Rachford” reports (Greeley 1921, 1923; Show, n.d). To compound matters, the Forest Service, in general, heavily curtailed range investigations in the district at this time because of the lack of funds, even though drought conditions in the 3 years following World War I would have warranted the need for this kind of work (Greeley 1921). In fact, the drought situation grew so severe in 1924 in parts of the Southwest that research on the Jornada range reserve had to be suspended until the range could recover (Greeley 1925).

Founding of the California Experiment Station

The birth of California Forest Experiment Station (CFES) came in mid-1925, when California Senator Hiram Johnson, along with the efforts of California Representative Walter F. Lineberger, finally succeeded in authorizing CFES with an appropriation of \$50,000 (American Forests and Forest Life 1925), which later was reduced to just \$32,412 (Clar 1959). With the announcement, it appeared that S.B. Show would be selected to head the new experiment station because Show had headed District 5’s research branch since 1920. But in early 1926, District Forester Redington transferred to the WO, and Show, who had impressed Chief Forester Greeley with his ideas for the future of District 5, was appointed to replace Redington (Cermak 2005). With Show out of the running, Edward I. Kotok, Show’s fire research collaborator, brother-in-law, and friend, became the prime candidate for the position. Since coming to the San Francisco headquarters, Kotok had risen in Forest Service

ranks, becoming more and more known for his administrative skills⁸⁴ (American Forests and Forest Life 1925). In October 1926, the decision came down from the Washington office, announced in *American Forests and Forest Life* that “Edward I. Kotok, for 15 years an officer of the California District of the U.S. Forest Service has been appointed director of the new Forest Experiment Station to be established in this state” (American Forests and Forest Life 1926). The next question in everyone’s mind was where the experiment station headquarters would be located. Two months later, Secretary of Agriculture William M. Jardine⁸⁵ answered the query.

In December 1926, Jardine announced that the new CFES headquarters would be the campus of the University of California, Berkeley.⁸⁶ Secretary Jardine gave several grounded reasons for his decision. First, since the state Agricultural College and new experiment station would both be employing many common lines of investigation in the production of timber crops with the experiment station, Jardine reasoned that it made good sense to put the experiment station nearby. Second, Jardine noted that the new experiment station’s Berkeley campus location would allow it the opportunity to establish a close cooperative relationship with the forestry school’s faculty and students under Walter Mulford’s chairmanship. Finally, in Jardine’s assessment, all forest research results in California, either by the state Agriculture College, the Forestry School, or the experiment station could easily be made known publicly through the Extension Service of the District 5 headquarters across the bay in San Francisco (American Forests and Forest Life 1926).

Work Ahead

After two decades of defining and redefining, initiating, forming, and maturing California forestry research, a conclusive order emerged. In 1905, the Forest Service took the lead in forestry science in California. At the beginning of this period, many people still believed in acquiring needed knowledge through the gradual buildup of facts through long commercial trial and use, and the handing down of results by tradition—the so-called trial-and-error method. Two decades later,

⁸⁴ For example, following the passage of the Clarke-McNary Act, Kotok became involved in cooperative fire control with the state of California.

⁸⁵ William M. Jardine was James T. Jardine’s older brother. William Jardine served as Secretary of Agriculture from 1925 to 1929 during the Coolidge and Hoover administrations.

⁸⁶ Other educational institutions competed for the station, but behind the scenes, Walter Mulford had undoubtedly exerted quiet but effective pressure to see that it was located on the Berkeley campus. He saw that this arrangement would benefit the staffs of both the school and the station (Cassamajor 1965).

The early Forest Service research program in California and the Hawaiian Islands arose in the light of this “search for order” as District 5 scientists and researchers tried to answer the day’s critical questions and to meet the region’s needs.

thanks to the leadership of District 5 men like DuBois, Show, and Kotok, many people also understood that forestry science, and the employment of highly trained investigators devoted full time to finding facts that underlay the growing use of forests, would achieve results much more quickly. The years 1905 to 1925 by necessity were building block years for the Forest Service research program in California. During the first decades of the 20th century, many people in California postulated important questions to Forest Service researchers regarding regional forestry problems, both in northern and southern California. In turn, they considered forest research as part of the solution to the problems of forest management, such as silviculture, silvics, and forest mensuration; forest protection, dealing with forest fires, insects and disease; and range management subjects such as forage and carrying capacity. They also believed that research and investigations into forest influences, forest economics, and forest products were necessary as well. The early Forest Service research program in California and the Hawaiian Islands arose in the light of this “search for order” as District 5 scientists and researchers tried to answer the day’s critical questions and to meet the region’s needs.

During this period, the Forest Service in California added substantially to the pre-1905 period of “fact-gathering” by conducting studies and investigations that defined research programs for decades to come. District 5 studies included research in three prominent areas: the best methods of growing trees and the selection of the most desirable trees to grow under given conditions, including natural and artificial regeneration studies that concentrated on nursery development, reforestation projects, and type studies; research that focused on brushfields in northern California and chaparral replacement in southern California; and forest fire behavior, control, and prevention. Naturally, there were many successes and failures in all of these areas, but nonetheless, the Forest Service in California steadily gained an understanding of these research topics. Beyond these three research areas, the Forest Service in California, through broad experimentation and cooperation with other USDA agencies, the state of California, and universities, conducted additional work in forest products development, insect and disease control, and limited range development.

The early decades of the 20th century provided a substantial foundation to the California forestry research program. But, there was much work ahead for Edward Kotok and the California Forest Experiment Station.

Chapter 3: 1926–1932, Forestry Research Comes of Age in California

By the time the California Forest Experiment Station (CFES) was established in the latter half of 1926, forestry research in the United States had gone through many decades of change. In a lecture before a forestry school class at the University of California, Berkeley, S.B. Show, head of California's District 5 Branch of Research, spelled out to the students the historical developments in forestry research in California, and the problems he foresaw for the future.

Forestry Research in America

According to Show, the earliest forestry research followed traditional lines, such as forest growth investigations, tree studies, and so on. These were valuable academically, but had no practical value. The creation of forest reserves and then national forests with many kinds of concerns made evident the almost complete lack of knowledge of necessary basic facts for administering them. Timber cutting, fire protection, grazing, and other forest management problems in these early years under the General Land Office (GLO) and then the Forest Service after 1905 had to be organized and administered using judgment and hunches—not scientific research. Recognition of the need for reliable information led to making silvicultural investigations one of the chief duties of forest assistants. The men were inadequately trained for this special work, and investigations were still along traditional lines. Projects were poorly selected. This system, according to Show, gave some results of value, but was still uncertain and cumbersome. The need for specialists soon became evident. To answer this need, the Forest Service organized experiment stations, starting in 1908. This program was originally built around planting research and fundamental ecological studies to determine the causes of forest types. Research was generally regarded as something apart from administration, which, in Show's opinion, caused many of their forest management decisions to be based on conjecture. Then just after World War I, there was a shift from planting research and purely ecological studies toward solutions to more practical concerns. In the early 1920s, Forest Service administration began to fully recognize that research should be directed toward problems of immediate importance, such as how to handle cutting on timberlands so that new and superior crops would be obtained promptly; how to develop plans for managing forest properties involving a knowledge of sites, yields, rotations, etc.; how to develop tables and methods of measuring timber, both for general use and in research work itself; and how to

Just after World War I, there was a shift from planting research and purely ecological studies toward solutions to more practical concerns.

protect old and young forests against fire, disease, and insects. In his concluding remarks, Show encouraged students in their pursuit of forestry, stating that both the Forest Service and industry were in need of more reliable information that currently was impossible to secure by existing research personnel (Show 1924b).

California's Forestry State of Affairs: 1926

In 1926, the situation in California was ripe for research, especially regarding problems in forest, forage, fire, and water management. The lumber industry at this time was at its peak of postwar prosperity. Prices were relatively high, many new mills were starting up, and the state's lumber production was at its highest level to date. Prospects seemed bright for the early realization of what was then being called "industrial" forestry. In California's pine region, the introduction of the caterpillar tractor meant that cheaper logs could be provided to industry with less damage to the forest than the donkey engine logging practices of the past¹ (fig. 27). Nevertheless, the need for increased silvicultural research was urgent because of increased logging in the state's pine forests. There were still some 11 million acres of uncut pine timber left in California, but the future rate of growth, and thus the profit of tree growing, depended on proper maintenance of these sites, something to which private lumber companies had given little or no thought. Forestry research was needed to give public and private sources the ability to increase stocking, and to control the composition of the forest that succeeded this cutting. On the other hand, in California's redwood region, the timber industry was busy launching the largest program of industrial forest planting ever undertaken in the United States. In fact, by 1927, owners of redwood forests in California were planting more land in California than was being planted on the national forests of California, Oregon, Washington combined. However, this commercial reforestation to assure a future redwood (See "Scientific and Common Names" section) lumber supply had proceeded on a slender foundation of knowledge. The need for silvicultural and forest management investigations in the redwood region was acute. For 2 years, Forest Service silvicultural research in that region had been especially wanting, mainly because of the absence of national forests there, and secondarily because the urgent need in the pine region, where national forests existed, took up Forest Service time, staff, and research dollars (Greeley 1927, USDA FS 1932b).

¹ In 1923, Duncan Dunning made an intensive field study of these steam-powered machines, which pulled or yarded, felled, and limbed trees from the stump to the deck. His study described the excessive damage to residual trees and the future productivity of the site. Thereafter, Dunning, along with S.B. Show, passionately opposed the use of these high-speed logging machines (Conners 2006).



U.S. Forest Service, Pacific Southwest Research Station

Figure 27—Early tractor with cleated tracks hauling logs. The use of tractors dramatically improved the efficiency of logging operations.

Research needs in other forestry areas—range management, fire protection and prevention, and watershed protection and development—had long been acute in California prior to 1926 as well. California’s District 5 Office of Grazing had applied the Forest Service’s research findings at the Jornada and Great Basin Stations to the state’s national forests, but accomplishments in grazing research on the forests had been mainly a byproduct, both in work and in thinking, of these findings. California needed technical personnel familiar with grazing research to grasp the regional grazing picture and to form a state management program. In the field of forest fire research, there was great pressure from Californians for improved protection. The challenge was to provide adequate organization and equipment to meet the state’s needs. The statistical fire research contributed by Shaw and Edward Kotok in the early 1920s marked some progress, but there was no organized fire research underway in the state. Nor had research into forest watersheds fared any better, despite a widespread general public interest in water management. In southern California, widespread water development activities, such as the San Gabriel project for the city of Los Angeles and the Boulder Dam project, were designed to provide urban and agricultural water needs in that part of the state. There, concerned counties and municipalities desired erosion-streamflow studies by the Forest

Service to help conserve and protect water and watersheds.² In the northern half of the state, because water was more readily available, pressure for water management studies was less compelling, beyond a scattered number of advocates who were unorganized in their demands (USDA FS 1932b).

All of the above—forest, range, fire, and water problems—as well as others, became, at least in part, subjects for research for the newly established CFES. This chapter will recount the history of CFES research on these issues during its first 5 years of service, but before exploring this account, some background history on national events that affected Forest Service research policy and organization in general is necessary.

A National Forest Research Program: 1926

By 1926, Department of Agriculture agency representatives, such as the Forest Service, Bureau of Plant Industry (BPI), and Bureau of Entomology (BE), as well as state forestry departments, universities, and agricultural experiment stations, had given input to a special committee on forest research of the Society of American Foresters (SAF).³ Their task was to answer one basic question: “Is forest research necessary?” Two years earlier, in November 1924, Chief Forester William B. Greeley had challenged the SAF with this question in a keynote address before the organization. During his speech, Greeley also asked other critical questions: “What is the outstanding importance and urgency of the forest problem in the United States?” and “What is the basic place of research in the solution of that problem?” Responding to Greeley’s challenges, the SAF appointed a three-man committee,⁴

² In 1927, the Forest Service became extremely sensitive to the issue of forests and flood control because the Mississippi River flood disaster of that year called into question the adequacy of the Nation’s public program of forestry. The Forest Service realized that such floods could not be controlled solely through reforestation, but on the other hand, forests did aid in the regulation of streams because they held the soil in place and held back rain and snow water more effectively than any other form of vegetative cover (Greeley 1927).

³ The SAF is the national scientific and educational organization representing the forestry profession in the United States. Founded in 1900 by Gifford Pinchot, it is the largest professional society for foresters in the world. The mission of the SAF is to advance the science, education, technology, and practice of forestry; to enhance the competency of its members; to establish professional excellence; and to use the knowledge, skills, and conservation ethic of the profession to ensure the continued health and use of forest ecosystems and the present and future availability of forest resources to benefit society.

⁴ The other two members were R.C. Hall, valuation engineer for the Bureau of Internal Revenue’s timber section, and A.B. Hastings, assistant state forester of Virginia. Material assistance in preparation of the report to the committee came from dozens of contributors, including prominent persons in the field of forestry and oldtimers. They ranged from the Bernhard Fernow administration, such as botanist George B. Sudworth, and Raphael Zon from Gifford Pinchot days, to Aldo Leopold, who contributed a small section on “Wild Life.” Notable California forestry researchers included C.L. Hill, E.N. Munns, and S.B. Show. Additionally, Berkeley professor Donald Bruce wrote the section on “Forest Measurements” (Clapp 1926).

chaired by Earle Clapp. In a lengthy report entitled *A National Program of Forest Research* (Clapp 1926) published by the American Tree Association,⁵ the committee not only answered that forestry research was indeed necessary, but outlined in detail the nature, size, and complexity of forestry research, the progress made to date in its solution, and the agencies, both public and private that were, or should be, working on forestry problems. In short, the committee set out to describe a coordinated national program of forestry research (Clapp 1926).

A National Program of Forest Research first described the forest problem of the United States and how forestry research was a vital part of the solution, whether it be forest management (silvics, silviculture, and forest mensuration), forest protection (fires, disease, and insects), or some other research area, such as forest range management (forage, animal husbandry, and carrying capacity), utilization of wood and other forest products, or forest economics. Besides specifically laying out the major forestry research problems in the United States and progress in these particular research areas, more importantly, the SAF committee's report explained the current role in forestry research that existing federal, state, educational, and private institutions played in a national program, and what they could do in the future. In essence, *A National Program of Forest Research* presented a much-needed research outline, and cited the long list of sciences that might be included in such research. The 1926 report ended with suggestions for an organic act for forest research in the Department of Agriculture, and how the research program should be financed through a 10-year national budget—an essential aspect for carrying out the mission of such a national research program (Clapp 1926). The publication was well received by industry groups. For instance, the American Forestry Association (AFA) editorialized that the report “marks a tremendously significant step toward placing forest research upon a plane enjoyed by research in other fields and which, because of its tremendous importance and fundamental basic character, should be demanded in the field of forestry” (American Forests and Forest Life 1927b).

McSweeney-McNary Forest Research Act: 1928

A National Program of Forest Research pointed the way for a focused Forest Service research program. By 1926, the Forest Service had gained the manpower

⁵ Charles Lathrop Pack founded the American Tree Association in 1922. Charles Pack had business interests in lumbering, railroading, building and construction, banking, real estate development, and consulting. In 1907, President Theodore Roosevelt appointed Pack to his Conservation Commission. Thereafter, Pack became president of many organizations, including the National Conservation Congress (1913–14), National War Garden Commission (1917–1919), the American Forestry Association (1916–20), and the World Court League. In 1930, Pack endowed the Charles Lathrop Pack Forestry Foundation, and established demonstration forests at many forestry schools throughout the country.

and the facilities to cope with the demands for forestry information, but it needed a unifying piece of legislation with specific congressional support and funding to progress even further. The “national program” presented by the SAF report in 1926 provided all the necessary needs and justifications for congressional legislation. That action came on May 22, 1928, when the McSweeney-McNary Forest Research Act (45 Stat. 699) sailed through Congress.⁶ Passed during the tenure of Chief Robert Y. Stuart (fig. 28),⁷ the act met all the criteria for an organic research act as proposed by the SAF report.

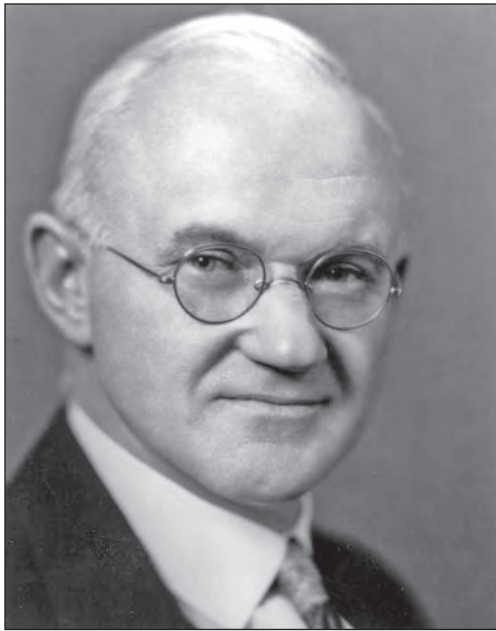
It authorized the Secretary of Agriculture:

...to conduct such investigations, experiments, and tests as he may deem necessary...in order to determine, demonstrate, and promulgate the best methods of reforestation and of growing, managing, and utilizing timber, forage, and other forest products, of maintaining favorable conditions of water flow and the prevention of erosion, of protecting timber and other forest growth from fire, insects, disease, or other harmful agencies, of obtaining the fullest and most effective use of forest lands, and to determine and promulgate the economic considerations which should underlie the establishment of sound policies for the management of forest land and the utilization of forest products [Storey 1975: 107].

To conduct these investigations, experiments, and tests, the act authorized the Secretary of Agriculture to maintain 11 regional forest experiment stations throughout the Nation, including the CFES. Most importantly, the McSweeney-McNary Forest Research Act (McSweeney-McNary Act) laid down a financial program for forest research expansion by providing federal authorization up to a maximum of \$3.375 million annually within the next 10 years for forestry research, a further authorization of \$3,000,000 available at the rate of \$250,000 a year, and beyond 1938, such annual appropriations as might be necessary to comply with the law.

⁶ Apparently, the McSweeney-McNary Forest Research Act would have passed a year earlier if not for resistance from the U.S. Department of Agriculture's Entomology, Plant Industry, and Weather Bureaus, which did not want to come under the act (Steen 1998).

⁷ On May 1, 1928, Herbert Hoover appointed Robert Young Stuart as chief forester upon the resignation of William B. Greeley, who left to become executive secretary of the West Coast Lumberman's Association. Stuart was a Yale Forest School graduate (1906) who joined the Forest Service as a forest assistant assigned to timber sales in Montana immediately after graduation. From this position, he worked his way up to inspector in the district headquarters at Missoula (1908–1909), to assistant district forester (1910–1911), and then transferred to Washington, D.C., as assistant to the chief of the Branch of Silviculture (1912–1916). After serving in France during World War I (1917–1919), Stuart left the Forest Service for a time to work with Gifford Pinchot in various posts in Pennsylvania. He reentered the Service in 1927 as chief of public relations prior to his appointment as chief forester (Clepper 1971).



U.S. Forest Service

Figure 28—Robert Y. Stuart, fourth Chief of the Forest Service, 1928–1933. During Stuart's administration, the McSweeney-McNary Act of 1928 passed, which established a network of regional experiment stations nationwide as the backbone of Forest Service research.

McSweeney-McNary Act was the first comprehensive provision for forest research ever made in this country. Unlike the piecemeal efforts of the past, it created in the United States a long-term and sustained method of financing and conducting forestry research work, and consequently allowed for a more orderly, inclusive, and continual attack upon the great number of unsolved problems that held back the development of sound forestry policy and practice. The McSweeney-McNary Act provided a means of bringing together investigations in forest and range management, forest products, forest economics, and erosion and correlating them on a regional basis. This regional correlation was the best line of attack by research on the forest problem as a whole, and was heavily lobbied for by California groups, such as the California Development Association (CDA) or the state chamber of commerce. At the request of numerous organizations throughout California, and with the tacit and behind-the-scenes approval of the California Experiment Station, the CDA sent a lobbyist to Washington to assist in the passage of the act. While in Washington, the lobbyist was also directed to try to reinstate the original amount of \$50,000 for the California Station as provided for in the bill creating the station (Murphy 1928; Steen 2004; Storey 1975; Stuart 1928, 1930).

Earle Clapp, in looking back at the act 10 years later, believed that the McSweeney-McNary Act accomplished five major goals. First, it authorized federal forest research of broad scope. Second, it specified that the regional level would be the main field structure, or organization, at which research work ought to be conducted. Thereafter, the Forest Service divided the country into geographic research regions where forest conditions and forest problems were similar or

**The 1928 Act
focused public
and congressional
attention on forest
research far beyond
anything that had
previously existed.**

related. Third, it authorized an initial 10-year financial investment program set high enough to raise research sights very materially over previous levels. In this regard, it also provided a long-time financial program without maximum limits. When the Great Depression hit after 1929, according to Clapp, this section of the act saved federal forestry research from major cutbacks. Fourth, the 1928 Act focused public and congressional attention on forest research far beyond anything that had previously existed. And finally, by passing the McSweeney-McNary act, Clapp believed that Congress endorsed and accepted forestry research as its own creation (Storey 1975). In the end, the McSweeney-McNary Act provided such a broad blueprint for forestry research goals that the Forest Service would not seek additional research legislation until 1978, when the Forest and Rangeland Renewable Resources Research Act passed (Steen 1998).

For California, the McSweeney-McNary Act more or less legitimized CFES, which had been authorized 2 years earlier. The act also opened the way for a larger and more adequate development of forestry research in California by giving CFES an average of a little over \$80,000 per year. That was quite a jump from the \$30,000 allotted to the station in 1926. The act also provided funding for various allied lines of research, such as diseases and insects, grazing, biological studies, and fire weather research, allowing the station to employ consulting pathologists, entomologists, biologists, and other specialists from allied USDA agencies. It also added \$25,000 to the station's budget through the amalgamation with CFES of California District 5's forest products office (see below). Now CFES looked forward to a total federal budget approaching \$200,000 per year, to which it could build up, within the next few years.

Once the McSweeney-McNary Act passed, Clapp proceeded with the development of a research organization he had been planning for almost 8 years. During these years, the WO Research Branch was reorganized into four functional divisions: Division of Silvics, with E.N. Munns in charge; Division of Range Research, led by W.R. Chapline; Division of Forest Products, with H.S. Betts as head; and the Division of Forest Economics, under R.E. Marsh (Storey 1975).⁸

⁸ For the next year and half, forestry research under the McSweeney-McNary Act seemed to fulfill its promise, but not without Clapp shouldering it up. Sitting firmly at the head of the Nation's forestry research table, according to S.B. Show's perspective, Clapp's *modus operandi* was clear. First, Clapp had written the nationwide report *A National Program of Forest Research* (Clapp 1926)—which Show viewed as “monumental and encyclopedic, with situation, needs, plan, program and estimated budget and legislation needed.” Second, Clapp had secured the basic legislative authorization for his program, including budget. Now, according to an admiring Show, Clapp intensively prodded for additional appropriations for new lines of work and projects—each year expediently taking what he could get. In his efforts to gain political support, Clapp often made researchers into political legmen. Whatever Clapp did not achieve in any given year, he prepared and pushed on his political action plan for next year (Show, n.d.).

Then came the stock market crash on October 29, 1929. The Great Depression slowed the full development of Clapp's research program, but it did not stop the energetic Clapp. Although additional regular funds for research programs were hard to come by, research appropriations under the McSweeney-McNary Act started to increase in 1930, climbing to \$1.16 million from \$970,000 a year earlier. Research funds continued to increase in 1931, and in 1932 they peaked at \$1.7 million. That same year, an additional \$800,000 was appropriated for the construction of a new laboratory for the Forest Products Laboratory (FPL) in Madison, Wisconsin (Storey 1975). During this stressful economic time, 11 regional experiment stations⁹ authorized by the McSweeney-McNary Act were established—basically the framework of the Forest Service research organization today.¹⁰ In S.B. Show's opinion,¹¹ Clapp had accomplished a miracle in establishing and building this system of regional experiment stations so soon. Additionally, Clapp had judiciously selected station boundaries and headquarters locations; in the long run, Show believed that this protected station directors from district and regional foresters, whom Clapp generally mistrusted (Show, n.d.).

As a final point, the McSweeney-McNary Act provided for USDA research programs in forest-related fields other than those assigned to the Forest Service. Despite the scarcity of funding from 1928 to 1931, the Bureau of Plant Industry, Soils, and Agricultural Engineering started a number of studies of native and naturalized diseases of forests and forest products under the act—if only on a shoestring budget.¹² The act also authorized funding to the Biological Survey in the

Clapp had accomplished a miracle in establishing and building this system of regional experiment stations so soon.

⁹ In 1931, the list of experiment stations and directors included the following: Alleghany Station, Philadelphia, Pennsylvania (R.D. Forbes); Appalachian Station, Asheville, North Carolina (E.H. Frothingham); California Station, Berkeley, California (E.I. Kotok); Central States Station, Columbus, Ohio (E.F. McCarthy); Intermountain Station, Ogden, Utah (C.L. Forsling); Lake States Station, St. Paul, Minnesota (Raphael Zon); Northeastern Station, Amherst, Massachusetts (C. Edward Behre); Northern Rocky Mountain Station, Missoula, Montana (R.H. Weidman); Pacific Northwest Station, Portland, Oregon (Thornton T. Munger); Southern Station, New Orleans, Louisiana (E.L. Demmon); and Southwestern Station, Tucson, Arizona (G.A. Pearson) (Storey 1975).

¹⁰ By this date the original forest and range experiment stations, such as Great Basin Branch Station, the Priest River Experimental Forest or the Jornada Experiment Range had been absorbed by the regional stations, and redesignated as branch stations or experimental forests (Storey 1975).

¹¹ Show saw Clapp as a "very able, imaginative and daring" person who ruthlessly drove through toward his goals, "shooting for the moon, demanding, cajoling and getting hard labor on his projects by selected administrators and researchers alike" (Show, n.d.).

¹² Epidemic diseases like white pine blister rust of course, were given special attention. Forest insect research continued as a BE assignment and fared somewhat better financially than did forest disease research in the Western States. A major reason for this was the extensive depredations of bark beetles in the West, which killed conifers in most parts of the region.

Organization of CFES permitted work to begin on the “exceptionally diverse problems of California and western Nevada—one of the principal sources of the present lumber cut, and a region where forest lands can be made highly productive.”

Department of Agriculture to determine “the life histories and habits of forest animals, birds, and wildlife, whether injurious to forest growth or of value as supplemental resource.” The Biological Survey was given the task of developing the “best and most effective methods for their management and control.” Finally, the Weather Bureau was authorized under the McSweeney-McNary Act to “investigate the relationships of weather conditions to forest fires as may be necessary to make weather forecasts” (Storey 1975).

California Research Station Administration, 1926–1931

On July 1, 1926, appropriations for the California Forest Experiment Station became available and CFES became the seventh Forest Service experiment station in the Nation. According to the 1926 Forest Service annual report, organization of CFES permitted work to begin on the “exceptionally diverse problems of California and western Nevada—one of the principal sources of the present lumber cut, and a region where forest lands can be made highly productive” (Greeley 1926).

However, Earle Clapp, District 5 Forester S.B. Show, and CFES Director Edward I. Kotok did not decide upon the experiment station’s organization and program until August 1st of that year. Furthermore, they were not able to decide on a suitable location on the Berkeley campus until October 1926. Hilgard Hall (fig. 29) was finally selected for the station’s first headquarters, and the station’s staff of four technical personnel—Director Kotok, Duncan Dunning,¹³ A.E. Wieslander,¹⁴ and junior forester Howard W. Siggins, along with two clerks (Dagmar Vinther and L.O. Baxter)—squeezed themselves into four rooms given up to the station by the Division of Forestry of the University of California and its faculty chaired by Walter Mulford. Kotok immediately knew that this “modest” working space would need to be increased as soon as possible to take care of an expanding research program (Cassamajor 1965, USDA FS 1927). Nonetheless, working alongside academic colleagues most likely proved satisfying for Kotok

¹³ Dunning had been a senior silviculturalist for District 5 headquarters in San Francisco from 1920 to 1926.

¹⁴ Previous to this assignment, Wieslander had been a technical assistant on the Lassen National Forest (American Forests and Forest Life 1926). Wieslander’s assignment was to undertake the immense task of making a vegetative type map of the entire state (Hill 1931).



Atkinson Photographic Archive,
University of California, Alan Nyiri

Figure 29—Hilgard Hall (1918), University of California, Berkeley, named after Eugene W. Hilgard, Professor of Agriculture and Botany (1875–1904), who was considered the father of modern soil science.

and his fellow scientists.¹⁵ To prevent any unnecessary overlapping of research, a special conference was held with Berkeley's Division of Forestry and Walter Mulford (USDA FS 1927). With all of the above arrangements completed, in February 1927, the formal opening of the CFES took place with a very simple ceremony (fig. 30). Then Kotok went to work (American Forests and Forest Life 1927a).

In its first year of operation, Station Director Kotok was tasked with organizing the new office and his staff and assembling a working library of manuals, handbooks, general treatises, and important periodicals for headquarters use. He and his staff also had to catch up on the large program of long-standing projects they inherited from District 5's Branch of Research under Show. Because of CFES' restricted initial personnel and resources in this critical year, they conducted activity only in a limited portion of the general field of forestry research, concentrating almost solely on forest management issues such as reforestation studies, with an altogether

¹⁵ Besides collaboration inducements, the station received incentives, not only from the school staff, but also from the faculties and facilities of the entire university. For instance, Walter Mulford invited Kotok and members of his staff to attend meetings of the Division of Forestry and arranged for Kotok to serve on certain special university committees. Mulford on his part served on District 5's investigative committee, and, as a member of the State Board of Forestry, he supported special appropriations to the station. Finally, the proximity of the station made possible part-time and summer work for forestry students—especially attractive assignments for graduate students (Cassamajor 1965).



American Forest and Forest Life

Figure 30—President W.W. Campbell of the University of California, E.D. Merrill of the School of Agriculture, Arthur W. Sampson, representing the Forestry School, and Edward Kotok, the new director, formally posed to celebrate the opening of the station on the university campus.

inadequate attempt to address other pressing problems, such as forest protection, forest range management, wood utilization, and forest economics as outlined by Clapp's national program of research.

Then there was the question of establishing field substations. When the CFES was established, it assumed supervision of the Feather River Experiment Station from District 5. The Feather River facility was then renamed the Feather River Branch Station, but it had no assigned staff. In 1926, District 5's Investigative Committee (D5-IC)¹⁶ recommended the establishment of eight additional field stations throughout the state besides the Feather River Branch Station. Although Kotok was never able to meet this ambitious proposal, on January 1, 1927, CFES set up a

¹⁶ California's D5-IC comprised representatives of all agencies engaged in forest research or investigative work in the California region. D5-IC met annually under the chairmanship of the District Forester at as early a date after the beginning of the calendar year as possible. During its 2- to 3-day meetings, D5-IC considered reports of work accomplished and plans for future work presented by the respective agencies. The committee endeavored to promote the effectiveness of forest research through mutual counsel and suggestions, especially by directing the coordination and cooperation between workers in the same and allied fields. Membership in D5-IC was determined by which agency heads attended the annual meeting. Besides the CFES, District 5 and USDA agencies (e.g., the offices of Forest Pathology, Blister Rust Control, Forest Insect Investigations, Biological Survey, or Weather Bureau) who were required to attend, other federal agencies, such as the National Park Service, the California State Forester, and faculty from the University of California often attended, participated, and reported on their research in D5-IC meetings (Stuart 1930).

second branch station at Devil Canyon near San Bernardino, California¹⁷ (fig. 31). There, the Forest Service established a nursery for the production of trees and shrubs for erosion control under the direction of Roscoe B. Weaver. He was able to do so thanks to donations of \$3,000 from the state of California, and another \$5,000 from other southern California municipalities, which supported a staff member at the nursery at Devil Canyon. The Devil Canyon nursery became the focal point of interest for studying the scientific reforestation of the burned mountain slopes and watersheds of southern California¹⁸ (USDA FS 1927). Eventually, Devil Canyon included a superintendent's house, laborers' cottage, laboratories, garage/shop, potting shed, upper and lower nursery buildings, arboretum, a willow cienaga (desert wetland), and plum, cherry, and apple orchards (fig. 32).

Kotok's field substation plan changed somewhat in 1929, when the Forest Service realized that planting research had not kept pace with other national forest activities, and lobbied Congress for special appropriations for the purchase of land to establish and enlarge nurseries.¹⁹ On June 9, 1930, Congress passed the Knutson-Vandenberg Act²⁰ to address this issue. The Knutson-Vandenberg Act set up a fiscal program for national forest planting authorizing appropriations for such work in subsequent fiscal years. This act allowed CFES and District 5 to establish a nursery near Susanville, California, which served northern California, and another nursery in the Sierras on the Stanislaus National Forest (Kotok 1930; Stuart 1929, 1930). By the fall of 1930, the nursery at Susanville was producing trees suitable for planting on California's national forests (Stuart 1931). However, the Depression and government economizing after 1932 reduced Knutson-Vandenberg Act funding

¹⁷ This action was taken after the Los Angeles Chamber of Commerce and the Angeles Forest Protective Association petitioned Secretary of Agriculture William M. Jardine for a \$1 million program of fire prevention and forest protection for the Angeles National Forest. Jardine referred the petition to the CFES. In 1926, Kotok and Edward N. Munns toured the area. They promised local officials that the Forest Service would consider establishing a branch station in the vicinity in the future (Robinson 1980).

¹⁸ Actually, the roots of reforestation in this area began as early as 1919 when Los Angeles County Forester B. Flinham proposed that the county establish and operate a scientific reforestation nursery, complete with research facilities, in the area. Flinham died in 1925 before his plan could reach fruition, but Los Angeles County Forester Spence D. Turner carried on the work of his predecessor and in 1926 established an experimental tree nursery at Tanbark Flats, which paved the way for a Forest Service station there in 1932 (Robinson 1980).

¹⁹ The first 10 years of Forest Service administration (1905–1915) was a period of experimentation to develop low-cost plantation methods. During the next 10 years, World War I and the restrictions on governmental expenditures that followed prevented any material expansion of the nursery program. However, from 1920 to 1925, a gradual expansion took place whenever small increases in appropriations became available (Stuart 1930).

²⁰ The Knutson-Vandenberg Act appropriations brought planting into balance with other activities on the eastern national forests, but no material enlargement in the West, including California, was possible at this time (Stuart 1930).



U.S. Forest Service, Pacific Southwest Research Station

Figure 31—View of the Devil Canyon branch station.



U.S. Forest Service, Pacific Southwest Research Station

Figure 32—Devil Canyon nursery, 1938.

nationally from a previous high of \$250,000 to \$154,000. This reduction adversely affected and the pace of Region 5's²¹ reforestation plans as well as the CFES research program (Stuart 1932).

In its second year of operation, CFES saw major changes in its general policy and programs, even though it operated largely on the same federal budget dollars. Regarding policy matters, D5-IC made it abundantly clear that the station was not to engage in any nonessential basic research, firmly stating in its 1927 annual report that the activities of the station must logically contribute toward the understanding and solution of one basic idea: "How to keep forest land productive for its highest use....There should be no place in the program for fundamental or even empirical research for its own sake, or for meeting some temporary exigency foreign to this basic demand" (USDA FS 1928). With that said, D5-IC's annual operational report went on to describe the CFES program as one almost solely devoted to forest management studies. However, D5-IC suggested that the weaker parts of the program (fire, economic studies, and forest influences) be given first consideration when increased federal funds became available.²²

In 1928, the station experienced expanding administrative responsibilities and growth. That year Kotok concentrated the majority of CFES staff time and funding on silvicultural investigations in the pine region of the state as recommended by D5-IC. In the spring of 1928, new technical staff, in the persons of C.J. Kraebel²³ and Walter C. Lowdermilk,²⁴ joined the station to accommodate the assigned

There should be no place in the program for fundamental or even empirical research for its own sake, or for meeting some temporary exigency foreign to this basic demand.

²¹ On May 1, 1929, all Forest Service "districts" were renamed "regions" to avoid confusion with ranger districts. The Secretary of Agriculture approved a change in the official designation of the nine districts, the district foresters, and other district officers of the Forest Service, by which region and regional supersede the term "district." Region 5, or the California Region, was responsible for all of California and southwestern Nevada, and S.B. Show was the regional forester in charge (Stuart 1930).

²² Fortunately beginning July 1927, the California Board of Forestry general budget earmarked a sum of \$20,000 for allotment to the station (Clar 1959).

²³ Kraebel was a Berkeley-trained silviculturist who had just returned to the Forest Service to take up station work in southern California after a number of years in Hawaii and in the National Park Service (Hill 1931).

²⁴ Born in 1888, Walter Clay Lowdermilk studied forestry in Germany under a Rhodes scholarship, and served as a ranger in the Southwest for the Forest Service just prior to the outbreak of World War I. Returning to America after the war, he became the Forest Service's district research officer in Montana until 1922, when he married and departed for China to study the Yellow River's flooding problems and the resulting famines for the International Famine Relief Commission. The Communist uprising in 1927 ended his stay in China, and Lowdermilk thereafter combined his study for a Ph.D. from the School of Forestry at Berkeley with research at the CFES on the influence of forest cover on soil erosion and streamflow. When the Soil Conservation Service (SCS) was established in 1933, Lowdermilk became associate chief to Hugh Hammond Bennett. At the SCS, he had a long and very interesting career as well, as associate chief (1933–1937), chief of research (1937–1939), and assistant chief (1939–1947) (Helms 1984).

The CFES had hoped to establish a forest of sufficient area to support a substantial operation under sustained yield, funded by an endowment from a private institution, but was unsuccessful.

tasks, along with two additional clerks. Additional responsibilities had come to the CFES on December 1, 1927, when District 5's Office of Products, led by C.L. Hill with M.R. Brundage as his assistant, was transferred to the CFES to obtain the advantages of regional unification of research activities in silviculture and forest products. Finally, state, southern California counties, and municipality cooperative funds made it possible for CFES to further extend its program beyond the federal allotment permitted. Public and southern California cooperative agencies rallied around forest planting and the conversion of the brushfields into high-coniferous forests, much as it had during the "eucalyptus fever" 20 years earlier. However, the Forest Service considered this problem of minor importance when compared to the more vital question of how to control runoff and erosion. The CFES tried to orient public interest in the right direction, but in the interim, the Devil Canyon branch station appeased the public urge for planting, giving CFES an opportunity for further studies in planting and nursery practice in this region (Stuart 1929, USDA FS 1928).

While dealing with the above issues, Kotok and his staff concerned themselves with two other matters. The first involved selecting "experimental-demonstration" forests for all of the important regions of the state, an action Earle Clapp had requested in a letter dated January 31, 1928. The CFES had hoped to establish a forest of sufficient area to support a substantial operation under sustained yield, funded by an endowment from a private institution, but was unsuccessful. To work out its experimental-demonstration forest program, D5-IC suggested that the station and District 5 form a committee to devise a statewide plan (USDA FS 1928). A year later, the Forest Service enacted its L-20 Regulation that allowed experimental forests and ranges to be set aside for long-term research unfettered by other management objectives. By 1930, the Forest Service established a comprehensive system of experimental forests and ranges within the national forests. These forest and ranges were carefully selected representative areas, large enough to meet present and foreseeable future needs, and permanently available for silvicultural, range, products, and other related forest research. In essence, these experimental forests would be field laboratories, and the work of forest and range experiment stations would be concentrated on them as fully as possible. Most of these experimental forests/ranges were to be from 1,000 to 4,000 acres. At this time, eight such forests were already established in the country, but in 1930, the Forest Service aggressively pushed the expansion of the system as a fundamental basis for the effectiveness of Clapp's regional program (Stuart 1930).

By March 1931, a committee composed of A.E. Wieslander (CFES) and C.E. Dunston (Region 5) proposed setting aside California's first experimental forest

area. The first site selected by them comprised 3,970 acres on the Plumas National Forest, which was to be designated as the Feather River Experimental Forest (FREF). This site was suggested for several reasons: it included timber stand conditions representative of the better sites of the Feather River region; the site was favorably located close to main roads, sawmill centers, and CFES' Feather River branch station at Quincy, the headquarters of the Plumas National Forest; and areas within the site had not been obligated to supply any established sawmill.²⁵ The second site selected by Wieslander and Dunston encompassed 4,100 acres on the Lassen National Forest, which was to be designated as the Swain Mountain Experimental Forest (SMEF) (fig. 33). This site was deemed suitable because it formed a distinct topographic unit that had not been committed to any Lassen management policy; it was readily accessible to roads, sawmills, and the towns of Susanville and Westwood; and finally, logging conditions on the site were exceptionally favorable for tractor and truck logging. Wieslander and Dunston felt that it was also desirable to establish two additional experimental forests, one in the east-side western yellow pine type, possibly near the northeast border of the Lassen National Forest, and another on the Stanislaus National Forest near the station's center of work there. The D5-IC was satisfied with Wieslander and Dunston's selections for the Plumas and Lassen National Forests. But they did not comment on their other suggestions. Instead, they suggested that Wieslander and Dunston search for an experimental forest area in the granite country (southern half of Sierras) and another covering more brush areas to furnish opportunities for planting and influence studies (Stuart 1931).

Then there was the question of selecting research natural areas or RNAs.²⁶ These were tracts of forest land set aside and withdrawn from all disruptive use and occupancy that also fell under the broad terms of Forest Service L-20 Regulation (Steen 1998). The purpose of RNAs was to permanently preserve, in an unmodified condition, areas representative of the natural growth of each forest or range type within each forest region, so that characteristic plant and animal life and soil conditions would continue to be available for the purposes of science, research, and education. The RNAs were not only invaluable to forestry research, but also equally beneficial to the research of biologists, plant ecologists, and other scientists (USDA

The RNAs were not only invaluable to forestry research, but also equally beneficial to the research of biologists, plant ecologists, and other scientists.

²⁵ The FREF as proposed was not approved. However, a decade later, the Challenge Experimental Forest at the western edge of the Feather River District of the Plumas National Forest was approved, an event that will be discussed in later chapters.

²⁶ In 1927, the Forest Service set aside the Santa Catalina Research Natural Area as the first "official" designated RNA in the country (Steen 1998).



U.S. Forest Service, Pacific Southwest Research Station

Figure 33—Swain Mountain Experimental Forest, 1979.

FS 1928) (fig. 34). To select RNAs, CFES and California Region 5 formed a committee that coordinated their selections with those suggested by Ansel Hall, Chief Forester of the National Park Service (NPS). In this regard, D5-IC cautioned Director Kotok not to overlook the extent to which timber cutting might be necessary in CFES research, because any NPS reserves selected would not be available for such use (USDA FS 1930). The Forest Service set up a joint agency advisory council, with whom Wieslander and Dunston could work for a solution to this problem²⁷ (Stuart 1928). In early 1931, Wieslander and Dunston proposed five RNAs scattered throughout California on the Lassen, Modoc, Inyo, and Mono National Forests, as well as one in Yosemite National Park. However, D5-IC was not satisfied with their RNA selections because they had chosen some areas based on the feasibility of administering them rather than selecting whole biotic units. Additionally, other selected sites seemed vulnerable to fire and foreign plant invasions, and no sites selected appeared suitable for grazing studies. The D5-IC thereafter recommended that the station keep its present RNA selection committee but suggested that Regional Forester Show appoint a larger committee to crystallize fundamental principles and policies for RNA selection as the necessary basis for making further selections. Show's committee subsequently met and recommended 16 specific

²⁷ Such councils were often created by the Forest Service to guide it in dealing with regional problems that crossed agency lines of authority, and to aid it in the development of sound regional policies.



U.S. Forest Service, Pacific Southwest Research Station

Figure 34—Craig's Creek Research Natural Area on the Six Rivers National Forest in Del Norte County, California, was representative of a typical knob-cone pine (*Pinus attenuata*) forest.

criteria to be used in selecting future RNAs. Any future final decisions were to be left up to Kotok and Show following a consultation visit to California by Earle Clapp in July 1931 (Stuart 1931).

In the meantime and up to January 1930, CFES had not received any increased federal funding to meet tasks such as experimental forest and RNA selection. The station was still working on substantially the same federal appropriation as that with which it started. This situation permitted only the continuation of silvicultural work taken over by the station from Region 5 headquarters, with very limited expansions into one or two other areas. Still needed but not yet covered by increased appropriations were additional personnel for the management studies in the pine and the redwood regions,²⁸ expansion of the forest influences studies, large increases in the scope of fire studies and initiation of research work on grazing, as well as some expansion in products research (USDA FS 1930; Stuart 1929, 1930).

²⁸ At this time, the commercial forests of California, by common usage, were divided into two broad regions—the coast redwoods and the interior pine forests. The redwood region of about 2 million acres lay along the northwest coast in a zone some 30 miles wide. The interior pine region lay along the westerly slopes of the Sierra Nevada at middle altitudes, on the northeasterly plateau, and on the northern inner coast ranges. In the late 1920s, there were approximately 21 million acres of merchantable timber with 12 million contained in California's federal forests and parks (Dunning 1929).

The proximity of Berkeley to the San Francisco headquarters also continued to provide an excellent opportunity for close cooperation between Region 5 and the university as well.

By January of 1930, the station's offices were bursting at their seams. By that date, besides Director Kotok and a half-dozen clerks, CFES had a 10-member technical staff. They included Duncan Dunning and A.A. Hassel in silvics and forest management; C.L. Hill, M.R. Brundage, and I.J. Mason in wood products; W.C. Lowdermilk and H.L. Sundling, studying forest influences; C.J. Kraebel working on ecology and forestation; L.H. Reinke on mensuration; and A.E. Wieslander working on cover type mapping (USDA FS 1930, 1931). Fortunately for the CFES, the University of California's school of forestry on the Berkeley campus needed additional space too. So when the forestry school moved into new quarters in Giannini Hall in August of that year, Director Kotok moved the station into Giannini Hall as well (fig. 35). The school's Division of Forestry had better laboratory facilities there than in Hilgard Hall, including a laboratory for plant ecology equipped for biochemical work; a silvicultural laboratory equipped for histological and simple chemical research; a fire laboratory to study the behavior of fuels; and laboratories for logging, mensuration, and economic studies, along with a wood utilization laboratory furnished and equipped with woodworking machinery (USDA FS 1931). No doubt CFES shared these university laboratories and other facilities.²⁹ The proximity of Berkeley to the San Francisco headquarters also continued to provide an excellent opportunity for close cooperation between Region 5 and the university as well.³⁰

Fortunately, in 1930, the CFES budgets began to expand as well owing to the McSweeney-McNary Forest Research Act. Increases were secured from a number of sources, which allowed the station to begin several additional lines of research and add scientific and technical staff. For instance, congressional appropriations from the McSweeney-McNary Act of approximately \$29,000 provided for research in two new fields—fire management and studies in the redwood region. In addition to this extra funding, a slight increase in other appropriations enabled Director Kotok to increase research staff for the pine region. These monies allowed him to add two researchers—V.A. Clements, who transferred to CFES from an assignment in Washington, D.C., and Earl Morrow, who became the station superintendent of the Feather River Branch Station. Additionally, Kotok found funding to

²⁹ The station would not move again until 1948, when the CFES moved into a new forestry building on campus, Mulford Hall, named after distinguished forestry school dean Walter Mulford. The years that the station spent on campus fomented and nurtured rapport and cooperative relationships with university administrators and forestry faculty and researchers alike (Aitro 1977).

³⁰ The move to Giannini Hall not only brought under one roof the forestry school and the station, but eventually also the educational headquarters of the NPS, the forest pathologists and entomologists of the USDA, the Blister Rust Control Unit, and the extension forester (Cassamajor 1965).



Atkinson Photographic Archive,
University of California, Alan Nyiri

Figure 35—Giannini Hall (1930), University of California, Berkeley, second home of the California Forest Experiment Station.

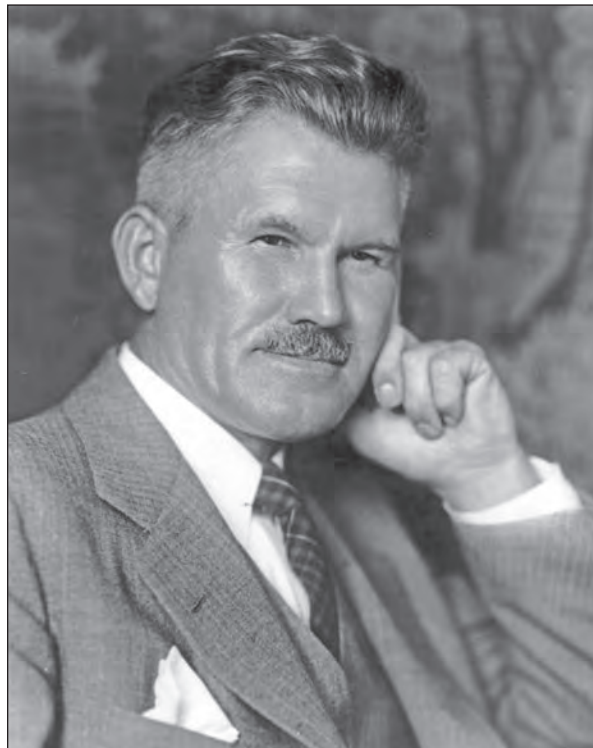
temporarily hire C. Raymond Clar from the California State Board of Forestry³¹ to assist Wieslander in preparing California's vegetation type map. With the above personnel additions, CFES staff had grown to 16, not counting Director Kotok. In addition to this permanent workforce, CFES seasonally employed some 46 students from Berkeley's school of forestry on project fieldwork (Stuart 1931).

In 1931, the CFES enjoyed another spurt of growth, again largely through McSweeney-McNary Act funding. Staff assignments in silvicultural investigations (pine and redwood), mensuration, forest products, fire research, and the Devil Canyon and Feather River Branch Stations remained the same, but additional appropriations of \$47,000 from the Research Act were sufficient to initiate grazing studies

³¹ C. Raymond Clar was attached to the station for type map work from August 1927 until the spring of 1931 (Clar 1959). Clar started out working for the California State Board of Forestry in 1927 and thereafter played an essential role in California state forestry fire policy. Clar is most noted for his definitive two-volume history of the California Department of Forestry, *California Government and Forestry from Spanish Days until the Creation of the Department of Natural Resources in 1927* (Clar 1959), and *California Government and Forestry—II* (Clar 1969).

and for the expansion of forest influences investigations at the California Station (USDA FS 1931). The grazing industry in California at this time presented the “strange spectacle of an industry eating itself up” because of overgrazing practices. Accordingly, Kotok assigned three technical men to the field of range management studies: senior forest ecologist Murrell W. Talbot, assisted by range examiners F.G. Renner and August L. Hormay. Legitimate grazing investigations were thus finally started on a modest scale, meeting in some small measure the acute need for range research in California. Besides addressing specific range management studies, the new range research staff were expected to also help answer questions regarding the relationship of grazing with the fire problem in California, and to increase understanding of how grazing affected watershed management. The station’s name was amended to reflect this new responsibility; CFES became known as the California Forest and Range Experiment Station, or CFRES (USDA FS 1932b).

In addition to starting range research at this date, the California Station expanded its watershed management research. Prior to 1931, watershed conservationist Walter Lowdermilk (fig. 36) had directed forest influence and erosion studies for the station. In 1929, Lowdermilk described the water supply problem as one of understanding the links between the forest-land vegetative mantle in southern and central California and the water supply for municipal, irrigation, and



National Archives, Negative number 114-G-90723

Figure 36—Walter C. Lowdermilk, world-renowned American expert on soil conservation who provided a basis for enlightened management of California’s watershed areas.

power uses. Among the many complex problems not fully understood, according to Lowdermilk, was the influence of vegetation on the delivery of water in the valleys, the transpiration of water by vegetation of different types, and the relationship of erosion to water supply. Until this time, the station had been stymied in its forest influence and erosion research conducted at the Devil Canyon Branch Station by the complexity of understanding entire watersheds as well as the lack of funding and personnel. Additional funding from the McSweeney-McNary Act, however, allowed Lowdermilk to add forest ecologists J.D. Sinclair and P.B. Rowe to his staff, so that the station could take on a new mission of full watershed research. With more cooperation from engineers responsible for the state water plan than ever before, and new appropriations and personnel, CFRES hoped to attack the field of water research anew (Lowdermilk 1929, USDA FS 1932b).

Closely associated with forest influence and erosion research was the cover type map of California being prepared by Wieslander. As produced, the cover type map showed in detail the timber and brush types for each county in the state. It would prove valuable not only as a background in future land use and economic investigations by CFRES, but also revealed with astonishing clarity the widespread and profound deterioration of vegetation that resulted from fire and its inevitable attendant soil erosion. The cover type map further aided in correlating the amount and quality of water yielded by any particular watershed with the condition of the vegetative cover of that area. By 1930, the map was approximately 50 percent complete (Kotok 1930, Kraebel 1932), but in 1931, the work of the type map was dovetailed into the Forest Resources Survey, or FRS,³² which added considerable work to the project. Authorized by the McSweeney-McNary Forest Research Act, FRS began its work in California that year, adding not just work but responsibilities to CFRES in the area of forest economics. Nonetheless, CFRES, through cooperation with the state because of local demand, still made some progress on the forest cover type map project (Stuart 1932).

³² The FRS was one of the most important and far-reaching undertakings ever launched by the Forest Service. Authorized by the McSweeney-McNary Forest Research Act on a 12-year basis, it was a comprehensive “appraisal of the Nation’s present and future requirements for forest products, the present and potential forest growth, existing volumes and qualities of timber, the areas and conditions of forest lands, and other facts needed as a basis for balancing the timber budget.” The survey was prosecuted, particularly the resource inventory and growth phases, by special staffs added to the regional experiment stations. However, by 1932, the FRS’s pace was curtailed because of the Depression and government economy program. As an interim measure, the Forest Service conducted a restudy of the existing data on the forest situation, obtainable without extensive first-hand field studies. This restudy indicated that since the so-called “Capper Report” of 1920, the area of forest land in the United States had increased by some 33 million acres (Stuart 1930, 1932).

California Forest Service Research Program History, 1926–1932

During its early years, the California Forest Experiment Station's research program³³ consisted of six lines of research: forest management, utilization of wood and other forest products, forest protection, forest influences, range research, and forest economics.

Forest Management

Forest research management seeks the facts that must be known to fully utilize the many and diverse forest types and soils of the country. The field was broad at this time, but prior to 1933, the Forest Service Branch of Research basically divided forest management research into three areas: silvics, silviculture, and forest mensuration. Scientists and researchers at the California Station contributed to each of these forest management areas.

Silvics—

Silvics, the fundamental science that underlies the study of forest growth, generally includes dendrology;³⁴ physiology; morphology; ecology, or the relationship of the forest to its environment (e.g., soil, climate, fires, insects, diseases, animal life, subordinate vegetation, and topography); ontogeny, or the life histories of important species; and genetic studies. For instance, dendrology studies were needed to explain the limited natural distribution of the Monterey pine and the Monterey cypress to extremely small areas on the coast of California, or the very limited areas occupied by the redwoods. As another example, fire exercises an extremely important function in forest succession in California, and ecology studies were needed to elucidate the role of fire for foresters. Or, for instance, genetics, by assessing the pronounced differences in rate of growth, amounts of seed produced, immunity or resistance to insect attacks, strength, durability, and other properties of the wood between individual trees under seemingly identical environmental conditions, also played an important part in developing better strains of trees for the state. All of these areas within silvics were inherently important to the California-based Forest

³³ It is not the purpose of this publication to enumerate and describe all investigations or research undertaken by the station. These are on file and available to the researcher or historian. Only fields of investigations and studies that show the direction and history of the station will be included from this point forward. Moreover, only forest officers and scientists who had a significant part in initiating or directing the work will be mentioned.

³⁴ With the creation of the Forest Service in 1905, George Bishop Sudworth became the chief dendrologist for the agency, a position he held until his death in 1927. With his demise, the position of dendrologist remained vacant until 1942, when the Division of Dendrology and Range Forage Investigations was set up in the Branch of Research with William A. Dayton as chief and Elbert L. Little, Jr., as dendrologist (Dayton 1955).

Service forestry research program in the years prior to 1933, with the exception of genetics, which the Eddy Tree Breeding Station, a private research institution located at Placerville, California, investigated separately from the Forest Service (see the end of this chapter) (Clapp 1926).

Silviculture—

Research in silviculture includes primarily the applied investigations that lie between fundamental findings in silvics and the commercial practice of forestry. In the 1920s, silviculture research was defined to include artificial forestation through seeding, nursery practice, and field planting; natural forestation via reproduction from seed and from sprouts; cultural operations, slash disposal, and other factors that influenced silviculture such as logging, utilization of timber and other products, and protection (Clapp 1926).

In California, the rapid growth of the state placed a heavy demand on its forests, requiring that California District 5 develop intensive forest management to meet this expansion. There were some 10 million acres of virtually idle brush lands, most of which the Forest Service thought should be growing a valuable forest crop. For instance, in northern California, there were large brush fields occupying some of the best yellow pine and sugar pine sites. These brush fields were the result of repeated burns, and once established, they were very difficult to reforest. In southern California, protection of watershed through forestation was crucial. The California Station met each of the state's regional reforestation needs through research conducted at nurseries established for that purpose (Greeley 1927, Show 1925).

While the station was just getting established, District 5 completed several research projects in northern California's pine region left over from when the district had a Branch of Research under S.B. Show. T.D. Woodbury produced a comprehensive resume of nursery work in northern California prior to the station's establishment that covered the initiation and subsequent history of all the work conducted to date (see Woodbury 1927). It pointed out some of the difficulties inherent in California's reforestation program from an administrative viewpoint. In the same manner, in 1924 and later, S.B. Show summarized his research work in nursery and planting practices at the Feather River Branch Station (see for instance Show 1924c) and elsewhere in northern California in *Forest Nursery and Planting Practice in the California Pine Region* (Show 1930). And in 1924, as noted in the previous chapter, Duncan Dunning completed an important study regarding the effects of cutting on the growth of remaining trees and on reproduction that once again stimulated interest in reforestation on District 5. In that year, District 5's Research Branch undertook a 10-year program of natural reproduction and planting experiments

Silviculture research was defined to include artificial forestation through seeding, nursery practice, and field planting; natural forestation via reproduction from seed and from sprouts; cultural operations, slash disposal, and other factors that influenced silviculture such as logging, utilization of timber and other products, and protection.

at the Feather River nursery on the Plumas National Forest, a project that the California Station inherited. Because Show had already conducted adequate research on a number of topics at this nursery regarding seeding, soil treatment, and watering vs. cultivation practices, additional research in these areas was deemed unnecessary. Further work was advisable, however, on experiments related to soil improvement, root development, and a few other areas (USDA FS 1927). But because of insufficient personnel³⁵ and resources, along with the station's inherited responsibilities for keeping up its remeasurement of sample plots throughout several northern California national forests, nursery experiments at Feather River largely fell by the wayside with the exception of some work regarding fertilizing transplanting beds (USDA FS 1930, 1931, 1932b).

Southern California research presented a similar picture. In 1926, the California Station attempted to follow three lines of artificial and natural forestation: planting in watersheds, planting and seeding on a small scale for control of natural reproduction study, and raising a small amount of stock for experimental planting by the station and for administrative planting on national forests. To these ends, the station, in cooperation with the State Board of Forestry and local county organizations, planted a 40-acre nursery at the Devil Canyon Branch Station near San Bernardino. Under the direction of Charles J. Kraebel (fig. 37), the nursery was established mostly for the production of trees and shrubs for erosion control. Before beginning his research program, Kraebel reviewed the work that Edward Munns had conducted at the Converse Flats nursery on the Angeles National Forest prior to World War I. Munns' work had borne out that the same difficulties encountered in planting in northern California occurred in the south, but to a more intensified degree. Nonetheless, Kraebel attempted to complete and extend Munns' work that Munns did before the Converse Flats nursery closed. The station felt obligated to continue this reforestation effort because the general public still wished to convert chaparral areas to woodlands and high coniferous forests (Robinson 1980; USDA FS 1927, 1928). However, after a prolonged drought during the summer of 1929, the station finally publicly acknowledged that under present conditions it would be impossible to transform the entire chaparral type, or any great part of it, into a conifer forest by planting. The station accepted the fact that in the last 20 years, the total acreage planted by the Forest Service was insignificant from the standpoint of watershed protection, or any other practical return. Despite this conclusion, work at the Devil Canyon nursery continued (fig. 38). The station thereafter focused much

³⁵ In the fall of 1929, junior forester H.W. Siggins had met an untimely death in a car accident, which left the station shorthanded in its plantation studies (Fowells 1978).



National Park Service

Figure 37—Charles J. Kraebel, an expert on natural forestation, watersheds, and erosion control.



U.S. Forest Service, Pacific Southwest Research Station

Figure 38—Devil Canyon planting beds and lathe house.

of its research work on three new directions: finding deep-rooted exotic tree or shrub species in America or elsewhere in the world that would survive in southern California, investigating the planting of firebreaks with succulent species of relatively low flammability, and propagation of desirable chaparral and hardwood species that would prove useful in the reclamation of critically denuded areas. All in all, the Devil Canyon nursery strove to secure a better quality of planting and

higher survival rate, rather than increased acreage, and worked with noted horticulturalist, plant explorer, and pomologist, Charles Swingle³⁶ (USDA FS 1930, 1931, 1932b, 1932b).

Although reforestation research success in both northern and southern California had been marginal at best, by 1932 Region 5's Investigative Committee (R5-IC)³⁷ thought that the time was ripe to increase work in this field and encouraged Kotok and the station to do so. But insufficient funds and personnel limited any proposed expansion of the program (USDA FS 1932c).

Pine region silvicultural investigations—

In its initial years, CFRES conducted several forest cultural operations to determine desirable silvicultural practices in California's pine region and followed up on earlier District 5 studies. For a number of years, District 5 researchers had a study underway in California to determine the effect of cutting methods on the rate at which natural reproduction becomes established. In connection with this study, over 20,000 trees were remeasured on sample plots at 5-year intervals. An analysis of these measurements developed a new classification of the trees in the western pine forests. This study indicated that certain classes of trees, readily recognizable in the forest, were especially subject to insect attack, whereas others were liable to windthrow or breakage. The growth rate of still other species was too poor to be worth retaining in the forest. This discovery made possible the establishment of far more discriminating selection criteria for cutting, and found general application on California's northern national forests. The simplicity of this method made checking of marking practices on timber-sale areas easier and more systematic, and the application of this methodology essentially revolutionized practices in marking timber for cutting on national forests elsewhere in the Nation (Stuart 1928).

One of CFRES's first silviculture investigations conducted involved a comprehensive logging and milling investigation in cooperation with the Fruit Growers' Supply Company that started with the trees in the woods and took them through the mill to the finished product. This investigation of "east side" logging and milling, led by M.R. Brundage, brought out the economic results of varied silvicultural practices, as well as of the costs and returns from using logs and trees of different sizes

³⁶ From 1922 to 1935, Charles Fletcher Swingle worked in various positions for the Nursery Stock Investigation, BPI, and thereafter for the Soil Conservation Service from 1935 to 1945, where Swingle established and administered the agency's nationwide nursery system. Swingle was most noted for his discovery of certain rubber plants in Madagascar that were believed to be extinct at the time. His papers are located at the Hunt Institute for Botanical Documentation, Mellon University, Pittsburgh, Pennsylvania.

³⁷ D5-IC changed its name to Region 5 Investigative Committee, or R5-IC, starting with its annual report for 1930 to reflect a Forest Service organizational name change made in mid-1929.

and qualities. The CFRES study was designed to include the economic influence of insects and diseases, as well as wildlife, on the growth and reproduction of the subsequent stand (Stuart 1930). A preliminary analysis of the results of this woods and mills study indicated that at this time it did not pay to saw lumber from western yellow pine logs 14 inches and under in diameter, as well as logs of other species of size, such as sugar pine, because the costs were greater than the value of the lumber (Stuart 1931). This coordinated logging and milling study resulted in the determination of costs and values for each species, size, and grade of logs and trees in western Sierra Nevada lumbering (Brundage et al. 1933).

Redwood region silvicultural investigations—

Silvicultural research at CFRES was not limited just to California's pine region. Studies were also conducted in California's redwood forests. In 1930, California's redwood region probably had the largest individual trees and heaviest stands by board feet per acre of any commercial forest region of the world. This fact, together with the extremely rapid rate of growth of the major species, and the ability of the redwood to sprout from the stump, made the region an important commercial forestry center. Prior to 1910, the Forest Service had published one or two preliminary studies on redwoods, but the absence of national forests in the redwood country, and the urgent need for all available Forest Service research resources in the national forests themselves, delayed Forest Service silvicultural efforts in the redwood region. Furthermore, prior to 1930, the station had difficulty in acquiring funding for personnel to launch a redwood regional research program. So until 1930, all research in this region was conducted by either the forest school of the University of California or by consulting foresters (USDA FS 1932b).

In 1930, the University of California withdrew from its redwood research program, but the Forest Service filled the vacuum in December of that year, when the station's overall financial situation changed through additional McSweeney-McNary Forest Research Act funding. McSweeney-McNary Act funding allowed the Bureau of Entomology (BE) to transfer Hubert L. Person and George R. Strubble to CFRES,³⁸ where they were assigned to investigate forest management silvicultural issues associated with California's redwood region. Silviculture studies in the redwood region were naturally somewhat similar to those in the pine region, particularly in the extensive use of permanent sample plots or strips. Because many

The extremely rapid rate of growth of the major species, and the ability of the redwood to sprout from the stump, made the region an important commercial forestry center.

³⁸ Person's and Strubble's transfer provided for an important phase of coordination of work between CFRES and the BE station at Palo Alto, California, until that BE station was relocated to the Berkeley campus in September 1930 thanks to the efforts of Walter Mulford (Wickman 2005).

governmental agencies were already working in the redwood region, and because Forest Service research policy was to aid rather than interfere, the station began its redwood management research on problems that were least likely to be handled by other agencies. Furthermore, the station confined its efforts to the commercial range in California's four northernmost counties (Del Norte, Humboldt, Mendocino, and Sonoma). To determine a niche for the station redwood research program, Person reviewed the current literature, interviewed university scientists, lumber associations, consulting and industrial foresters, and civic groups, such as the Save the Redwoods League, and made several field trips throughout the redwood region (USDA FS 1931).

Besides picking up the threads of past University of California work and carrying out those lines of research that seemed of most importance, Hubert Person commenced several new redwood management studies. Because any silvicultural study would have some bearing on the problem of restocking after logging, CFRES began its redwood research program by first surveying the actual redwood country conditions. Following this survey, Person focused on the effectiveness of planting and the possibilities of securing reasonable stocking by slight changes in logging methods. Logging practices in this region were in general very destructive, resulting in excessive site deterioration. On most cutover areas, growth was only a fraction of what it should be. Obviously, this situation called for studies similar to those being carried out by the station in the pine region. In addition to cooperative studies with lumber companies on natural reproduction and planting of cutover redwood areas, the station also planned to study logging damage (USDA FS 1932b). In addition to this work, CFRES made observations on young redwood stands in California, showing that the spacing of the trees produced a much greater effect on the density of the wood than did soil composition³⁹ (Stuart 1928). In the absence of any national forests with redwoods, the station began discussions regarding acquiring such experimental forest areas in proper locations, by gift or purchase. Person recommended the acquisition of at least one experimental forest of about 1,000 acres, but it would be years before such an area could be obtained (USDA FS 1932b).

³⁹ In 1932, S.B. Show summarized the state of affairs of the redwood region in *Timber Growing and Logging Practice in the Coast Redwood Region of California*. In this piece, he described the status of timber growing in the redwood region, the important characteristics of the region and the forest, the effects of past and current treatment of forest land, and the measures necessary to produce full timber crops. Both past and present practice in the region involved clearcutting an area and starting the new crop from bare ground. Show advocated for selective logging, but opportunities for using this method of reforestation had not been thoroughly tested yet. Regardless of whether planting or natural reforestation or both were used, Show saw fire protection on cutover lands as essential. Through education and law enforcement, he called for a halt in the prevalent practice of light burning of redwood cutover lands in favor of grazing or agriculture, because he felt the lands were more valuable for industrial forestry (Show 1932).

Other station silvicultural investigations conducted by CFRES in this early period included proper management of southern California chaparral forests to prevent erosion and rapid runoff; the distance that wind carried seeds of various conifers; the damage done by forest fires to stands of various ages; methods of thinning young stands to increase their productivity; damage to woodlots through overgrazing; and methods of cutting in various forest types to insure rapid restocking of forest tree species (Stuart 1928).

Mensuration—

Forest mensuration investigations included status and standardization of volume and yield tables, and studies regarding the laws of form and growth (Clapp 1926). Initially, mensuration studies at CFRES were fairly standard growth and yield forecasts derived from data on even-aged stands collected from permanent and temporary sample plots on various California species in cooperation with the forest school at the University of California (USDA FS 1927, 1928). However, in 1930, CFRES statistician L.H. Reinke, working in close collaboration with Berkeley professor Donald Bruce,⁴⁰ made a significant contribution in the field of mensuration. By combining the concepts of the modern science of statistics with familiar graphic processes—the former contributes accuracy and the later flexibility—Reineke and Bruce applied curvilinear-correlation methods to study a wide range of forestry problems that many believed insolvable on account of their complexity or the volume of data involved. In the pre-computer age, their publication *The Correlation Alinement Charts in Forest Research* (Reineke and Bruce 1931) resulted in an outstanding contribution to the field of forest mensuration (Stuart 1931).

Utilization of Wood and Other Forest Products

As noted in the last chapter, following the establishment of the Forest Service in 1905, forest products research in California began immediately, and in 1908 was incorporated in the district organization upon the establishment of District 5. Early District 5 products research covered a wide range of subjects, but for the most part, the bulk of them centered on wood preservation. By 1913, District 5's products office had five technical personnel, which was its largest workforce to date. Forest products work was suspended during World War I, but reinstated in 1920 with fewer technical personnel. When the CFES was established in 1926, forest products

⁴⁰ Donald Bruce, who once worked for the Forest Service in California, was a pioneer in forest mensuration and the author of many publications on the subject, including a widely used textbook (Bruce and Schumacher 1935). After a period at the University of California at Berkeley, he became a partner in the well-known consulting firm of Mason, Bruce, and Girard (Curtis and Marshall 2004).

research in California was still under the auspices of District 5 and was directed by C.L. Hill. But at this time, D5-IC criticized Hill's work plan because he endeavored to cover too many activities. There were ongoing projects involving not just wood preservation, but lumber seasoning and several economic investigations, as well as cooperative work requested by the PL in Madison on constantly varying subjects (USDA FS 1927, 1928, 1932b).

Starting in 1926, Hill also began working with the recently organized California Economic Research Council (CERC).⁴¹ In December of 1927, D5-IC reigned in Hill's office and transferred Hill, his staff of two, and his research projects from District 5's San Francisco headquarters to the CFES at Berkeley. This transfer brought some realignment of forest products objectives, and "cleaning up" of the old projects as Hill followed D5-IC suggestions to focus and downsize his program. For greatest efficiency, Hill therefore concentrated his research program upon a strictly limited number of projects related to regional forest products problems (USDA FS 1928, 1932b). Several older projects were completed and their files either closed or given a secondary research status, such as those involving air seasoning,⁴² the prevention of blue stain in lumber,⁴³ and marine pilings⁴⁴ (Stuart 1928, USDA FS 1928).

Meanwhile, a new attitude had taken hold of forest products work in the Forest Service following World War I. Prior to the war, the FPL, and to some extent the field units, were concerned mainly with the problems of the wood industries,

⁴¹ In 1926, the California Economic Research Council was formed, and included some 150 agencies in the state engaged in the production or use of economic research information. The objectives of the CREC were to provide an avenue for mutual knowledge of projects and results among such agencies, and to stimulate and advance economic research and allied technical research by suggestion and by advisory activity with the goal of correlation and standardization. Dean W.E. Hotchkiss of the Graduate School of Business of Stanford University initially chaired CERC, and Hill served as chair of the Committee on Natural Resources, where he laid the groundwork for cooperation between the state, other agencies, and CFES regarding a comprehensive land use survey and classification under the McSweeney-McNary Act (USDA FS 1928).

⁴² This project resulted in a joint publication on the subject. See Fullaway et al. 1928.

⁴³ The blue stain project grew out of an unintentional partnership with the FPL, the Office of Forest Pathology, and the sugar pine industry. No significant publications resulted from this research topic while CFES was involved in it (USDA FS 1930).

⁴⁴ As noted in the previous chapter, in the early 1920s, District 5's Office of Products had spent considerable time studying the relative durability of different woods exposed to marine woodborers. During this investigation, District 5 made an intensive and comprehensive study of marine borers using the service records on some 200,000 piles in San Francisco Bay. In a joint publication with the FPL entitled *Marine Borers and Their Relation to Marine Construction on the Pacific Coast* (Hill and Kofold 1927), Hill made a significant contribution to the subject of preservatives and processes for protecting the harbor pilings in California, and in other coastal areas of the country. Thereafter, the project was turned over to the forest school at Berkeley (Stuart 1928, USDA FS 1928).

without adequate reference to the effect a project had upon forestry in general, or upon other Forest Service forestry problems. However, starting in the early 1920s, a new research attitude slowly evolved. First, the Forest Service emphasized that Forest Service products research had an obligation toward the administration of the national forests as a whole. With the passage of the McSweeney-McNary Forest Research Act in 1928, a second shift of emphasis—one that considered a national point of view—as opposed to a regional perspective developed as well in wood products research.⁴⁵ The main objective of all foresters, but especially of forest researchers, was to find increased application of forestry practice in the woods of the Nation as a whole, including privately owned forest lands. In other words, the Forest Service's major task was to bring about optimum management of all forest-land resources in the Nation, regardless of ownership. Therefore, for CFRES to accept and undertake research that affected the wood industry, resolution of the problem now had to contribute to the practice of forestry as a whole and not just benefit a particular industry. Private or industrial problems that could not meet the test imposed by the above corollary would have to be undertaken by the interested parties (USDA FS 1928, 1932b).

The first significant CFRES project based upon this new attitude toward Forest Service-industry research partnerships was an investigation of logging and sawmill waste conducted jointly with California's lumber industry, a study that turned out to be very extensive and significant. In 1927, in a publication aimed at the railroad industry (fig. 39), Hill forewarned against forest decimation without renewal and discussed reducing waste in production and use—an argument that had lent support to the passage of the McSweeney-McNary Forest Research Act (from USDA FS 1930). Two years later, in cooperation with the Pickering Lumber Company of Standard, California, and with R5-IC's approval, Hill began a logging and sawmill waste investigation on the Stanislaus National Forest. The woods and mill study was designed to show the costs incurred and values realized from trees by following them as they were carried from the standing forest to the finished lumber upon the sawmill shipping deck. Hill's study also measured the wastes and losses both in the woods and mill, and showed the effect of different timber marking and cutting methods upon both forest perpetuation and the cost of conversion to the timber operator. Hill's wood products staff supervised and coordinated this very "hands on" project, but various Region 5 offices—namely forest management—the FPL,

Starting in the early 1920s, a new research attitude slowly evolved. The Forest Service's major task was to bring about optimum management of all forest-land resources in the Nation, regardless of ownership.

⁴⁵ This new research attitude was most likely explained to the principal western district offices and experiment stations at the annual conference gathered at the FPL in June 1928. Director Kotok and C.L. Hill attended this annual wood products research meeting (American Forests and Forest Life 1928a).



Figure 39—Typical railroad lumbering operation.

other USDA agencies, and the University of California's Division of Forestry took part in various phases of the study. Based on the Pickering Lumber Company study results, CFRES conducted similar studies elsewhere in the state. However, instead of carrying actual trees throughout the study record, as was done in the Pickering Lumber Company study, R5-IC suggested the desirability of using "synthetic" or "built-up" trees for the purpose of analytical study. By the following year, the Stanislaus (Pickering) Study perfected this process, and project data was worked into final shape for publication. However, despite its innovative research techniques, the study was never published because of a lack of funding (USDA FS 1930, 1931, 1932b).

Other important projects at this time were not as successful. They included completing a 20-year-old project involving the study of lumber depreciation, and conducting research on several new and desirable projects such as heptane production. As it turned out, the lumber depreciation study met difficulties and did not result in any promising research. Over time, actual practice in sawmill production of lumber and the lumber grading structure upon which the whole practice stood had changed since the bulk of the older research had been conducted. Therefore, CFES dropped the project by 1930 (USDA FS 1930). The heptane production study

was a minor study, but fit into the objective of improved forest land management. One of the primary uses of heptane at this time was to alleviate knock in internal combustion engines. The heptane project (fig. 40) found that this wood-derived byproduct produced by distilling the resin of Jeffrey and Digger pines had an advantage over that obtained from petroleum in the ease and cheapness of its recovery. In 1929, Hill published the results of this work, but nothing more came of the project (Aitro 1977; USDA FS 1930, 1931, 1932b).

A final demand on Hill and his staff in the period prior to 1933 that cannot be overlooked was extension work by the forest products office. One of the station's main missions was to make research information available to the public upon request. Consequently, CFRES attempted to disseminate information on any research line to the public as soon as possible. As a result, California forest industries placed a disproportionate demand on Hill's office for product information, a reflection of the value of the results of research to industry at this time (USDA FS 1932b).

Forest Protection

Forest protection research at CFRES was aimed at safeguarding forests from damage caused by forest fires, fungi, mistletoes, and insects. In California, protection from fire consumed much of the station's time and funds. Protection from diseases and insects was left to the cordial cooperation with the BPI and the BE and will be discussed in a later section on other USDA agency research.



U.S. Forest Service, Pacific Southwest Research Station

Figure 40—Heptane field experiments conducted by C.L. Hill.

Nothing less than fire exclusion will promote real progress toward a fully productive forest property.

In California, as noted earlier, the need for a major campaign to improve methods of protecting against forest fires was brought into focus by the disastrous fire year of 1910. After that year, District 5 Forester Coert Dubois gave fire research priority during his administration, emphasizing the need for improvement in fire organization and fire suppression techniques. Before World War I, little attention was paid to physical conditions surrounding fire and the possibility of their control or adapting fire attack to their requirements. But after the war, S.B. Show, in collaboration with Edward Kotok, again began fire studies. In the early 1920s, they investigated light burning, fire damage, and fire ecology and conducted a statistical analysis of fire suppression performance based upon the study of individual fire reports. For instance, in 1924, Show wrote in *Scientific Monthly* on managing forest properties in the California pine region as a problem in applied ecology (Show 1924a). The next year, Show and Kotok published *Fire and the Forest* as USDA Circular 358 (Show and Kotok 1925), which looked closely at historical damage done by recurring fires in California's pine region, dating back to 1685. They believed that centuries of repeated fires therein had led to a deteriorating forest in which damage was steadily accelerating. They concluded that: "nothing less than fire exclusion will promote real progress toward a fully productive forest property.... An adequate scheme of forest management and protection must recognize that even more important than preservation of what forest values we now possess is the task of restoring a forest depleted by centuries of repeated fire" (Show and Kotok 1925: 18). Nonetheless, adequate appropriations supporting fire science research in California were not forthcoming until the establishment of CFRES and the subsequent passage of the McSweeney-McNary Act (USDA FS 1932b).

During the period 1926 to 1932, as will be seen, forest fire control continued to be the most difficult and pressing of all forestry problems plaguing California, and CFRES became one of the leading forest experiment stations in the country conducting fire research. In the period after 1926, fire science research involved three factors: studying the occurrence and increase of the rate of spread of forest fires in various cover types, the measures necessary to prevent and suppress fires, and the damage that fires did. During this time the CFRES fire research program meshed closely with District/Region 5's administration as Director Kotok and District/Regional Forester Show worked closely together, even though they had tremendous administrative duties elsewhere (Cermak 2005).

In northern California, Show and Kotok explored the relation between fire and ground cover types, such as grass, chaparral, brush, and the various timber species. They also obtained data on the risk of fires starting, the quantity of fuel on the ground, the ease of controlling fires, and the rate at which fires spread. Their

research resulted in *Cover Type and Fire Control in the National Forests of Northern California* (Show and Kotok 1929), an analysis of the records of over 10,000 fires. *Cover Type and Fire Control* furnished valuable conclusions upon which to base more efficient protection by establishing the length of the average fire season for each cover type, the preponderance of incendiarism in the chaparral and brush types, and the relative difficulty of protecting each type. Facts derived in *Cover Type and Fire Control* afforded the basis for District/Region 5 to place fireguards, to determine suppression crew size, to advocate for road and trail development, and to combat incendiarism in northern California (Show and Kotok 1929, Stuart 1929).

In late 1929, along similar lines, Kotok and Show published data on California's pine region. They investigated the average number of possible human-caused fires in a given season, the rate of burning in pine country, and the average annual percentage of area burned for different types of brushland and woodland therein, as well as compiling information on the major California pine region cover types and their influence upon risk of starting, available fuel, rate of fire spread, ease of control, and accessibility of fire. This research resulted in *The Determination of Hour Control for Adequate Protection in the Major Cover Types of California Pine Region* (Show and Kotok 1930), perhaps the most outstanding contribution of the year to the solution of California's fire problem. Continuing their earlier studies on the interrelationship between cover type, fire hazard, and fire control, *Determination of Hour Control* analyzed the speed-of-attack factor design needed to hold burned acreage to an accepted minimum (Aitro 1977, Show and Kotok 1930). Show and Kotok showed that fires must be caught within a certain amount of time that varied with the type of forest cover, the degree of risk, the amount of fuel, and accessibility, to control them while they were still small. The desired "hour of control," or degree of protection that was feasible to undertake, according to their report, was determined by devising a correlated detection and suppression system, including the means of communication and travel that would ensure the presence of a force of firefighters of specified size and equipment anywhere within a specified time after a fire started (Stuart 1930).

Following their departmental bulletin on hour control, increased funds were made available to CFRES through the McSweeney-McNary Act to carry further their studies and others. Until this time, District 5's policy of putting out all fires as soon as possible, established in 1920, had been no match for the 1924 fire season, which resulted in 1,932 fires on California's national forests that burned 762,000 acres and caused \$1,275,000 of damage (fig. 41). Subsequent fire seasons in 1926 and 1928 were almost as disastrous (Cermak 2005, Godfrey 2005, USDA FS 1932b). Therefore, in 1929, CFRES founded the Shasta Experimental Fire Forest

This research resulted in the most outstanding contribution of the year to the solution of California's fire problem.



U.S. Forest Service, Pacific Southwest Research Station

Figure 41—Typical fire in California pine region.

(SEFF), which became a proving ground for Show and Kotok's theses regarding fire control.⁴⁶ The Forest Service had rarely gone "all the way" in trying out any fire research idea. What was proposed at SEFF was an innovative change from the policy of gradually strengthening protective forces along accepted lines, to the selection of one forest unit, the Shasta National Forest, where extra efforts could be made to thoroughly test both old and new ideas under controlled conditions. Kotok, along with District 5 Fire Chief Jay Price, and local Shasta National Forest officers, selected approximately 1.6 million acres on the Shasta National Forest, consisting of Sacramento Canyon, McCloud Ranger District, and part of the Pitt Ranger Districts, for the experimental forest. This area represented all fire risks (e.g., lightning, incendiarism, presence of highways and railroads, lumber operations, grazing activity, and other human activities), and contained extremely hazardous cover, which was the result of disturbance of the original forest conditions by logging operations and previous fires. The objectives for the SEFF were to determine the best system of fire control for the selected unit, to adapt and extend the principles evolved on the experimental forest to other California national forests, and to single out and intensely study any other incidental phases of fire control. Thereafter, CFRES

⁴⁶ The establishment of the SEFF gave Show and Kotok the demonstration area they were seeking, but they were unable to pursue research there because of meager resources at hand. However, when the New Deal unfolded, they saw a golden opportunity to use the whole of Region 5, not just SEFF, as their demonstration area (Cermak 2005).

conducted studies regarding prevention, detection, suppression, communication, transportation, headquarters and guard station improvement, and supervisory and training organization on the Shasta Experimental Fire Forest (USDA FS 1930, 1931).

With the founding of SEFF, plans were made for the organization of a fire research program at SEFF. Within six months, Kotok hired a three-man fire research staff to run the Shasta Fire Control Project, which was headed by George M. Gowen, and assisted by A.A. Brown, and J.R. Curry (Cermak 2005, Stuart 1931). Foresters had strongly advocated this action, which offered the opportunity to test and observe in detail all phases of the fire problem. Thereafter, fire research became of primary importance to CFRES (USDA FS 1932b), and by 1931, the California Station aggressively attacked the forest-fire problem by beginning this series of studies designed to round out Show and Kotok's work, which had already established protection principles of great value (Stuart 1931).

Meanwhile, during the fall and winter of 1930, CFRES staff devoted their time to field and office work that addressed several major fire control factors, beginning with detection. This phase involved investigating visibility mapping, lookout point selection, lookout performance, color filters and photography as aids to detection, and motor patrols. For instance, in 1929, Gowen, Brown, and Curry conducted a detection study specifically involving the principles of visibility mapping from high points. The three-person team spent 1930 and 1931 developing the project into one of protection planning, and in 1932 reported their findings, which aimed at "maximum coverage by direct visibility of fire occurrence zones with the minimum of lookouts." Out of this study came the first school for visibility mappers (Cermak 2005: 201–202). Work was also begun by CFRES on fire suppression (squads, speed of line construction, use of water, firebreaks, firelines, motorways, and fire control equipment), fire behavior (spark ignition tests), and fire damage. Meanwhile, Kotok recognized the necessity of adding similar work in southern California to the station's fire research program (USDA FS 1931, 1932b).

At the same time, Kotok and Show advocated a statewide detection system and formed a Forest Service-wide fire committee at the station to scrutinize every aspect of the detection problem. Kotok headed the group, and he left no stone unturned in researching this project, from structure design to psychological testing of lookout operators. The group concluded that California needed an "integrated network from the Oregon border to the Mexican line to insure rapid and accurate fire discovery," (Thorton 1994: 12) and though many lookouts were already built, Kotok's group recommended building more, replacing existing buildings, and abandoning deficient sites. The group's recommendations would dovetail nicely

**Fire research became
of primary importance
to CFRES.**

No other effects of the forest play a more important part in human economy and have attracted greater popular attention than has its influence upon the climate, soil, the regularity of streamflow, and erosion.

with the arrival of the emergency programs that came with the New Deal following President Franklin D. Roosevelt's election. Agencies such as the Civilian Conservation Corps (CCC) would be of great assistance to the Forest Service in improving fire control throughout the state. This aid also sped up fire research at CFRES as well (Thorton 1994).

Forest Influences

According to Clapp's *A National Program of Forest Research* (Clapp 1926), "no other effects of the forest play a more important part in human economy and have attracted greater popular attention than has its influence upon the climate, soil, the regularity of streamflow, and erosion." Despite Clapp's statement, until 1926, the Forest Service in California had only conducted fragmentary work in forest influences. The only project worth mentioning in the northern half of the state was an experiment in sand dune fixation by forest plantations, carried out in Golden Gate Park in San Francisco. But in southern California, where much of the water was obtained from wells, the influence of the forest upon the water table was of great importance and interest to the Forest Service. In the agricultural districts of this part of California, chaparral played an important role in the prevention of erosion and stream regulation (Clapp 1926). A brief chronological history of the vicissitudes and reported work on forest influences in southern California might best explain how CFRES began its work on the subject.

The first steps toward definitive forest influence studies in southern California happened in 1911, when a fire burned over 75 percent of the watershed of Waterman Canyon on the San Bernardino National Forest. To learn from the event, District 5 proposed a comparative streamflow study between Waterman Canyon and the unburned Devil Canyon on the Angeles National Forest. The Washington Office Central Investigative Committee (WO-CIC) disapproved the project, but despite this rejection, that year a series of articles appeared in the proceedings of the Society of American Foresters on forest influences (USDA FS 1932b: 36). The articles claimed that converting chaparral into high forests could possibly boost humidity, lower temperatures, and augment rainfall. Largely because of this information, WO-CIC reversed its decision the next year. In 1913, when the Converse Experiment Station was opened, forest influence studies were assigned to it with the objectives of determining the effect of brush cover on streamflow and the relative value of chaparral and forest cover as a conserver of water. Three years later, E.N. Munns made his final report on the Waterman-Devil Canyon study, but because of differences in geological formation of the two watersheds and unsatisfactory observation data, his report was inconclusive. In 1917, the Converse Station closed

because of America's entry into World War I, but after the war, Munns picked up the subject again. In cooperation with the state of California, he published a general survey of all the important watersheds in California entitled *Erosion and Flood Problems in California* (Munns 1923). However, District 5's research branch conducted no forest influences research at this time because D5-IC felt that until sufficient funds were available, District 5 should keep out of this broad subject area (USDA FS 1930, 1932b).

So when CFRES designated forest influences as a major line of study for southern California and began work in the field, there was already a moderate interest in the problem. But before plunging into this new line of work, Kotok and D5-IC carefully reviewed all the collected data pertinent to the study of forest influences in southern California, which they realized involved many engineering, meteorological, and ecological questions. Satisfied that the research topic was an important one, they sought appropriations from Congress and financial support from southern California community interests, such as the state, counties, and municipalities (USDA FS 1927).

Because erosion from burned chaparral and forest areas caused the loss of many farms, resulted in silted-up reservoirs, and destroyed much other property in southern California, CFRES' first forest influences study was devoted principally to the development of techniques and methods in measuring erosion and runoff from watersheds. Their first project examined a 60-acre watershed near the mouth of Devil Canyon that had burned in 1925 (USDA FS 1928). To observe the natural process of soil erosion on burned-over areas by vegetative cover type, permanent sample plots were established in various cover types, along different slopes and aspects, and in adjacent unburned areas. In conjunction with the large-scale study of what came to be called the Barranca Burn Study, CFRES established a meteorological station at the Devil Canyon nursery. The California Station also selected smaller areas elsewhere in order to make a comparative study of superficial runoff and erosion on burned and unburned chaparral-covered slopes (USDA FS 1928, 1930, 1931). In 1930, Charles J. Kraebel reported on the Barranca Burn Study (Aitro 1977). But ironically, a year later, heavy rains destroyed the station's runoff and erosion experiment (USDA FS 1932b).

While Kraebel worked on this project, in 1928, CFRES changed its methodological approach to watershed management investigations. Instead of attempting to evaluate the influence of a variety of factors within a complex of phenomena as was being done by Kraebel in the Barranca Burn Study, CFRES' new plan was to isolate variables under experimental control, then trace the operation of such variables into intermediate complexes of plots, and then finally study them in the larger

Erosion from burned chaparral and forest areas caused the loss of many farms, resulted in silted-up reservoirs, and destroyed much other property in southern California.

The problem of forest influences in southern California went far beyond simply erosion control and streamflow regulation, which were the main objectives in more humid regions of the country.

complexes of watersheds. Thereafter, the station, in cooperation with the University of California's Division of Forestry,⁴⁷ began studying isolated factors of watersheds through field and laboratory methods. This change in methodology eventually led to striking results. Director Kotok presented the objectives of this new approach at a conference called by Earle Clapp on the subject. Kotok and R5-IC thought that the station should focus on watershed management toward the maximum yield of water for use by urban and irrigation interests in southern California. A study of this nature, Station Director Kotok explained, would involve a new methodology, along with a combination of experiments and new technology that used various instruments and tanks to study runoff, watersheds, and the relationships of soil and vegetation to water. They believed that the problem of forest influences in southern California went far beyond simply erosion control and streamflow regulation, which were the main objectives in more humid regions of the country. The ultimate objective, according to them, was water conservation, "namely the conservation for beneficial human use of every possible drop of the rainfall which is received" (USDA FS 1930: 51). However, because the problem of water in southern California was so critical, and because investigations were so complex and involved so many federal, state, and local agencies,⁴⁸ CFRES closely confined its investigations to the role that the mantle of forest vegetation played in water economy, erosion, and erosion control (USDA FS 1930). Later that year, thanks to supplemental congressional funding for USDA agencies involved in erosion and runoff experiments, along with substantial aid from the state and from five counties and two cities in southern California (USDA FS 1932b), CFRES was able to pursue this aspect of the influence of forests on watersheds.

With adequate funding available, Kotok was ready to set CFRES on a course of forest influence study. To lead the way, in 1929 he employed watershed conservationist Walter Lowdermilk, who had just returned from China after years of watershed and erosion work there, to oversee forest influences research for the station (Hill 1931). Within a short time, Lowdermilk's investigations at Devil Canyon indicated that surface runoff from forest soils from which the litter had been removed was from 10 to 30 times the runoff from soils with a complete and undisturbed mantle of forest litter. The simple reason for this, in Lowdermilk's assessment, was

⁴⁷ In 1933, the school of forestry officially offered courses in forest influences under Joseph Kittredge (Cassamajor 1965).

⁴⁸ Besides the Forest Service, important agencies studying water problems in this region of California included the U.S. Weather Bureau; Geological Survey; Bureau of Public Roads; State of California Department of Public Works, Divisions of Engineering and Irrigation and of Water Rights; University of California, Division of Irrigation Investigations and Practices and Division of Forestry.

that when muddy water from a denuded area percolated into the ground, the fine material carried in suspension was deposited close to the surface. As these particles built up, they clogged up the pores of the soil, thereby making the soil impervious. This sealing effect resulted in flash flooding. On the other hand, according to Lowdermilk, a forest cover broke the force of the rain. This action kept the rain-water clear by straining out any pore-clogging material that might be picked up, so that when the water finally reached the soil it was absorbed easily and rapidly. Essentially, the water-absorbing capacity of forest litter had little influence on runoff, as many erroneously believed. However, by keeping the water clean, forest litter kept the soil profile open to percolation (Helms 1984, Stuart 1929).

Along with this important discovery, Lowdermilk used new technology and a new method of measurement that he initially called a “lysiphytometer”—later to be known as a lysimeter (fig. 42). This technology was akin to using giant “flower pots,” some of which were 10 by 20 feet in area and six feet deep. Transpiration, or the consumption of water by vegetation during growth, was studied by growing representative plants in these large especially designed tanks filled with soil. With lysimeters, Lowdermilk believed that CFRES could gather statistically accurate data associated with the many variables and factors involved in understanding evaporation versus plant transpiration. During 1929, CFRES installed four lysimeters at Devil Canyon and two at North Fork administration site in the foothills of the Sierra National Forest⁴⁹ (fig. 43). Data from the latter installation, along with work at the station at Strawberry Canyon east of the Berkeley campus in 1931, were used in studies of California’s pine forest region, as well as for research on southern California chaparral conditions (Lowdermilk and Hamilton 1933; Sinclair 1936; USDA FS 1930, 1932b).

In addition to the research at Devil Canyon, in the summer of 1929 the Forest Service agreed to make a pilot study of the San Dimas watershed with the cooperation of William A. Johnston of the San Dimas Water Company, and the support of the Los Angeles County Forestry Department and the Chamber of Commerce. Kotok, Clapp, and Lowdermilk selected the site for the study after making a thorough survey of the watershed. By March of the next year, Lowdermilk had set

By keeping the water clean, forest litter kept the soil profile open to percolation.

⁴⁹ Essentially, during each spring, Lowdermilk planted chaparral species of the surrounding cover into three lysimeters, and three were left bare. Twice a year, at the beginning and end of the growing season, the soil mass in each set of three lysimeters was brought to its full holding capacity. The records of the water entering the instrument and the water draining through the instrument were expected to indicate the water loss from the soil mass—in one set of three lysimeters as evaporation and, with certain manipulation, in the second set of three lysimeters as transpiration from an included plant. Basically, the lysimeters demonstrated the feasibility of this new method of volumetrically measuring the loss of moisture from drained soil masses (USDA FS 1930, 1931).



U.S. Forest Service, Pacific Southwest Research Station

Figure 42—Lysimeters at Strawberry Canyon, California.



U.S. Forest Service, Pacific Southwest Research Station

Figure 43—Two North Fork lysimeters, 1937.

up four small experimental plots in San Dimas Canyon and he initiated studies to measure rainfall and to determine how much erosion took place on cleared versus uncleared chaparral slopes. For the next 2 years, Lowdermilk and others conducted field checks of numerous other mountain areas in southern California with the objective of finding the best possible location for a full-fledged forest research facility, or experimental forest. Having found no better site, in June 1932, Lowdermilk formally recommended the San Dimas and the nearby Big Dalton watersheds, to serve as paired watersheds for the project. Three months later, Director Kotok and E.N. Munns, by then the head of forest influences research at Forest Service headquarters in Washington, approved his selections. Thus, the San Dimas Experimental Forest (SDEF) was born (Robinson 1980, USDA FS 1931).

Initially, 13,000 acres in San Dimas and the nearby Big Dalton Canyons were set aside for the experimental forest. Later, SDEF was expanded to just over 17,000 acres. This site was selected for four major reasons: its vegetative pattern was typical of the southern California mountains; the region was isolated and considered ideal for controlled study of waterflow; the two main drainages contained numerous small tributaries suitable for a variety of experiments; and, because the canyons were harnessed by county flood control dams, they provided controls for measurement of waterflow. At Tanbark Flats, Lowdermilk established his headquarters with living and laboratory facilities for his research staff. In December 1932, CFRES staff, Region 5 research staff, and researchers from all over the West assembled at a conference held there (fig. 44). At this meeting, they discussed in great detail the experiments that would be carried out at SDEF, a comprehensive research program that Lowdermilk estimated would take 30 years or more to complete (Robinson 1980) (fig. 45).

In the interim, between 1927 and 1932, Kotok and Lowdermilk published a barrage of publications on the subject of forest influences. In his articles, Kotok focused on the influence of forest cover on water supply. He summarized a number of surveys investigating forest devastation (overcutting, destructive fires, overgrazing, and other abuses of forest and uncultivated lands) and its contribution to soil and water problems and generally described the erosion problem in forestry.⁵⁰ On the latter subject, Kotok emphasized the necessity of maintaining soil cover to check erosion, referred to experiments on the influence of soil cover upon runoff and erosion, and pointed out that on badly eroded land, the forester had the dual job

⁵⁰ For instance, in 1932, Kotok published in *American Forests* an article entitled "Solving the Forest and Water Riddle" that described recent results of experiments conducted in California (Kotok 1932).



U.S. Forest Service, Pacific Southwest Research Station

Figure 44—Forestry scientists looking over lysimeters at 1939 water influences conference at the San Dimas Experimental Forest.



U.S. Forest Service, Pacific Southwest Research Station

Figure 45—1939 water influences conference group at San Dimas Experimental Forest.

of devising means to check erosion and of starting a new forest. On the other hand, Lowdermilk's publications were more technical. They discussed factors influencing surface rainfall runoff, or the forest litter influence on runoff, percolation, and erosion. Other articles by Lowdermilk covered watershed management problems, such as obtaining maximum beneficial water production, or brush and forest-lands management for maximum irrigation water yield. In consideration of brush woodland forest influence on rain intensities, and disposition by retention, runoff, seepage, evaporation, and transpiration, Lowdermilk suggested storing water in underground reservoirs (Aitro 1977), a technology, which is only now being explored with success with the Central Arizona Project.⁵¹

Range Research

Research into forest influences was not the only new major line of research that came to CFRES in the late 1920s and early 1930s. Range research also became an increasingly important field of study at the station, but not before several major national events involving the Department of Agriculture and the Forest Service.

First, on March 1, 1926, the Office of Grazing Research in Washington, D.C., was transferred from the Branch of Grazing to the Branch of Research in the Agriculture Department. This transfer completed the combination of all the research activities of the Forest Service into one unit (Greeley 1926). A similar transfer on the district/regional level, however, did not immediately follow suit, largely because of a lack of funding.⁵² So, in California, District 5's Office of Range Management continued to handle grazing investigations separately from CFRES. District 5 investigations were limited to specific problems of an immediate nature on certain national forests, such as browse range and deer management on the Tahoe and

⁵¹ Central Arizona Project (CAP) is designed to bring about 1.5 million acre-feet of Colorado River water per year to Pima, Pinal, and Maricopa Counties. The CAP carries water from Lake Havasu near Parker to the southern boundary of the San Xavier Indian Reservation southwest of Tucson. It is a 336-mile-long system of aqueducts, tunnels, pumping plants, and pipelines and is the largest single resource of renewable water in the state of Arizona. In 1990, legislation passed authorizing CAP to develop state demonstration recharge projects and established the State Water Storage Fund to finance development of these projects with revenues derived from a property tax collected in Pima and Maricopa Counties. The purpose of the state demonstration project statutes was to allow for construction of permanent, large-scale underground storage facilities for direct recharge of excess CAP water. These facilities provide a means of storing excess CAP water not currently used by CAP subcontractors for future recovery during periods of severe water shortages.

⁵² Nationwide, Forest Service range research was largely still confined to the Great Basin Experiment Station in Utah, the Santa Rita Range Reserve in southern Arizona, or the Jornada Range Reserve in southern New Mexico. There were fewer than 40 full-time Forest Service forest range research and technical workers in the entire country (Rowley 1985, Stuart 1929).

Forest Service range research centered on four broader areas: range forage, range management, artificial revegetation, and watershed protection.

Lassen National Forests, respectively, and grazing related to western yellow pine reproduction on the Modoc National Forest. The District 5 Office of Range Management also oversaw studies pertaining to all of California's national forests, such as artificial and natural reseeding, chemical eradication of certain poisonous plants, and erosion control. Jesse W. Nelson from District 5, along with individual national forest staff, such as Modoc National Forest Supervisor F.P. Cronemiller,⁵³ handled these projects. However, the time they devoted to them was limited. Nelson readily admitted that District 5 needed to approach range research on a larger scale, and with a much broader program, and looked forward to when CFES embraced more pressing problems affecting grazing administration. But, research dollars were needed. In 1927, some D5-IC members, growing impatient with the grazing industry's disinterest in range research, suggested that silvicultural and water conservation interests might be better pressed for support (USDA FS 1928, 1930, 1931).

Passage of the McSweeney-McNary Forest Research Act the next year changed this situation both nationally and regionally. Because of McSweeney-McNary Act funding, range research nationwide doubled over the next 2 years. Clapp's 1926 *National Program of Forest Research* generally defined range research as including taxonomy, ontogeny, physiology, ecology, biological relationships, fire, food values, genetics, exotics, and influences investigations. Range research also included forage management, or the relationships among range and timber, erosion, fire, and wildlife, animal husbandry, and carrying capacity studies (Clapp 1926). By 1929, Forest Service range research centered on four broader areas: range forage, range management, artificial revegetation, and watershed protection. Furthermore, responsibility for range research was extended to include all range lands, both public and private, within each regional boundary (Rowley 1985). Finally, in August 1930, the Southwestern Forest and Range Experiment Station was organized as a regional unit of the Forest Service. Headquartered in Tucson, Arizona, under a cooperative agreement with the University of Arizona and directed by G.A. Pearson, the new station brought together and expanded the Jornada and Santa Rita Range Reserves range investigations, which thereafter became experimental ranges (Price 1976, Stuart 1931). At the same time, as noted earlier, CFRES took over all range research responsibilities from District 5 and changed its name to the California Forest and Range Experiment Station (CFRES).

⁵³ In 1935, Cronemiller was appointed to the position of assistant regional forester in charge of the Division of Wildlife and Range Management in Region 5. Under Cronemiller, grazing management took a turn for the better (Godfrey 2005).

The above evolution in range research came at an appropriate time, for systematic range research had been conspicuously wanting in California. In 1930, California had close to 150,000 livestock grazing on its national forests. The inauguration of range research in the state by CFRES was doubtless of great importance, because the interrelationship of grazing with timber production and watershed protection especially demanded the study of ways to restore depleted ranges and assurance of sustained profitable production of livestock without injury to other resources (Stuart 1930, 1931). The San Joaquin Valley foothills were one livestock area of particular concern in California. Here, long dry summers made the maintenance of forage growth difficult. Besides improper grazing management that had seriously damaged range, timber, and watersheds there, successive years of exceptional drought placed the local grazing industry in an extremely precarious situation. Hence, CFRES concentrated its first studies on this land hoping to make it more useful to the livestock industry, while duly safeguarding an important public interest in water yield and the prevention of soil erosion (Stuart 1932).

Meanwhile, until 1930, Region 5 drew upon the systematic research findings in other Forest Service regions and applied them in California so far as circumstances permitted. Although this transfer of range research to the station rounded out the station's regional research program, a true range research program had yet to be initiated in California (USDA FS 1932b). To bring this goal to fruition, in 1931, Director Kotok hired three range specialists: Murrell W. Talbot, F.G. Renner, and August L. Hormay. However, a major problem yet to be resolved at this time was finding a satisfactory work center for range research. Kotok and Talbot actively looked for such an experimental range along the most promising areas of public domain available in the Sierra western foothills—preferably somewhere near the Stanislaus, Sierra, or Sequoia National Forests. While searching for this research site, Talbot, as grazing research head, began two regional grazing projects, one in California's San Joaquin Valley and the other in northern California's pine country (USDA FS 1932b).

Foothill-Range project—

Talbot's first range research study was called the Foothill-Range project. Its broad objective was to determine how the foothills surrounding the San Joaquin Valley should be grazed to contribute the most to the livestock industry, without serious interference with other important public uses of the land. Tentative plans for the Foothill-Range project included studies on the effect of grazing on the composition, feed value, and maintenance of the forage crop. Life histories of important range plants were also studied to determine their growth habits and conditions favorable

to their establishment and maintenance. Finally, there were comparative water yield and soil erosion investigations on ungrazed, lightly grazed, and overgrazed areas on both sheep and cattle ranges. In connection with this last endeavor, Talbot installed temporary and permanent unfenced and fenced plots in different range types and at elevations ranging from 600 to 3,000 feet along San Joaquin Valley rangeland. Next, Talbot devised an extensive 8-page form to collect data for the foothills project. This investigational questionnaire asked for direct plot information pertaining to soils, forest litter, fires, grazing management, rodents, erosion, vegetation density, composition and utilization, and development of ungrazed plants. Initial results from these plots indicated that insufficient forage production in the critical early winter period was a major problem (Stuart 1932, USDA FS 1932b).

Pine-Range project—

The second research project undertaken by Talbot and the CFRES was called the Pine-Range project. Its broad objective explored the kind and amount of grazing that could be practiced in commercial timber areas, especially in certain northern California national forests, without serious conflict with other important land uses. The CFRES wanted to better understand the effects of different kinds and intensities of grazing by sheep and cattle on such points as pine reproduction, the composition and feed value of the forage, soil erosion, and recreational development. Talbot tentatively planned to center this project in the “east-side” pine types (USDA FS 1932b).

Forest Economics Research

Until 1931, forest economics research at the station centered on completion of the state cover type map. The State Forester furnished valuable cooperative assistance in this effort by detailing state rangers to assist in mapping and by providing transportation for mappers during non-fire season (Clar 1959, USDA FS 1927). The station's type map project was one of evolution, and had last been undertaken more than 20 years earlier during the joint federal-state forest survey (1903 to 1907) (Clar 1959). From its simple beginnings came one of the most important projects conducted by the station. At first, the goal of CFES was to complete in a comparatively short time a rough type map of the country outside of the national forests, to graphically show the major vegetative types found in California⁵⁴ (Wieslander

⁵⁴ Interestingly, this project was initiated 2 years prior to the nationwide FRS authorized by the 1928 McSweeney-McNary Research Forest Act.

1935). This project was supervised by A.E. Wieslander⁵⁵ and was carried out first for the northern part of the state, involving over 1,700 townships—845 of them within national forests. Work was pushed forward in that area as far as finances permitted. The mapping of southern California did not begin until 1929 and was then handled as a winter job, starting on the Angeles National Forest (USDA FS 1928, 1930, 1932b). Many agencies and individuals participated in this initial vegetation survey, including lumber companies and other timber owners, the Division of Forestry of the University of California, the state forester's office, the administrative organization of the Forest Service, the U.S. Geological Survey, the Office of White Pine Blister Rust Control, superintendents of national parks, and certain counties. Soon, a wide variety of engineering, scientific, and other nonfederal organizations in the state perceived the value of these maps, causing demand to increase to an unexpected level with offers of financial assistance for this undertaking from various sources (Wieslander 1935).

In the interim, the nationwide FRS reached California. In anticipation of this event, in August 1930 Director Kotok and Regional Forester Show agreed to dovetail the work of the California cover type map with the FRS because it added funding to the cover type map project. However, the agreement added four new data fields to the data collection process. These fields required the gathering of information on cutover lands, defined as all logged lands whether burned or not; burns, or lands not cutover on which the stand had been killed by fire; noncommercial rocky areas within timber types, and site classification of all forest or potential forest land (USDA FS 1931). The simple vegetation map project conceived in 1926 was intensified even further in 1931, when southern Californians demanded that the map supply data for the proper evaluation and protection of watershed cover. The obvious value of this request soon led to the addition of this data to the maps statewide (Wieslander 1935). Now the most vexing problem before the CFRES was publication of the maps during the government economic hardship caused by the Depression. However, in 1932, the California Economic Research Council came to the project's aid by helping to secure a doubling of the state appropriation for cooperation for this project. This action speeded up publication. Thereafter, the Forest Service and the state of California jointly published the project as two sets of maps. The first map set was a statewide vegetation type map (220 sheets). The

A wide variety of engineering, scientific, and other nonfederal organizations in the state perceived the value of these maps, causing demand to increase to an unexpected level with offers of financial assistance for this undertaking from various sources.

⁵⁵ In turning over the project to Wieslander, Kotok said, "If you don't finish the project in 2 years, I'll be very much surprised." Because the inventory work was expanded to include other variables and be merged with the larger Forest Survey project discussed later, it was still far from completed when Wieslander retired in 1956 (Casamajor, n.d.: 4).

second map set (137 sheets) was an economic cover map for California. The latter set depicted five broad land classifications: forested, watershed, grazing, cultivated, and barren (USDA FS 1932b, Wieslander 1935).

Other USDA Agency Research

While the CFRES was getting established and beginning investigations along the six lines of research embedded in CFRES' program, other foresters were not idle. District/Region 5 and other USDA agencies also conducted forestry research in California.

District/Region 5—

Forestry research conducted by District/Region 5 took place in three offices: the Office of Forest Management, the Office of Range Management, and for a short time, the Office of Fire Control. Of these three offices, after 1931 only the Office of Forest Management continued to conduct a separate forestry research program in cooperation with CFRES. However, Region 5's Office of Forest Management relegated its research activities to conducting narrowly focused studies such as investigating tractor-logging engineering problems, spark-arrester studies, and a limited number of silviculture problems, such as mill scale practices, logging damage, or slash disposal experiments. It also conducted forestry investigations on each national forest, some experimental planting studies with trees supplied by both the Feather River and Devil Canyon Branch Station nurseries, and sundry other projects, which do not come under the purview of this publication (USDA FS 1927, 1928, 1930, 1931). Finally, District/Region 5's Office of Forest Management prepared reports on proposed experimental forests and RNAs, in the California region. By 1932, CFRES and Region 5 made a positive recommendation for the proposed Feather River Experimental Forest, to be located on the Plumas National Forest, and the Swain Mountain Experimental Forest, in the Lassen National Forest.⁵⁶ The establishment of an Eastern Lassen Experimental Forest was still up in the air. They recommended seven RNAs, including the Devils Garden and Lava Beds RNAs in the Modoc National Forest; the Summit Camp RNA in the Eldorado National Forest; the Reagan Meadow RNA on the Trinity National Forest; the Sweetwater RNA in the Mono National Forest; and the Indiana Summit RNA (fig. 46), to be

⁵⁶ The withdrawal report by C.E. Dunston and A.E. Wieslander, November 12, 1931, was approved by Chief Forester Stuart on March 22, 1932 (Gordon 1978).



U.S. Forest Service, Pacific Southwest
Research Station

Figure 46—Upper boundary of Indiana Summit Research Natural Area on Inyo National Forest.

located in the Inyo National Forest.⁵⁷ Once the regional forester and the director of the experiment station approved these reports, they were sent off to the Chief forester for final action (USDA FS 1932b).

Forest Pathology and Entomology Research

In the period after 1926, the Bureau of Entomology and Plant Industry continued to assign forest entomologists and pathologists to forest experiment stations (Stuart 1929). In 1927, John M. Miller, of the Office of Forest Entomology, conducted research work on this topic for District 5, but his work was largely limited to the Sierra, Inyo, and Modoc National Forests. In cooperation with District 5, the station, and private industry, Miller also conducted small control projects in the southern part of the state (Greeley 1927, USDA FS 1927). However, a year later, one of the most serious insect infestations on the national forests nationwide occurred in California,⁵⁸ when an outbreak of bark beetle on the Modoc National Forest and

⁵⁷ The first RNA approved in California was the Indiana Summit RNA on the Inyo National Forest, which was established in 1932. The Jeffrey pine forest at Indiana Summit is part of a large tract of essentially pure Jeffrey pine forest stretching from the eastern flank of the Sierra Nevada across the divide between the Mono Basin and Owens River drainage. Much of this forest has been harvested for timber, and the RNA preserves a rare pristine example. Today, California has 52 RNAs, which are managed to serve the objectives of the RNA system. Additionally, more than 40 areas have been approved but have not yet been established (Cheng 2004).

⁵⁸ The insect outbreak was so severe that the AFA editorialized that “highly trained scientists were giving practically their entire time to control work and were without funds for developing through research more efficient methods of control.... This is reason enough for urging the passage of the McSweeney bill which would write into law a definite federal policy covering forest research in all its branches” (American Forests and Forest 1928b). The McSweeney-McNary bill initially authorized an increase for research on insect affected forests, but the Bureau of the Budget apparently reduced it in the final authorization (American Forests and Forest Life 1929).

surrounding patented lands became extremely destructive. As much as half of the valuable mature pine timber was killed in some sections. To check the infestation, the Forest Service logged the affected trees before the beetles emerged the following spring. The trees were then salvaged before they had deteriorated too badly to make usable lumber.⁵⁹ To further help CFRES address this problem; the BE's Office of Forest Insect Investigations assigned an additional entomologist to work with the station (Stuart 1928). By 1929, this tree-killing insect infestation in California's northern forests was halted through a combination of logging and natural causes (Stuart 1929), but by the close of 1931, there were strong indications that a serious bark-beetle epidemic was building up in the western yellow pine stands in California. Because the attacking species had two generations each season, the degree of infestation in different places could not be determined until the late fall. In response, arrangements were made with the BE to collect the necessary information to combat the invasion, and a staff of two entomologists, J.M. Miller and G.R. Struble, a scientific aide at the time, and two agents was thereafter assigned to CFRES under the McSweeney-McNary Forest Research Act as cooperative personnel for forest insect investigations (Stuart 1931, USDA FS 1932b). As predicted, in 1932 there was a serious increase in the destructiveness of the western pine beetle in northern California. Region 5, along with CFRES, began cooperative work with the owners of private stands of forest intermingled with pine timber on the Sierra National Forest, but losses were heavy both in the mature forest and in seed trees left on cutover areas (Stuart 1932).

The Office of Pathology (OP) was also busily at work in District/Region 5. During the period 1926 to 1932, pathologist E.P. Meinecke processed years of accumulated data concerning District 5's forests, while pathologist S.N. Wyckoff of the Office of Blister Rust Control worked diligently on local control of white pine

⁵⁹ By far the most serious menace to California's forests was insect invasions, such as bark beetles, which were always at work in coniferous forests. They threatened to become an epidemic when conditions favorable to their multiplication arose. The Forest Service at this time controlled bark-beetle epidemics by felling the infested trees and peeling or burning the bark. As a rule, epidemics occurred in the older and therefore less-resistant stands (Greeley 1927).

blister rust⁶⁰ in District 5 (USDA FS 1927). In 1930, white pine blister rust had spread rapidly throughout Idaho and Oregon, and foresters feared that similar conditions were bound to develop in the sugar pine region of California (Stuart 1930). The disease had not yet reached the important sugar-pine producing portions of California by 1931, but it was known that this tree, like other American five-needled pines, was susceptible (Stuart 1931).

Wildlife and Recreation Research

By 1926, wildlife and recreation research within the Forest Service structure was barely in its infancy. In *A National Program of Forest Research*, Earle Clapp (1926) proposed that wildlife research should focus on the place of each species in the ecology of the environment followed by related research on life habits. Once these facts were established, in Clapp's opinion, the Forest Service could build an effective technology of conservation and control that addressed the biological balance of forests (Clapp 1926). In California, understanding the management of growing deer populations and their effect on forest range resources was a key problem. Of the more than 600,000 deer on the Nation's national forests at this time, 227,000 browsed on California's forests (Greeley 1926). To address the problem, in 1928, the Agriculture Departments' Bureau of Biological Survey (BBS) began to conduct cooperative wildlife investigations with the CFRES, and plans were underway to assign a forest biologist to the forest experiment station—the first such assignment in the country (Stuart 1928). The concept of wildlife research in the 1920s was very different than the environmental/ecological approach of today. For instance, in 1927 when F.E. Garlough was assigned to work with CFRES, he outlined a research program that included studies not just of the natural habits of animals such as deer, but studies on the damage to forests caused by wildlife and experiments with poisons like strychnine and arsenic for eliminating wildlife considered harmful to productive forests, such as rodents, rabbits, squirrels, porcupines, and coyotes (USDA FS 1928). In 1929, E.E. Horn replaced Garlough. Horn, a more enlightened biologist,

⁶⁰ White pine blister rust was introduced in the East from Europe between 1898 and 1908, although the disease is believed to have originated in Asia. In 1910, it was introduced into British Columbia and has since spread through the West. In North America as a whole, it has caused more damage and more money has been spent to control it than any other conifer disease. Thousands of white pine (*Pinus strobus*) stands have been seriously damaged, and many have been entirely lost. Historically, control efforts have focused upon removing the alternate host, members of the *Ribes* family, from stands of white pine. However, this never proved to be very effective, despite the thousands of hours of work that were invested. Likewise, effective chemical controls have never been developed. As blister rust is an introduced species, rather than one that evolved here, genetic resistance is limited in the white pines. For this reason the mortality from this disease has been extremely high.

wished to study animals in relationship to regeneration of forest and range species, to erosion, soils, and watersheds, to plant distribution, and to animal life, forest fires, and deforested areas. However, D5-IC regrettably informed him that there was little probability of getting money for these general studies of biological relationships. They suggested that Horn focus on projects of practical service to forest management, such as the rate of invasion of burns by rodent populations—advice that Horn followed (USDA FS 1930b, 1932b).

In the field of recreation research, Clapp, Kotok, and others at this time did not fully appreciate the critical impact of the growing number of people using California's national forests for recreation in terms of fire control, roads, and campground facilities. Earle Clapp's *A National Program of Forest Research* provided only a brief statement that the greatest contribution that research could make to recreation was the maintenance of wildlife in forests, and the maintenance of the forest itself (Clapp 1926). The state of California, however, did understand the growing problem of recreation in California and authorized some related research. For instance, in 1929, the state forester demonstrated concern regarding the effect of excessive tourist travel on plant life, especially regarding the welfare of old redwood groves. Thereafter, the state engaged pathologist E.P. Meinecke to study the problem. Meinecke believed that recreation activity was a serious detriment to the roots and soil of forests. He recommended the formulation of a state park management policy that would regulate use in parks to stay within the physical capacity of the vegetation (Meinecke 1929). Meinecke thereafter wrote a series of publications regarding camp planning, camp construction, and campground policy that served to direct California State Park and Forest Service managers in constructing recreation facilities in the early 1930s.⁶¹ Despite this early research on the adverse impacts of recreation to parks and forests, formal research in forest recreation would not begin to evolve until the 1940s (Camp, n.d.).

⁶¹ Interestingly, Meinecke, in a short paper entitled "The Trailer Menace" published in 1935, warned of the impacts that camper trailers would have on national forest and national park lands. In Meinecke's view, the new type of trailer obviated camping altogether, and thought that two or more of them in a campground gave the "appearance of ill kept city slums in which cabins and huts, of all colors and all designs, are scattered without order or plan and completely destroy the last vestiges of camp intimacy in the wild" (Meinecke 1935: 1).

California and Hawaii State Divisions of Forestry

Under the stimulus of Section 4 of the 1924 Clarke-McNary Act,⁶² the California Division of Forestry,⁶³ and the Territory of Hawaii cooperated with the Forest Service to promote the growing of forest crops. In California, reforestation efforts under the Clarke-McNary Act were limited in scope, but in Hawaii, a major reforestation effort took place after 1926, thanks to this legislation because forest planting was considered Hawaii's greatest forestry need, and Hawaii's forestry policy and programs focused almost exclusively on protecting watershed resources through planting programs or similar work.⁶⁴

From 1927 to 1932, the Territory of Hawaii expended almost \$115,000 toward the distribution of forest planting stock. The Forest Service contribution under the Clarke-McNary Act at this time was an additional 15 percent of that amount. Although the majority of federal dollars were used to support production of tree seedlings for reforestation, some of these expenditures were also used for reforestation research. However, the Forest Service still did not consider the commercial use of timber resources of the islands, and official or personal contact between officials of the Territory of Hawaii and CFRES were almost nonexistent (Greeley 1927; Nelson 1989; Stuart 1928, 1930, 1931, 1932).

Regarding fire protection, which included fire research, California participated in cooperative expenditures under Section 2 of the Clarke-McNary Act from the day of its passage. By 1932, federal appropriations for cooperative work in California amounted to just under \$170,500 with the state of California contributing an additional \$160,000 and private agencies another \$350,000. In that year, Hawaii

⁶² The Clarke-McNary Act, passed in 1924, authorized an annual federal appropriation of \$2,500,000 for five objectives. First, it encouraged the protection of forest and water resources and the continuous production of timber on lands chiefly suitable for that purpose. Second, it sought to promote permanent and adequate protection against fire on all classes of state and private forest land, whether timbered, cutover, or burned for watersheds supplying water for domestic use or irrigation. Third, it provided for a comprehensive study of the forest tax question. Fourth, it supplied farmers with young forest trees for planting idle lands, windbreaks, and shelterbelts. And fifth, it gave advice to farmers in the proper handling of already established woods.

⁶³ California created a Department of Natural Resources under the general supervision of a director, with a Division of Forestry administered by the state forester and guided by a state board of forestry in the creation of policies. This new department took over all the powers and duties of the former state forester and began to match expenditures (Greeley 1927).

⁶⁴ The Forest Service helped the territorial government establish its forestry policy in the early 1900s, and there was minor assistance provided for tree species adaptability thereafter. For instance, in 1910, forest examiner Louis Margolin completed a 6-month assignment in Hawaii to study and prepare a report on the many species of eucalyptus (*Eucalyptus* spp.) planted previously on the island. But further Forest Service assistance to Hawaii was sporadic prior to 1926 (Nelson 1989).

initiated a program of cooperative forest fire protection under the Clarke-McNary Act as well. It was on a much smaller scale and totaled less than \$2,000 (Stuart 1932).

Eddy Tree Breeding Station

Because of the importance of genetics⁶⁵ to forestry research in California, in 1927 D5-IC invited the Eddy Tree Breeding Station, located at Placerville, California, to report on its research. The Eddy Tree Breeding Station was a private institution devoted to genetic research, founded in 1925 by James G. Eddy, a lumberman and timber owner from Everett, Washington (USDA FS 1928). Aware of the history of forest depletion in New England, in the Lake States, in the South, and in the early years in the Pacific Northwest, Eddy feared that a timber shortage was inevitable unless some way could be devised to make forest land produce more timber. Essentially, he wanted to find a way to develop fast-growing trees to avoid what he perceived as an impending forest famine. Meanwhile, the work of horticulturist Luther Burbank on techniques of plant breeding in the practical production of flowers, fruits, and field crops, in Santa Rosa, California, was gaining worldwide attention. Eddy decided to contact Burbank to ask him if genetics could be applied in some way to forestry. After some discussion, they agreed that genetics could be applied to forestry, much in the same manner that it was used for the improvement of fruit trees. During several subsequent consultations with Burbank, along with discussions with Earle Clapp, Edward Kotok, and University of California faculty members, such as Walter Mulford and the geneticist Ernest B. Babcock, Eddy

⁶⁵ The earliest attempt to improve forest trees was made more than 250 years ago, when an Englishman named Hamner noticed that the heaviest tree seed produced the strongest and fastest growing seedling. By the beginning of the 19th century, a French scientist named Vilmorin began comparative experiments with pine seed from different companies. Eventually, he founded a company of the same name. Today, the Vilmorin Corporation is the world's oldest seed company. In the United States, almost immediately after the establishment of the Forest Service in 1905, work was performed on forest genetics. At this time, the American Breeders Association formed a committee on breeding nut and forest trees. The first chairman of the committee was Chief Forester Gifford Pinchot. In 1908, Pinchot submitted a report on breeding forest trees and thus laid down a foundation for forest genetics work in this country. This report clearly stated the effects of natural and artificial selection, showing how detrimental to the quality of our forests had been the practice of removing the best trees and leaving inferior ones to perpetuate themselves. As a supplement to this report, botany professor Willis Linn Jepson at the University of California made valuable suggestions on breeding trees in California (Mirov 1939).

was encouraged to invest in and develop plans for a tree-breeding institution.⁶⁶ Therefore, in the summer of 1924, Eddy decided to go forth with his idea of a tree-breeding station and employed Lloyd Austin⁶⁷ to seek a suitable location for the institute and direct the work there. After scouring the forest regions of the Pacific coast, they finally settled on an inland site three miles east of Placerville, which had a comparatively mild climate, good soil, ideal topography, water supply, accessibility, and other requisites favorable for growing trees. Additionally, the Placerville site was situated near the lower edge of the main western yellow pine timber belt in the central Sierras, where several other important timber species typical of the lower Sierras were found nearby. In the spring of 1925, land was cleared, an irrigation system established, and seed was collected on the 65-acre site and stored in an underground basement along with valuable records. The following spring, work began on nursery plantings (Austin 1927, 1929; Austin et al. 1974; Stockwell and Walker 1948; USDA FS 1948b).

The initial staff of the Eddy Tree Breeding Station consisted of Lloyd Austin, who served as director until 1940; forester John S. Barnes; and propagator H.M. Lumsden.⁶⁸ When Austin and his staff began their work, they had to decide three fundamental issues that would influence the course of the program for years to come. First, should a limited group of trees be selected for experimentation, or should an attempt be made to improve all of this country's timber trees? Careful consideration was given to breeding possibilities in several groups of trees, including pines, redwoods, firs, ashes, and walnuts. The genus *Pinus* was eventually chosen for intensive study among the softwoods group, and walnuts among hardwoods. Second, should the final objective be wood quality, or growth rate, or some other desirable attribute? Growth rate was selected. Austin and his staff decided that from fast-growing timber pines, those resistant to cold, droughts, insects, and diseases could later be segregated. And finally, should the main effort be concentrated on improving existing timber trees by selecting the best available strains,

Should a limited group of trees be selected for experimentation, or should an attempt be made to improve all of this country's timber trees?

⁶⁶ In 1924, Eddy appeared before the U.S. Senate Select Committee on Forestry while it met in Seattle to persuade the senators of the need for a station to experiment with tree breeding, but failed to convince them.

⁶⁷ Lloyd Austin at that time was working in pomology at the University of California at Davis and had no forestry training whatsoever, but he had visited Luther Burbank on several occasions and was interested in tree breeding (Austin et al. 1974).

⁶⁸ Before being appointed director, Lloyd Austin was on the staff of the Division of Pomology, University of California where he studied fruit tree breeding for a number of years. John S. Barnes was a graduate of the University of Michigan and had recently taken graduate work in forestry at the University of California. His duties covered field work of all sorts, particularly pollination and cone collection. Lumsden joined the staff in early 1926, having previously been a forestry instructor at the University of Michigan. He was charged with all work at both the nursery and the arboretum (Austin 1927).

**The Eddy Tree
Breeding Station
also distributed pine
seeds to nurseries
throughout the United
States and a few
foreign countries,
including many rare
species.**

or should the effort be directed primarily toward the production of new strains by hybridizing? Austin decided to spend most of the station's funds and manpower upon progeny testing, although hybridization of species was not neglected. Species testing of geographic races, including forms of species of pines other than those native to Europe, and individual seed trees of ponderosa pines whose progeny might show outstanding performance, was the first research work done at the station (Austin 1927, 1928a, 1932; Austin et. al. 1974; Stockwell and Walker 1948; USDA FS 1948b).

By 1928, Austin and his staff moved into a new administration building, the original 65-acre tract of land was increased by 20 acres, and James Eddy turned over ownership of the land to the station. In that year, W.G. Wahlenberg⁶⁹ succeeded John S. Barnes as station forester, and Francis I. Righter,⁷⁰ who would later become a notable geneticist at the station, replaced Lumsden as propagator. At this early date, the station's nursery section had the largest collection of pine species ever grown at one time in any part of the world. A total of 87 species and many important varieties were represented, and in the case of several of the major species, seed was secured from nearly a dozen localities within the species' natural ranges. At this time, the station also distributed planting stock for experimental plantations in various parts of the Pacific coast, shipping to 20 different organizations from San Diego to Seattle. The Eddy Tree Breeding Station also distributed pine seeds to nurseries throughout the United States and a few foreign countries, including many rare species. Besides this nursery and seeding work, during the next few years, the Eddy Tree Breeding Station conducted and maintained long-term progeny tests, experiments in pollination, vegetative propagation, x-ray stimulation of mutations, and cultural experiments involving time of sowing, seedbed density, fertilization, and size of seed and irrigation. Each year, the station reported its work and findings to D5-IC (Austin 1929; USDA FS 1930, 1931).

In its early years, things went well with the Eddy Tree Breeding Station, but by the end of 1930, the station began to face financial difficulties because of the economic depression. Accordingly, Austin decided to incorporate the station under

⁶⁹ Wahlenberg came to the Eddy Tree Breeding Station with 6 years of experience in forest research at the Savenac nursery in Montana and had spent some time at the Southern Forest Experiment Station (USDA FS 1930).

⁷⁰ Francis Irving Righter entered Cornell University as a forestry student and graduated in 1923, having majored in forestry and minored in genetics. Two years later he took the Civil Service examination for a position in the Forest Service, was accepted, and spent a year at the Southern Forest Experiment Station at New Orleans, Louisiana. He was, however, interested in genetics, and in 1925 accepted an offer by Austin to work at the Eddy Tree Breeding Station. Righter was on the Institute of Forest Genetics staff when the Forest Service took it over in 1935 (Austin et al. 1974, USDA FS 1930).

the name “Institute of Forest Genetics,” to express the broad nature and scientific character of the investigations being conducted there. A national board of trustee of 15 to 18 prominent and well-qualified scientists and businessmen was selected to guide the destiny of the institution, and the property and control of the Eddy Tree Breeding Station was turned over to them. Board of Trustee members included prominent figures not only in forestry and forestry research, such as Earle Clapp, William Greeley, and Ralph Hosmer, but persons working at allied scientific institutions like Walter Mulford of the University of California. Personnel and objectives of the organization remained as before, but it was hoped that the nomenclature change would bring additional financial support from the business community. Austin and others at the Institute of Forest Genetics, which by this time had become the most complete arboretum of pine in the world, felt that the development of rapid-growing trees could stimulate reforestation by making it profitable and desirable for the individual landowner to grow timber as a crop (Austin 1932, 1937; *Journal of Forestry* 1932; USDA FS 1948b).

Vigorous Beginning

From 1926 to 1932, the California Forest Experiment Station went through the pangs of growth that any new institution of its nature went through. At the establishment of the station, the California Experiment Station had a staff of four technicians that included Director Kotok. The station also had two clerks at the Feather River Branch Station under its jurisdiction, which had no assigned staff. In the beginning, the station’s activities centered on forest management in California’s pine region. Six years later, CFRES personnel had grown to 26 permanent staff, eight clerks, and five cooperating personnel from other USDA agencies. In addition to the permanent force, during the field season, CFRES employed some 30 or more students from the University of California, or other short-term assistants, and two additional clerical assistants. Six years later, CFRES had six lines of research: forest management, utilization of wood and other forest products, forest protection, forest influences, range research, and forest economics. Additionally, the station had responsibility not just over the Feather River Branch Station in northern California, but also the Devil Canyon Branch Station in southern California, as well as two experimental forests—the Shasta Experimental Fire Forest (1929) that concentrated on the fire problems of Region 5, and the undeveloped Swain Mountain Experimental Forest (1932) for the study of white and red fir.

Much of the growth of CFRES was attributable to the passage of the McSweeney-McNary Forestry Research Act and other federal legislation, as well as state and private institution support. Unlike Region 5, which felt the effects of the national economic crisis in its budget and declining revenues from forest resources such as timber sales and grazing fees (Godfrey 2005), CFRES was sustained by the appropriations from the McSweeney-McNary Forest Research Act, which provided steady research funding to CFRES during the national economic crisis that began after 1929. From its vigorous beginning, CFRES would see even greater program and facility expansion during the remainder of the 1930s. As will be seen, the McSweeney-McNary Act continued to provide steady support to the CFRES research program, and in the coming years, the station was also able to take advantage of the labor and funding provided by Franklin Delano Roosevelt's New Deal programs to increase its forestry research program into genetics—a seventh line of research—and to acquire several additional experimental forests in California for various research purposes.

Chapter 4: 1933–1941, A New Deal for Forest Service Research in California

By the time President Franklin Delano Roosevelt won his landslide election in 1932, forest research in the United States had grown considerably from the early work of botanical explorers such as Andre Michaux and his classic *Flora Boreali-Americana* (Michaux 1803), which first revealed the Nation's wealth and diversity of forest resources in 1803. Exploitation and rapid destruction of forest resources had led to the establishment of a federal Division of Forestry in 1876, and as the number of scientists professionally trained to manage and administer forest land grew in America, it became apparent that our knowledge of forestry was not entirely adequate. So, within 3 years after the reorganization of the Bureau of Forestry into the Forest Service in 1905, a series of experiment stations was established throughout the country. In 1915, a need for a continuing policy in forest research was recognized by the formation of the Branch of Research (BR) in the Forest Service—an action that paved the way for unified, nationwide attacks on the obvious and the obscure problems of American forestry. This idea developed into *A National Program of Forest Research* (Clapp 1926) that finally culminated in the McSweeney-McNary Forest Research Act (McSweeney-McNary Act) of 1928, which authorized a series of regional forest experiment stations and the undertaking of research in each of the major fields of forestry. Then on March 4, 1933, President Roosevelt was inaugurated, and during the “first hundred days” of Roosevelt's administration, Congress passed his New Deal plan, putting the country on a better economic footing during a desperate time in the Nation's history. Many foresters at the time looked forward to a New Deal in forestry as well. But before that story can be told, a brief description of some of the key New Deal programs that would affect their desires for a new day in forestry research is necessary.

New Deal Programs

Roosevelt's New Deal contained several relief programs for the unemployed that were designed to bring immediate assistance to the millions of native-born unemployed and to restore their morale and health. The first of these programs was the creation of the Civil Works Administration (CWA) on November 9, 1933, a temporary agency to employ millions of people to help them survive the winter of 1933–34. By January 1934, the CWA had provided employment to more than 4 million Americans, and in California, the CWA employed more than 150,000 Californians

in a wide variety of activities, such as building airports, bridges, roads, schools, and other public structures. The CWA remained in operation until March 1934, when the federal government terminated the program owing to its tremendous costs. With the pending expiration of the CWA, Congress established other relief projects. There was the Public Works Administration (PWA), created on June 16, 1933, under the authority of the National Industrial Recovery Act (NIRA).¹ It called for a comprehensive program of public works and channeled special allotments to fund capital improvements for federal projects. As a result, the Forest Service received funding for a great many improvements. Projects ranged from the development and improvement of roads, to a wide range of much-needed Forest Service buildings, the most common being ranger stations, fire lookouts, garages, residences, and maintenance shops. Then there was the Works Progress Administration (WPA)² created in 1935 to supersede NIRA and other short-term programs. The WPA funding was used to construct schools, post offices, and other public structures. A program closely related to the CWA, PWA, and the WPA was the popular Civilian Conservation Corps (CCC), which combined relief and conservation and put millions of unemployed young people to work in national forests. The CCC evolved from the Emergency Conservation Work (ECW) program, an interagency effort established on March 31, 1933, involving the Departments of Labor, Army, Interior, and Agriculture and administered by an interagency advisory board. From the beginning, the CCC program was intended as a temporary emergency measure, and therefore required reauthorization periodically. Camps of CCC enrollees, young men between the ages of 19 and 28, carried out emergency conservation work on each national forest. The Army was placed in charge of all CCC camps themselves, and controlled the enrollees when they were in camp. Alternatively, the Forest Service handled all the men while they were on the job, including their transportation between camp and work points. A total of 166 camps were eventually authorized for California national forests and the enrollees set out to build a variety of building types, such as ranger stations, guard stations, offices, and large and small warehouses (Godfrey 2005).

¹ One of the express purposes of the National Industrial Recovery Act was to conserve natural resources. Toward this end, NIRA set up lumber codes for industrial forests requiring practices based on sustained yield that would keep the land from becoming wholly unproductive, which was thought of as a great gain over the destructive methods previously in general use. Meanwhile, the Forest Service offered its knowledge and research experience to industry through a lumber code that set forth minimum standards of logging with a conservation theme. However, on May 27, 1935, the Supreme Court declared NIRA's code system unconstitutional because it unreasonably stretched the Commerce Clause of the constitution (Silcox 1934).

² In 1939, the WPA changed its name to the Works Projects Administration.

As will be seen, the California Forest and Range Experiment Station (CFRES) took advantage of the New Deal “alphabet” relief and recovery programs such as CWA, NIRA, PWA, WPA, and the CCC to obtain lands and construct many of its research facilities at a number of experimental forests that it would acquire during the New Deal years. These programs contributed indirectly to a new era for forestry research in California by supplementing the appropriations available through the Forest Service budget. However, these programs cut like a two-edged blade. They certainly helped build up needed CFRES facilities and bought experimental forest lands, but in some respects, regular dollars needed for research were forgone at the expense of these federal activities. Ironically, because these emergency programs dollars could not be used for research activities, CFRES was left at times with excellent facilities with no funding for conducting investigations.

A National Plan for American Forestry: Copeland Report

On that March morning of President Roosevelt’s inauguration in 1933, Earle Clapp, head of the Forest Service Research Branch, perhaps hoped that Congress and the president would move just as quickly on forestry issues as they seemed to be willing to attack the relief and recovery of the Nation from the Great Depression. Opportunity was not wanting. Shortly after Roosevelt’s inauguration, Agriculture Secretary Henry Wallace submitted for the president’s consideration *A National Plan for American Forestry* (USDA FS 1933) (known more commonly as the Copeland Report)—a two-volume nearly 1,700-page report on the state of forestry in America with recommendations.³ Beside calling for planned forestry development through cooperative arrangements with forest industries for sustained yield and to build up

³ On March 27, 1933, *A National Plan for American Forestry* was transmitted to the Senate. The idea for this report, according to Clapp, developed during a meeting of a small group of people in the fall of 1931. While reviewing the forest situation from the standpoint of the responsibilities of research organizations in general, and of the research organization of the Forest Service in particular, they came to the conclusion that one imperative need was for an entirely fresh examination of the whole forestry situation in the United States as a basis for clarification and reorientation. This opportunity came “out of a clear sky” on March 30, 1932, months before the 1932 presidential election, when Senator Royal S. Copeland from New York called for a congressional investigation of forestry under Senate Resolution 175. The central purpose of Copeland’s investigation was to outline a coordinated plan that would “insure all of the economic and social benefits which can and should be derived from productive forests by fully utilizing the forest land” (Clapp 1934, Godfrey 2005). In July of that year, Earle Clapp wrote to all experiment station directors that the Copeland resolution offered a “great opportunity” to restate American forestry in a positive fashion, much like the Capper Report had done a decade earlier (Steen 1998). Regional Forester S.B. Show, along with Director Edward Kotok and his staff, responded to Clapp’s letter by preparing a lengthy, detailed, and very comprehensive report on California’s forestry situation including research (USDA FS 1932a).

public forests (Stuart 1933), the *Copeland Report* brought together the latest forestry information and included two sections on Forest Service research.⁴ The first section written by Clapp himself provided a history of the BR, which Clapp portrayed as a “nearly heroic struggle for independence from the administrative side of the agency.” Clapp’s chapter contained an impressive list of accomplishments. It also criticized previous Forest Service administrations for “routinely using Research as a dumping ground for those who did not fit well in Administration.” The second section, written by Earl Frothingham,⁵ provided a recommended research program for the future. Frothingham’s piece pointed out that although the Forest Service research program had been coordinated and given independence, much of forestry research was still being conducted outside the agency,⁶ making it dependent upon the works of the Bureau of Plant Industry (BPI) for forest pathology; the Bureau of Entomology (BE) and the Bureau of Chemistry and Soils (BCS) for handling naval stores; the Biological Survey for forest biology;⁷ the Bureau of Fisheries (BF) for research on fish living in forest waters; and the Weather Bureau for contributions to fire research.⁸ Subsequent developments would make the Forest Service less dependent on the work of some of these USDA agencies (Steen 1998). Despite the enormous staff time that the experiment stations and Clapp’s Branch of Research put into this project in the latter half of 1932 and early 1933, the

⁴ Regular research activities were curtailed by the experiment stations in order to prepare raw material for the report. Then, in Washington, D.C., the BR digested the information to formulate the final report. In this effort, a considerable number of ranking officers of the Forest Service field force, and experiment station staff members, like S.B. Show and Edward Kotok, were detailed to the Washington office to assist in writing and rewriting various sections of the report (Stuart 1933).

⁵ Earl Frothingham was Director of the Appalachian Forest Experiment Station in Asheville, North Carolina.

⁶ At this point, the bulk of forest research in the United States was being done and would continue to be done by government agencies, such as the Forest Service, although in the aggregate considerable amount of research was being conducted by forest schools, universities, states, and other public or semipublic agencies. The BR directed the research, but the regional forest experiment stations were charged with all regional work in forest management and other wild lands, and in a few instances, investigations in forest products (Graves and Guise 1932).

⁷ The McSweeney-McNary Act authorized experiments and investigations as needed to determine the “life histories and habits of forest animals, birds, and wildlife, whether injurious to forest growth or of value as supplemental resource, and in developing the best and most effective methods for their management and control.” However, this work was assigned to the Biological Survey (Storey 1975).

⁸ The McSweeney-McNary Act also authorized investigations of the “relationships of weather conditions to forest fires as may be necessary to make weather forecasts.” This work was assigned to the Weather Bureau at the time (Storey 1975).

Copeland Report landed with a dull thud.⁹ President Roosevelt appeared disinterested in it, and Congress took no action on the plan, largely because the monumental two-volume report strongly and repeatedly advocated federal regulation of the forest industry, a concept that Congress would not support (Steen 1998, Stuart 1933). For instance, the *Copeland Report* stated that practically all of the major problems of American forestry centered in, or had grown out of, private ownership, and that there was a serious lack of balance in constructive efforts to solve the forest problem between public and private land ownership. The report ultimately recommended greater public ownership of forest lands versus private ownership and proposed a land acquisition fund of \$50 million per year for that purpose¹⁰ (Godfrey 2005, Steen 2004).

The Battle for a National Forestry Plan

Regardless of the indifference to the *Copeland Report*, things were looking good for the Forest Service by August 1933, thanks to the relief and recovery measures of various New Deal programs. Then came the shocking news on the morning of October 23, 1933—Chief Forester Robert Stuart had died¹¹ (Silcox 1934). Stuart's untimely death came in the midst of a transition period in the Nation's forestry policy, and the campaign to implement the *Copeland Report's* recommendations for a single national forestry plan into a single bill before Congress. Within a week of Stuart's death, President Roosevelt approved the appointment of Ferdinand A. Silcox¹² to succeed Stuart. Inevitable questions arose regarding Silcox's appointment. Forest Service leaders had not been consulted prior to the appointment, and some

Practically all of the major problems of American forestry centered in, or had grown out of, private ownership, and that there was a serious lack of balance in constructive efforts to solve the forest problem between public and private land ownership.

⁹ For an excellent description of various reactions to the *Copeland Report*, see Steen 2004.

¹⁰ At the start of the New Deal period, reforestation became a prime factor in the New Deal's sustained-yield forestry effort, and timberland acquisitions were a major component of Region 5's program. Region 5's acquisition program included plans to buy up cutover pine regions, and to acquire various redwood forest tracts from private landholders for a future redwood national forest. The depressed timber market meant many private holdings were tax delinquent, and owners wished to liquidate their holdings to the Forest Service. The National Forest Reservation Commission, a commission authorized by the Weeks Act (1911), approved Region 5 acquisitions of these lands (Godfrey 2005).

¹¹ Stuart died on October 23, 1933, under questionable circumstances of whether he had or had not committed suicide (Steen 2004).

¹² Ferdinand A. Silcox was a contemporary of early California District 5 Forester's Frederick E. Olmsted and Coert DuBois who had come west when the forest reserves were transferred from the General Land Office (GLO) to the Forest Service. After serving as District 1's Forester under Chief Forester William B. Greeley and in the 20th Engineer group during World War I, Silcox transferred to the Labor Department after the Great War to act as an arbitrator in shipyard labor problems. There he met Rexford Tugwell, a Columbia University economics professor, who became a leading spokesman and prophet of the New Deal. Assistant Agricultural Secretary Tugwell secured Silcox' appointment through political lobbying with the president (Godfrey 2005).

Silcox, in what can only be described as a power struggle with his regional foresters, reorganized procedures between the Washington office (WO) staff, regional foresters, and experiment stations directors.

regional foresters, like Stuart B. Show, felt that Silcox had been out of the Forest Service for too many years, and that he was far out of date. Silcox tried to assuage these concerns by making quick trips to various regions and attending regional forester meetings to educate himself on the current state of affairs (Godfrey 2005). To enlist the support of research scientists, in December of 1935, he delivered an address entitled “Science in the Service of Society” at the Minnesota Agricultural Experiment Station that emphatically defended the role of scientists in the Forest Service (Silcox 1935b).

However, by 1935–1936, Chief Silcox, in what can only be described as a power struggle with his regional foresters, reorganized procedures between the Washington office (WO) staff, regional foresters, and experiment stations directors. First, Silcox asked Earle Clapp, BR head, to become his associate chief.¹³ Clapp accepted the promotion with great reluctance, writing to Forest Service scientists across the country that he was “leaving Research with an uneasy feeling about its future” (Steen 1998). Then Silcox began a new plan of regular staff conferences. The regional foresters, directors of the forest experiment stations, and members of the central staff were to meet quarterly (except in the summer) to consider questions of policy and strategy (Silcox 1935a). Finally, in 1936, Silcox reorganized the WO, increased the number of divisions from 8 to 23, and based them upon function. Research was grouped into five distinct divisions (Silvics, Forest Products, Forest Economics, Forest Influences, and Range Research). Forest protection, which included fire, disease, and insect control, was placed in a group of divisions designated as national forest administration under Silvics. Then Silcox appointed a staff of eight assistant chiefs of the Forest Service¹⁴ who served collectively as Silcox’s staff, with such lines of duties as were delegated by the chief of the Forest Service (no longer referred to as chief forester) and performed on his behalf (Silcox 1936).

After this shake-up of the Forest Service administration, Silcox, Clapp, and others resumed the campaign to implement the recommendations of the *Copeland Report* through an all-inclusive bill before Congress. They circulated bill drafts and set the target passage date for 1936. But because of bad political timing, and continued economic woes, their lobbying efforts failed (Steen 2004). Despite not achieving a national plan, the period after 1936 was not bereft of other legislative

¹³ Before Clapp left his position as BR head, the Rocky Mountain Forest and Range Experiment was established in Fort Collins, Colorado, thereby completing the chain of continental forest experiment stations officially authorized by the McSweeney-McNary Act (Silcox 1935a).

¹⁴ Although these assistant chiefs were not to be administrative officers interposed between the Chief and his division chiefs, in S.B. Show’s opinion, they had the potential to block off access by regional foresters to the Chief (Godfrey 2005).

accomplishments, such as the passage in 1937 of the Norris-Doxey Cooperative Farm Forestry Act and the Bankhead-Jones Farm Tenant Act.¹⁵ During this interim period since Clapp left the BR, Raymond E. Marsh, a long-time assistant of Clapp's, had served as "acting" head. Marsh held this position for 2 years, along with his position as the head of Division of Forest Economics Research. Marsh continued along the path chartered by his mentor Clapp, but certainly not with the same intensity as his former boss. In 1937, Marsh moved on to be Assistant Chief for Program Planning, and Clapp put Clarence L. Forsling¹⁶ in charge of the Branch of Research, a position he reluctantly accepted (Forsling 1978, Storey 1975). Clapp believed that Forsling was "one of the strongest and most promising of the new forest experiment station directors," and Forsling held the post until 1944, when he transferred to the Interior Department and served as Director of the Grazing Service (1944–46).

Meanwhile, in September 1938, the McSweeney-McNary Act celebrated its decennial year. To honor the occasion, the *Journal of Forestry* published a special issue on the act (Journal of Forestry 1938). The *Journal* attested to the substantial advances made in federal forest research, calling its passage "second in importance and significance only to the Act of March 3, 1891, authorizing the President to set

¹⁵ These pieces of legislation supported economic studies related to farm forestry and agricultural cooperatives, respectively, and bolstered various economic research studies at the experiment stations (Steen 1998). The Cooperative Farm Forestry Act passed on May 28, 1937, authorized cooperation in developing farm forestry in states and territories, and had an annual appropriation of \$2.5 million (USDA FS 1937a) to raise and distribute trees and plant them on farm woodlands; to advise farmers with respect to protecting and managing farm forests and harvesting, utilizing, and marketing farm-forest products; and to investigate farm-forestry problems and methods generally. Overall administration was left to the Soil Conservation Service, but parts of the appropriation were available to the Forest Service (USDA FS 1939b). The relevant portion of the Bankhead-Jones Farm Tenant Act required the Secretary of Agriculture to develop a program of land conservation and utilization to correct maladjustments in land use and assist in such things as reforestation and the protection of fish, wildlife, and natural resources.

¹⁶ Clarence Forsling joined the Forest Service in 1915 as a grazing assistant assigned to the Cache National Forest in Utah after receiving his B.S. at the University of Nebraska. Forsling served the agency for 35 years. His years of service included work on the Jornada Experimental Range in New Mexico (1916 to mid-1920), Office of Grazing Studies in Washington, D.C. (mid-1920 to 1922), as head of the Great Basin Experimental Station in Utah (1922–1929), director of the Intermountain Forest and Range Experiment Station (1929–1934), Director of the Appalachian Forest Experiment Station (1935 to mid-1937), when he became assistant chief of the Forest Service in charge of research.

No stations were forthcoming for Alaska, Hawaii, and the West Indies as authorized by the McSweeney-McNary Act.

aside forest reserves from the public domain” (Journal of Forestry 1938). The *Journal* furthermore editorialized that the “scientific basis of American forestry” has emerged largely under the act and that in this

...brief span of ten years the Forest Service has developed an effective and efficient forest research organization, an organization which has served the public well, an organization which has met its problems with ability, an organization which is destined to serve the American public in a still wider field of usefulness [Journal of Forestry 1938: 830].

The *Journal of Forestry* issue featured several articles on the state of affairs in silviculture, fire control, managing range resources, watersheds, and numerous other important subjects (Journal of Forestry 1938). Earl Clapp contributed the lead article (Clapp 1938) that highlighted the contributions and achievements under the McSweeney-McNary Act. In his article, Clapp also aptly pointed out that the current picture had some shadows as well, putting forward that although a station had been authorized for the Plains Region,¹⁷ no stations were forthcoming for Alaska, Hawaii, and the West Indies as authorized by the McSweeney-McNary Act. Clapp also noted that the McSweeney-McNary Act had not explicitly provided for investigations in the crucially important fields of forest and range influences. Clapp felt that serious financial limitations had been placed on the nationwide Forest Resources Survey, or FRS, authorized by the act, and he argued that the act made no provision for the publication of investigative results by the Forest Service. Consequently much-needed information frequently was delayed several years until it appeared in formal publications. Finally, he stated that although provision was made for the collection of basic data needed in national planning, there was no specific provision for forest land and forest resource planning—a statement referring to his failure to achieve the basic recommendation of the Copeland Report (Clapp 1938).

Meanwhile, Clarence Forsling’s general plan for the Research Branch was to improve the organization, and obtain a budget sufficient to address the problems faced by the Forest Service. He wished especially to expand studies in forest products, forest economics, and range management (particularly the influence of forest and range plant cover on runoff and erosion). In regard to organization, Forsling tried to cut down the number of regional stations and consolidate and redistribute

¹⁷ The McSweeney-McNary Act did not specifically call for a station to serve the Great Plains region. However, the myriad of problems connected with the planting of shelterbelt stands in the region was just beginning, which made the need for such a station evident in Clapp’s mind (Silcox 1935a). In 1936, the act was amended to authorize a Great Plains Forest Experiment Station (Silcox 1936).

the territory covered by each¹⁸ (Forsling 1978). Like his predecessor, Earle Clapp, Forsling also struggled to fully activate the research program authorized by the McSweeney-McNary Act. Increasingly, Forsling recognized that the gap between needed work and what was being accomplished was steadily widening. For instance, Forsling pointed out that in 1938, the Forest Service's research program met only about two-thirds of the needs visualized in the Forest Research Act passed 10 years prior. Furthermore, Forsling stated that new problems had arisen, or had become better recognized, since its passage. Although it was true that from a dollars-and-cents standpoint, Forest Service research appropriations had increased from \$906,000 in 1928 to \$2.6 million in 1938, Forsling saw a research appropriation need at a level of \$10 to \$12 million (Storey 1975).

In the interim, the Roosevelt administration started to support the national forestry plan asked for by the *Copeland Report*. On March 14, 1938, the President recommended to Congress an immediate study of the Nation's forest problem (Journal of Forestry 1940, USDA FS 1939b). Congress responded to the presidential suggestion and on June 13, 1938, adopted Senate Concurrent Resolution 31 creating the Joint Congressional Committee on Forestry (JCCF). The JCCF was charged with investigating the present and prospective forest situation, including research¹⁹ (Steen 2004, USDA FS 1938b). Roosevelt reiterated his support for JCCF on November 18, 1939, in a letter addressed to the Society of American Foresters (SAF) (Journal of Forestry 1940), and Chief Silcox and Earle Clapp provided testimony to the congressional committee that emphasized the need for public regulation—a crucial point that had undermined the *Copeland Report* in 1933 by antagonizing industry. Much of this information came from regional foresters and experiment station directors like S.B. Show and Edward Kotok (Steen 2004). The Forest Service annual report for 1939 also called for public ownership of privately owned forest land (USDA FS 1939b). In the midst of this private vs. public ownership of forest lands battle, tragedy once again struck the leadership of the Forest Service. On December 20, 1939, Chief of the Forest Service Silcox died suddenly

The Roosevelt administration started to support the national forestry plan asked for by the *Copeland Report*.

America was in “transition from a philosophy of exploitation to one of planning and applying sustained management and orderly utilization.” Kotok felt that organized research was the “surest, quickest, and most economical way of obtaining the information.”

¹⁸ Forsling succeeded in combining the Adirondack and Northeastern stations prior to his leaving the Forest Service. Other combinations would eventually follow. By 1978, reorganization efforts included combining the Northern Rocky Mountain and the Intermountain Stations, and the merging of the Southwestern and Rocky Mountain Research stations. By this date, the Central States Station was merged with several others and, together with the Great Lakes Station, became the North Central Station (Forsling 1978).

¹⁹ At this point, according to CFRES Director Edward Kotok, from a forest-resource standpoint, America was in “transition from a philosophy of exploitation to one of planning and applying sustained management and orderly utilization.” Kotok felt that organized research was the “surest, quickest, and most economical way of obtaining the information” (Kotok 1948: 2).

at his home of coronary thrombosis (USDA FS 1940d). However, prior to Silcox' death, Clapp had begun a nationwide educational program designed to obtain public understanding of his point of view of the forest problem in the United States and to drive the Forest Service into a "New Crusade" for conservation (Godfrey 2005), and President Roosevelt felt compelled to name Associate Chief of the Forest Service Clapp as "acting" Chief, even though Clapp had angered Roosevelt with his earlier efforts to oppose the transfer of the Forest Service to the Interior Department (Steen 1998).

Early in 1940, Acting Chief Clapp and the Forest Service presented background material to the JCCF and recommended an overall action program. The basic purpose of the Forest Service program was to create and maintain a nationwide economy, through productive use of forest land. They felt that doing so would help solve such pressing problems as rural poverty and unemployment and create added security and stability for families, communities, industry, and labor (USDA FS 1940d). However, Clapp's efforts proved unsuccessful. On March 24, 1941, after some delay and after digesting a huge mass of detailed information provided by the Forest Service,²⁰ and the recorded testimony of industrial and other forest land owners such as farmers, and many others, the Joint Congressional Committee on Forestry submitted its report to the Congress. The JCCF report stressed the need for more public cooperation with private owners of forest lands (USDA FS 1941b), but in fall 1941, when a "Forestry Omnibus Bill" was reported out by the JCCF to Congress, it did not contain any federal regulation of privately owned forest lands. Therefore, the Forest Service failed to support it, and the Omnibus Bill died in committee (Steen 2004).

The demise of the Forest Omnibus Bill that fall ended the social/public forestry movement in America.

The demise of the Forest Omnibus Bill that fall ended the social/public forestry movement in America. Meanwhile, in August 1940, as a result of what was happening in Europe and the Far East, Acting Chief Clapp placed the Forest Service on a war footing, pointing out that although America's first line of defense was her manpower, much of the Nation's immediate strength lay in its natural resources, such as forest lands (USDA FS 1940d). As involvement in World War II approached, total annual appropriations for the Forest Service remained at a constant amount, but various research programs received decreasing assistance from the various New Deal programs that had started in the early 1930s. Then, quickly, the Forest Service research program was thrown into a war effort after the Japanese bombed Pearl Harbor on December 7, 1941. By then, the Forest Service had greatly reoriented its work programs and pushed defense projects to the forefront, slowing down

²⁰ For instance, CFRES staff submitted various materials for the JCCF, such as statistics on forest areas, timber types, and consumption in California as requested (Aitro 1977).

basic forestry research work. Most functional lines of research (silvics, economics, influence, and range research) were forced to retrench, with the exception of forest products, which mushroomed as the Forest Products Laboratory began doing extensive work for the armed services.

Research Station Exponential Growth, 1933–1938

In 1933, the area of the California station's responsibility was that of Region 5, which included all of California, plus a strip of Nevada of 9 to 10 million acres. California's forest area included approximately 20 million acres that supported a timber stand estimated at about 363 billion board feet. The Nevada area had very little timber, limited mainly to mountain juniper and subalpines. Millions of acres of land, running through every topographic class, were also used for the grazing of cattle and sheep, a major industry in the state. Although the station's territorial responsibilities remained the same as when the station was established in 1926, its research program and physical facilities grew in leaps and bounds. For instance, in 1926, the California Experiment Station had a staff of four technicians and two clerks. Ten years later, there were 32 permanent technical staff and 12 clerks, besides a force of relief workers, which at its peak had reached nearly 1,000 (USDA FS 1937b, 1937d; Casamajor, n.d.). During the Great Depression, the station and its projects also turned out to be an important source of part-time, full-time, and career employment for University of California foresters and students (Casamajor, n.d.). According to Station Director Kotok, at this time,

...many of the graduates of the forestry school found themselves without jobs. The first opportunity for direct extra money that the station... received, we recruited these forestry graduates who were without jobs and gave them these temporary jobs. We trained them specifically in such research jobs in which they could apply their skills later as administrators [Show 1965: 9].

Subsequently, A.E. Wieslander's cover type map project, begun in 1926, initially tested many of these young recruits. Thereafter, they were transferred to different planning jobs (Show 1965).

To meet the demand of station scientists and research staff, the station's library grew as well. The function and services of the station library were under the direction of Annie M. Avakian. By the end of the decade, the station's library catalogued 10,000 volumes and received over 100 scientific and professional periodicals, not to mention branch libraries at various facilities, such as the San Dimas Experimental Forest (SDEF) and the Institute of Forest Genetics (IFG) (both discussed below). Besides routing magazines, monthly accession lists, and circulating books, library

Kotok organized a corps of employees whose sole duty was to conduct tours for distinguished visitors.

staff fielded research questions, translated key articles (French, German, Spanish, and Russian), assembled specific subject matter for lectures and manuscripts, and published a one-page publication *Library Notes* in which brief abstracts of selected publications were presented. Finally, Director Kotok designated the library as the agency for distribution of all station publications (USDA FS 1940a).

In addition to the collection of books and other research material, CFRES, with the cooperation of the University of California and WPA labor, established an herbarium on the Berkeley campus. By 1938, the herbarium contained a collection of more than 25,000 species and was widely used by botanists and ecologists. For CFRES, it was a very important adjunct to the vegetation type mapping project because it furnished reference material of known sources for field-mapping crew training. By this date, CFRES also proposed building a separate seed collection herbarium at Berkeley as well (USDA FS 1939a).

Interestingly, by the end of 1935, the increase in visitors to CFRES and its branches, especially at SDEF, had become a serious drain on staff time. Station Director Kotok realized that making public contact was a valuable asset, but scientists, who for the most part constituted the majority of visitors, could hardly be satisfied with a “canned” lecture. To solve the problem, Kotok organized a corps of employees whose sole duty was to conduct tours for distinguished visitors, many of whom came from as far away as Sweden, Germany, and even India. Visitation demands had not only increased at the station, but by late 1935, the need for a statistical service became evident as well (USDA FS 1935). To meet this demand, Station Director Kotok organized a centralized statistical division and placed it under the direction of Kathleen G. Brecheen. She and her staff of emergency workers from the NIRA and PWA programs handled government statistical analyses as requested by various divisions and Region 5. These services, which saved much division staff time, included both routine calculations and advisory work (USDA FS 1941a). At CFRES, the statistical services section was placed under the forest products division, where it conducted statistical research not just for the CFRES, but also for outside agencies, such as the California Economic Research Council (CERC). H.R. Josephson was one important employee hired through NIRA funding. Josephson received his M.S. in forestry at the University of California in 1933, and joined CFRES in January 1934, to work in the wood products division helping C.L. Hill on various projects, such as compilations regarding forestry statistics for CFRES divisions, as well as wood requirements of wood-using industries for building in various California urban communities. Another assignment that took up the time of the statistical section included an evaluation of the purchases for the redwood region for Hubert Person (USDA FS 1934: January, February, March, April). By

1939, personnel at the section numbered 16, of whom 13 were WPA clerks. In this precomputer era, much of their time was devoted to keeping up with the current statistical literature in order to receive the fullest benefits from new trends in methodology and statistical design in current routine project work. Their work was essential in forest management, fire, and genetics research (USDA FS 1940a).

Probably the most important individual administrative development during the 1930s at CFRES occurred when the Forest Service acquired the IFG at Placerville, California. Since 1933, IFG had continued to suffer financial reverses, despite grants from the Carnegie Foundation and temporary aid from the BPI, the Forest Service, and the Soil Erosion Service (later Soil Conservation Service). This assistance barely kept it afloat. Rather than lose valuable work underway, Congress appropriated \$40,000 to purchase the institute so that CFRES could carry on the valuable lines of investigation as part of its research program. On August 23, 1935, after a long series of negotiations between Clapp and Kotok and the IFG's Board of Trustees, the institute was gifted to and officially transferred to the Forest Service.²¹ The IFG kept its designation but was placed under CFRES' forest management research division. This action marked the first step in a program of genetics studies long contemplated by the Forest Service. However, the scope and application of the IFG's research expanded beyond California to the Nation, and now involved cooperative work with various other experiment stations²² (Austin et. al. 1974; Silcox 1935a, 1936; Stone 1968; USDA FS 1935: September).

Acquiring IFG was but part of an enormous push to expand the station's research program. When the station was established, its activities largely pertained only to forest management in the pine region, and to conducting a forest survey (type map) of California. A decade later, the CFRES research program included forest management in California's pine and redwood regions, as well as range research, fire research, forest influences, forest survey, forest products, forest economics, and genetics with the acquisition of the IFG (Casamajor, n.d.; USDA FS 1937d). The CFRES grew regionally outward as well, thanks to the quick actions of both Regional Forester Show and Director Kotok in taking advantage of the CCC

Acquiring IFG was but part of an enormous push to expand the station's research program.

²¹ Apparently, there was competition between the Forest Service and the BPI over acquiring the institute. Lloyd Austin preferred the latter organization because he felt they were more scientific and could better understand the institute's fundamental research goals than the practical-minded CFRES (Austin et al. 1974).

²² At this time, parallel work in the East was assured through congressional approval of genetic studies at the Northeastern Experiment Station at Amherst, Massachusetts. However, the Forest Service budget was too tight at this time to allow genetics work at other stations, such as in the South, which had to wait until World War II drew to a close to obtain sufficient congressional increases for research in genetics (Harper 1978).

Construction of the station's desired physical facilities were nearly complete thanks to New Deal emergency employment programs.

program. Director Kotok wanted to expand the work of the station further by developing experimental forests throughout California—a research program ambition dating to the station's beginnings. Therefore, when President Roosevelt requested a detailed work program for each CCC camp, S.B. Show submitted a list that provided a sufficient number of camps allocated to the work on the experimental forests and ranges on Director Kotok's wish list. In the end, Regional Forester Show managed to secure 127 CCC camps on national forests for Region 5—a remarkable number. By June 30, 1933, all of the camps were fully occupied and the enrollees ready for work. Some Forest Service regions in the country had no plans for their experiment stations, and unlike Region 5, had to wait many years before they found the necessary labor to build them (Godfrey 2005, Show 1965).

During the years 1933 to 1937, Station Director Kotok made a conscious effort to acquire experimental forests and ranges for the California station and to develop physical facilities on them using emergency program labor with a long-term point of view in mind. By the end of 1937, Director Kotok commented that the construction of the station's desired physical facilities were nearly complete thanks to New Deal emergency employment programs. Thereafter, a drastic curbing of emergency funds in 1937 slowed construction, and in 1938, a dire curtailment of CCC funds occurred. Nonetheless, besides its Giannini Hall offices on the campus of the University of California, by 1938, CFRES had 10 experimental forests, areas, and ranges. Only two, the Shasta Experimental Fire Forest (SEFF) (1931) and the Swain Mountain Experimental Forest (SMEF) (1932), had been established prior to the New Deal. However, the utility of the old and new experimental forests, according to Kotok, in providing adequate quarters for field parties, in supplying a base of operations in representative forest types, and in making available important centers for the assembly of the interested scientists, would be amply demonstrated in the future (USDA FS 1939a).

The history of each new experimental forest will be discussed later in the text, but for now, they included the following. In 1938, three experimental forests and one experimental area were established to study forest management. They included the Feather River Experimental Forest (FREF) (1933) on the Plumas National Forest that studied west-side mixed conifers, SMEF (yet undeveloped) on the Lassen National Forest for the study of white and red fir (see "Scientific and Common Names" section), and the Blacks Mountain Experimental Forest (BMEF) with Branch Station (1934) on the Lassen National Forest. There was also the Stanislaus Experimental Area²³ with Branch Station—a small 30-acre experimental area for

²³ An experimental forest had yet to be approved here, but eventually the Stanislaus-Tuolumne Experimental Forest (STEF) was designated in 1943.

the study of ponderosa and sugar pines. For dedicated range research, the San Joaquin Experimental Range (SJER) with Branch Station (1934) near the Sierra National Forest was devoted to cattle range problems in the San Joaquin Valley and foothills, and the Burgess Springs Experimental Range (BSER) (1935) with Branch Station on the Lassen National Forest was dedicated to cattle grazing problems on the east-side cutover forest ranges. On the other hand, SEFF with Branch Station (1929) on the Shasta National Forest concentrated on the fire problems of Region 5. Finally, forest influence research was conducted at two locations. Research on chaparral cover of southern California forests was conducted at the SDEF (1934) on the Angeles National Forest, while influences on woodland grass cover types of the Sierra Nevada were studied at the Kings River Branch Station (1938) on the Sierra National Forest, which was divided between two units, the Big Creek Unit and the Teakettle Creek Unit (USDA FS 1937b 1937d).

In addition to the above experimental forests, there were also several research withdrawals that did not have experimental forest status. First, there was the Devil Canyon watershed study unit on the San Bernardino National Forest with Branch Station and nursery. In 1930, the Devil Canyon unit was selected for the first intensive forest influence study in California after a 117-acre area at Devil Canyon was completely denuded by fire in 1925 (Kotok 1930). At Devil Canyon, CFRES staff continued to conduct intensive research on watersheds.²⁴ Then there was the Butterfly Valley research unit on the Plumas National Forest, set aside to study mixed conifers, which in 1937 was fenced and accessible. Finally, there was the Badger Wells research unit on the Modoc National Forest, whose research value unfortunately had been severely damaged by a bark beetle epidemic in the mid-1930s (USDA FS 1937d, 1940b).

Although by 1937 many items on the station's experimental forest wish list had been fulfilled, Director Kotok and the CFRES staff felt they urgently needed three additional experimental forests. For forest management research purposes, the station wanted an additional experimental forest in the Sierra Nevada foothills second-growth pine forest. At this time, more than a quarter million acres of this second growth, which had succeeded the cutting of the mining days, was just reaching or approaching merchantable size. The CFRES staff felt that destructive exploitation by migratory small mills was already beginning there, and proceeding at an accelerating pace. Station staff also desired two experimental forests in the

**CFRES staff
continued to conduct
intensive research on
watersheds.**

²⁴ This forest nursery of just over 2,700 acres also provided nursery stock used by the CFRES and cooperating agencies.

redwood region to meet the urgent problems of older redwood forests of Humboldt County, and the younger ones of Mendocino County. Finally, they also hoped to gain an experimental sheep range, preferably in the foothills tributary to the Sacramento Valley. Sheepmen were making urgent demands that their industry receive the same help that was given to the cattle industry through the San Joaquin Experimental Range. Finally, in the not too distant future, station staff wanted to acquire a northern experimental watershed forest, preferably on one of the watersheds tributary to the Sacramento Valley, where many conditions (soil erosion, cover, rainfall) were significantly different from those found in the southern part of the state (USDA FS 1937b, 1937d, 1939a). As will be seen, only a few of these wishes, such as the establishment of an experimental forest in the redwood region of the state, were fulfilled prior to the beginning of World War II.

Forest Problems of California and Lost Leadership

While vying for additional experimental forests, the station was tasked by Acting Chief Earle Clapp to educate the California public regarding the differences between public and private management of forest resources—the frequently opposing forces that were then testifying before the Joint Congressional Committee on Forestry or JCCF. Clapp hoped that if people became interested in the forestry problem they would naturally want to do something about it, and that interest would reach the JCCF. In support of Clapp’s education program, Director Kotok and the California Station produced a lengthy report entitled *The Forest Problems of California*²⁵ (USDA FS 1940c).

²⁵ This report detailed difficulties associated with private ownership, which controlled half of the commercial forest land in California (5.5 million acres of pine timberland and 1.4 million acres of redwood). In comparison, public ownership (federal, state, county, and municipal forests) controlled the other half of California commercial timber. However, although publicly owned forests in California accounted for 40 percent of the total annual growth of commercial timber, it furnished only 12 percent of the annual cut, mainly because cutting was regulated and public timber was generally located in more inaccessible districts. *The Forest Problems of California* also closely described the national forests in terms of their extent, and the problems affecting them, particularly in regard to protection, use, and proper development of their four major resources: water, timber, forage, and recreation. The crux of the water problem on the national forests rested in the condition of the vegetative cover, which in turn depended on effective fire protection and prompt restoration of cover where natural processes were slow to recover. But in 1940, 15 million acres of water-yielding protection forest were in private holdings, which, according to *The Forest Problems of California*, prevented a well-managed forested watershed. The most critical problem in timber on the forests pertained to the difficulty of properly utilizing the 90 billion board feet of government timber and adjacent private holdings through sustained-yield management plans. Many public units were intermingled with private holdings, which, according to *The Forest Problems of California*, hindered this type of utilization and presented problems in fire, insect, and disease control, as well as reforestation (Godfrey 2005).

But, on December 4, 1940, the leadership of the CFRES changed abruptly when Earle Clapp named Station Director Edward Kotok as Assistant Chief of the Forest Service in charge of the Division of State and Private Forestry. In his new position, Kotok directed a number of cooperative programs underway between the Forest Service and state and extension foresters that sought to improve forest management, fire control, and forest planting in the various states. Kotok was also placed in charge of two other projects. The first was the New England Forest Emergency Project, which was concerned with forest fire hazard reduction and timber salvage following the 1938 New England hurricane,²⁶ and the Prairie States Forestry Project, which supervised WPA shelterbelt projects (Journal of Forestry 1941). Murrell W. Talbot, who headed CFRES' grazing division, was made associate director, a position he held until war's end,²⁷ although he is officially considered as the station's second Station Director.

CFRES Contributions to the “Grandeur” in Forestry, 1933–1941

It would be great if one could say that research at the CFRES in the New Deal period resulted in a giant step forward in forestry. But in forest research, as in other research, as one CFRES researcher pointed out, “bits of information must be combined with other facts in order to achieve even a small step forward. Aristotle once said, ‘From all the facts assembled there arises a certain grandeur’” (Fowells 1978: 11). During these years, facts gathered by CFRES scientists certainly contributed to some grandeur in forestry, as the station delved into five lines of research set out by Forest Service Chief Silcox: forest management, range research, forest products, forest economics, and forest influences (forest and range).

²⁶ In September 1938, New England was hit by a terrific hurricane, which left the most dangerous and widespread forest-fire hazards the region had ever known. On large forest tracts, and on some 30,000 farm wood lots, it left an estimated total of 3 to 4 billion board feet of downed timber. This amount represented more than one-sixth of the total annual cut of timber in the entire United States at this time. To handle the crisis, the Forest Service set up the New England Forest Emergency Organization with headquarters in Boston, Massachusetts. Timber salvage recovered an appreciable part of the wrecked forest resource there. By June 1941, the Forest Service had taken delivery of and paid for the equivalent of nearly 700 million board feet of timber from farm woodlands and other forest lands in six New England states (Journal of Forestry 1938; USDA FS 1939b, 1941b).

²⁷ Talbot graduated in forestry from the University of Missouri in 1913 and joined the Forest Service shortly thereafter working at various positions in the Southwest. He came to CFRES in 1931 and worked chiefly on range research. After World War II, Stephen B. Wyckoff was named Station Director, but Talbot remained on, serving as associate director until his retirement in 1955 after 42 years of service. Subsequently, he worked as a consultant in forest range management to the government of Spain and in watershed management for the Charles Lathrop Pack Forestry Foundation (Journal of Forestry 1941).

Forest Management

By the end of the 1930s, the CFRES forest management research program included three basic areas: silvics, silviculture, and forest fire protection.²⁸

Silvics—

When CFRES acquired IFG in 1935, it became the center of most silvics research at the station. During its first year of operating IFG as a Forest Service facility, Lloyd Austin and his staff's initial concerns pertained to the physical transfer of the property and records, reorganizing them to conform to Forest Service methods of handling research, and then analyzing and interpreting them. Little new investigative work was undertaken until this back work was well in hand (Silcox 1936, USDA FS 1935: November).

While Austin and his staff conducted this backlog work from 1935 to 1938, they were also occupied with the development of improved facilities (early buildings were demolished and replaced) and the task of filling various staff positions necessary for the full realization of the institute's program. By 1938, the institute had a superintendent's residence, office, laboratory, seedhouses, staff house, warehouse, nurseries, and an arboretum of 33 acres of established plantings (fig. 47). Here, the institute's five technical personnel and three workers could research general subjects such as progeny tests, breeding and hybridization, cytology, taxonomy, and the physiology of forest trees. While Director Austin publicized the work of the institute and the science of genetics (e.g., Austin 1928b, 1938), important CFRES scientists, such as Francis I. "Pete" Righter, physiologist Nicholas T. Mirov,²⁹ and cyto-taxonomist Palmer Stockwell,³⁰ began to publish on various aspects of the subject as well. With a complement of new technical personnel and new facilities,

²⁸ During the New Deal period, no significant mensuration studies were conducted at CFRES, except for performing the seasonal 5-year growth measurements of the sample plots at the Stanislaus and Feather River Branch Stations (USDA FS 1940a). There was also a need for satisfactory volume and taper tables for redwoods (USDA FS 1937b). The CFRES began this work in 1938 (USDA FS 1939a), but the work would not be completed until World War II (USDA FS 1940a).

²⁹ Nicholas T. Mirov was a Russian-trained plant physiologist who emigrated to America after political disruption in his native country forced him to leave. He received his Ph.D. at the University of California, Berkeley. In 1937, he joined the staff of the institute as the first plant physiologist appointed by the Forest Service. Mirov spent 27 years at the institute where he demonstrated the importance of physiological studies in determining relationships among plants (Stone 1968).

³⁰ Palmer Stockwell received his Ph.D. in cyto-taxonomy from the University of Arizona and did some work at Stanford University's Carnegie Institute Laboratory prior to joining the institute's staff in 1937 (Austin et al. 1974).



U.S. Forest Service, Pacific Southwest Research Station

Figure 47—View of buildings at the Institute of Forest Genetics.

attention was now given to planning and coordinating a long-range research program. In the past, IFG devoted research efforts to two types of studies. The first type was the production of new and superior forms of timber trees. By 1936, preliminary studies resulted in a number of hybrid pines. Furthermore, they learned that particular pines produced fertile flowers at the very early age of 2 to 5 years, thereby dispelling the myth that tree breeding could not be accomplished in the short term.³¹ Apparently, the time necessary to run through a breeding cycle, long considered a major disadvantage in tree breeding, had been greatly exaggerated, and was only slightly longer than that required by a number of other major crop plants. The second past study goal for the institute was pioneering the genetic approach to the problems of forestry, and the development of better techniques for general application by public and private forestry agencies (Austin et al. 1974; Mirov 1939; Silcox 1936; USDA FS 1939a, 1940a, 1940c, 1940b, 1965c).

Up to 1939 or so, the station's forest genetics division placed its research emphasis on the production of rapidly growing hard pines especially through the selection of vigorous strains and individuals of the ponderosa pine—California's most important tree. However, it was felt that, although progeny testing was a

³¹ For instance, Luther Burbank thought that conifers would have to be 20 years of age before producing flowers (Austin et al. 1974).

The time arrived for field testing promising hybrids of economic value and selected strains of pine.

very important part of the IFG's program, it had been overemphasized because of the lack of technical personnel in other important fields. It was also decided that progeny tests underway were sufficient to demonstrate the possibilities of this pine breeding method, and that no further progeny tests should be initiated until all results of past tests had been completely analyzed and reported. Research emphasis therefore swung to hybridization, in part pushed by Director Kotok and energetically carried out by geneticist Righter. Although IFG continued to analyze past progeny test data for publication, the institute suspended any new progeny and selection experimentation for several years. Instead, the time arrived for field testing promising hybrids of economic value and selected strains of pine.³² This work was done in cooperation with other governmental agencies and private landowners. Special attention was directed to various indigenous pines of California, with a view to producing hybrids that combined certain of their desirable attributes in new forms. Laboratory work was carried out mainly in Berkeley, but fieldwork on native pines was carried on along what was called the "El Dorado transect," a belt several miles wide that traversed the Sierras from Folsom to Echo Summit, paralleling U.S. Highway 50. The IFG staff members also began to take advantage of the concentration of scientists at CFRES, freely consulting them on their hybridization program, and cooperating with them on a number of projects, such as preliminary work to produce a blister-rust-immune white pine.³³ A white pine that was immune to blister rust was needed because by 1940, the Forest Service had spent some \$30 million on *Ribes* eradication work, yet blister rust continued to spread in California (Austin et al. 1974; Hill 1939; Stockwell and Walker 1948; Talbot 1940; USDA FS 1940a, 1941a, 1948a).

The future of IFG looked bright in 1939–1940. Some staff even expressed their desire to expand its applied and fundamental research further. But World War II brought a loss of relief labor, and the exigencies of war necessitated a reorientation of the genetics program. Thereafter, no new work was contemplated and ongoing work was reconsidered (USDA FS 1942a). Furthermore, in 1940, Institute Director Austin voluntarily demoted himself to staff geneticist. The decision had been made

³² The history of the IFG's research program cannot be fully understood without some discussion of the basic disagreement over approaches that developed between Lloyd Austin and Francis Irving Righter. In sum, Austin was committed to a program of using the variation within the institute's principal commercial species. The logical tactic therefore was to progeny test selected individuals. On the other hand, Righter chose the strategy of combining the desirable characteristics of species-to-species hybrids, and, if possible, of using hybrid vigor. With limited staff and facilities, the two strategies were, in effect, mutually exclusive (Duffield 1979).

³³ N.T. Mirov, for instance, in 1938 investigated the vegetative propagation of white pine as a possible method of blister rust control (Aitro 1977).

to move the institute's full-time staff and library to Berkeley. Austin felt strongly that the staff, which was not administrative but scientific, should be headquartered at Placerville, the site of the laboratory (arboretum) and reference library holdings, with trips as necessary to Berkeley, but he was overruled. Forest Service regulations required that all division chiefs work at stations. Lloyd Austin declined to leave Placerville where he had built his home and his family lived. So, given no choice in the matter, Station Director Kotok accepted his resignation and replaced him with his colleague Francis Righter (Austin et al. 1974).

Silviculture—

In the period 1933 to 1941, CFRES reforestation studies gave fairly distributed attention to two fields: natural reproduction and forestation, or direct seeding. Studies in the field of natural reproduction included studies of seed production and seedling incidence and survival. These studies aimed to determine the physical conditions that limited natural reproduction, and that were subject to control by silvicultural treatment favoring the pines. This was California's major means of forest regeneration on lands that had not been subject to too much abuse through harvesting or fire or both. Seed production was studied by means of cone and seed counts, and seeding incidence by the use of seed traps.³⁴ The CFRES research in natural reproduction of native plants included the topics of collecting, diseases, dispersal, dormancy, germination, handling, insects, longevity, physiology, production, storage, treatment, and viability (USDA FS 1934: September, November; 1935: January, October; USDA FS 1937d). Before his untimely death in 1929, H.W. Siggins conducted some of the earliest work on conifer seed distribution and rate of fall at CFRES. Thereafter, scientists such as N.T. Mirov published articles that discussed related subjects, such as germination methods for coniferous species³⁵ (Aitro 1977). Researchers at CFRES had not given up on direct seeding, but they were very cautious and reluctant to profess any faith in the possibilities of direct seeding of ponderosa and sugar pines because of the uniformly disastrous failures of 1908 to 1913. For instance, one CFRES report in 1933 stated bluntly: "We have not

Studies aimed to determine the physical conditions that limited natural reproduction.

³⁴ Early in the New Deal years, CCC and State Emergency Relief Administration crews gathered and cleaned seeds of more than 100 species of plants for the station, and they weeded seeding and planting beds, extracted and cleaned seed for research purposes for the Devil Canyon and Feather River nurseries.

³⁵ In addition to this work on conifers, CFRES staff scientists, such as Charles J. Kraebel and N.T. Mirov published several articles pertaining to collecting and propagating the seeds of California's wild plant life, including CFRES Research Note 18 (Mirov and Kraebel 1937), a popular manual printed in 1937 and supplemented in 1940, that described the collection, extraction, germination, treatment, and storage of seeds for 255 species of California flora (Aitro 1977).

The goal of the station's pine management division was to discover, test, and demonstrate those forest practices conducive to sustained timber production in California's mixed-conifer forests.

dared to risk duplication of those earlier failures on a large scale" (USDA FS 1935: April). Nonetheless, the station continued to dabble with direct seeding in connection with the study of natural reproduction of coniferous species in California's pine country. But in 1940, Duncan Dunning reported that the net results were mostly negative, and not very new. He surmised that there were still problems in obtaining good seed, site treatment, and preventing rodent damage. With unprotected seeding, rodent destruction of pine seed was still so great as to make the work fruitless (Aitro 1977; USDA FS 1935: April, October, 1937b). On the other hand, CFRES appeared to be more successful in forestation experiments of succulents on sites selected for firebreaks in several southern California national forests. Experiments showed that direct seeding of succulents such as the Australian saltbush and common iceplant was possible and far superior to the results from transplanted nursery stock. Because of their succulence and great resistance to fire, these plants offered considerable hope for covering the firebreaks in southern California and reducing the tremendous cost of annual clearing (USDA FS 1935: April, October).

Pine region silvicultural investigations—

By the New Deal period, pine region silvicultural investigations had become a designated part of the CFRES research program, and the goal of the station's pine management division was to discover, test, and demonstrate those forest practices conducive to sustained timber production in California's mixed-conifer forests. By 1940, the division had six permanent and three temporary technical employees, three branch field stations (Blacks Mountain, Feather River, and Stanislaus), and several experimental forests at the division's disposal. Investigations at these locations, as described below, were directed mainly toward the more urgent practical problems faced by managers of public and private forests, rather than more abstract biological problems. Studies fell into several categories: harvesting methods, reforestation of wastelands, thinning techniques, and some silvics. Research results were made available through conferences with lumbermen and forest managers, and by reports and publications (Talbot 1940).

Swain Mountain Experimental Forest—

As noted in the previous chapter, the Swain Mountain Experimental Forest or SMEF, the first in California, was formally designated in early 1932 as a place for field studies and demonstration of forest management practices in the true-fir types of California. The experimental forest, located on the Lassen National Forest, occupied most of a volcanic mountain, a compact 6,080 acres, which was stocked with true fir stands, and was recommended as an experimental forest by A.E. Wieslander. The SMEF eventually proved to be worth Wieslander's confidence.

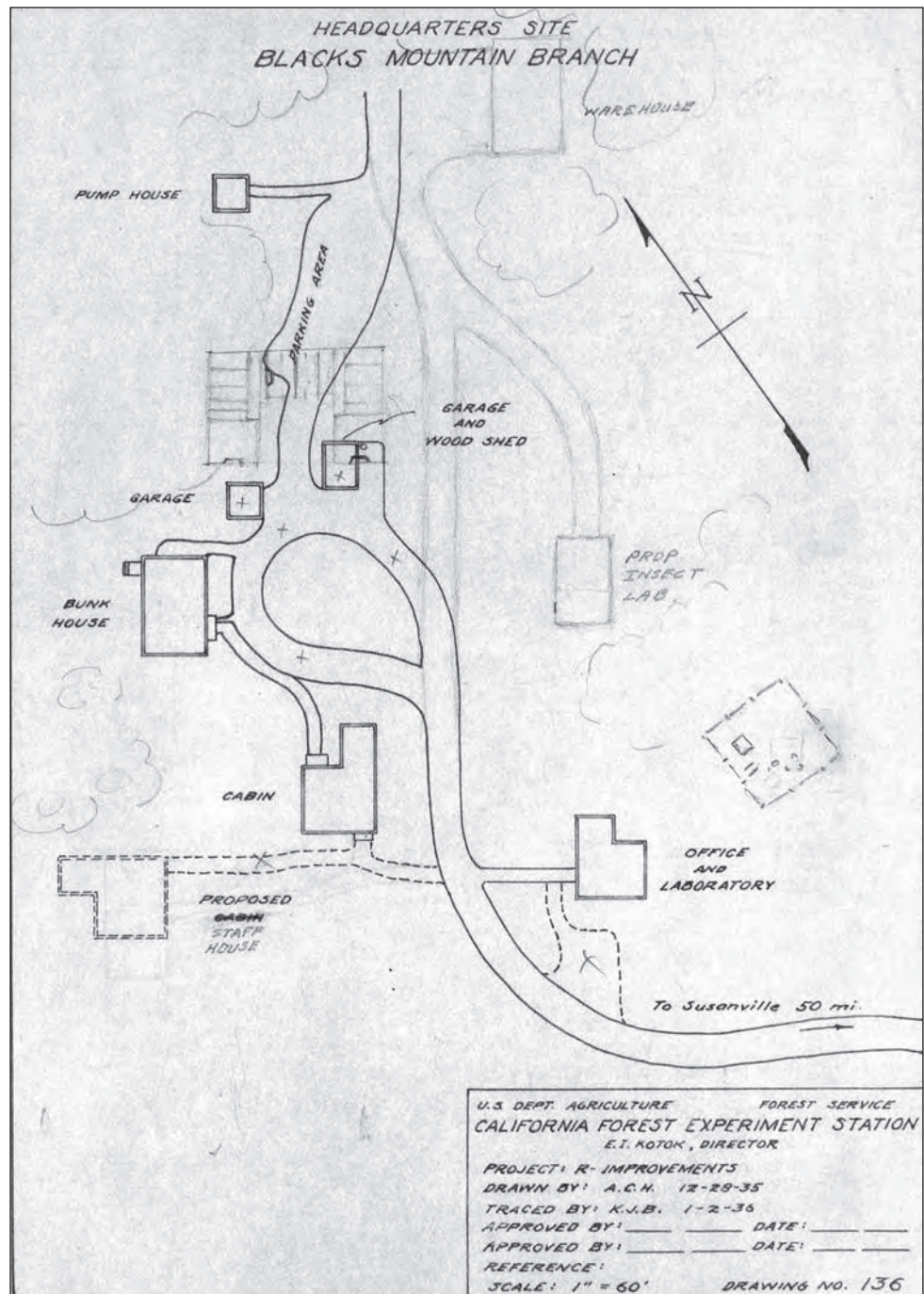
However, the experimental forest sat idle for the next 23 years until 1955 when an access road was finally constructed into it. A number of reasons were responsible for delaying activities at Swain Mountain. Principal among them was the limited interest in true-fir investigations prior to World War II, and limited CFRES funding, which annually amounted to only one-and-a-half person-years of direct timber management research and operation at SMEF (Gordon 1978; USDA FS 1937d, 1940b, 1956).

Blacks Mountain Branch Station and Experimental Forest—

The research fate of the 10,252-acre Blacks Mountain Experimental Forest, or BMEF, created on March 28, 1934, differed considerably from that of SMEF, although its designation was not without controversy. Apparently, some members of Region 5's staff doubted the usefulness of this experimental forest, and especially one as large as proposed. Nevertheless, with the support of Station Director Kotok and Regional Forester Show, who often worked hand-in-glove with Kotok, BMEF was set-aside as CFRES' principal site for management studies of the interior ponderosa pine type in poor sites—the only forest cover type on the forest. The Station/Region 5 program at BMEF had the following research objectives: studying methods of harvesting to convert old growth into regulated productive forests, investigating methods of reforesting waste lands, experimenting with methods of thinning and pruning timber trees, as well as various silvics studies (Gordon 1982; USDA FS 1937d, 1940b).

Located in the Eagle Lake Ranger District of the Lassen National Forest 40 miles northwest of Susanville, California, about half of BMEF lay in a gently rolling basin with the remainder extending up the moderate slopes of Blacks Mountain to the north and to the summit of Patterson Mountain to the east (fig. 48). Construction of BMEF facilities by WPA builders began almost immediately after the Chief of the Forest Service approved the experimental forest. They were completed in one year. Newly built facilities included a residence, dormitories, garages, and shops for the research staff and maintenance people (Gordon 1982). (fig. 49)

Meanwhile, from July 1933 to November 1934, a 10-member CCC crew conducted an impressive 100-percent inventory of trees over 3.5 inches in diameter at BMEF. This “legendary” project, designed by Austin Hassel, mapped all timber types as well as types of low vegetation such as grass and brush by species to the quarter-acre. Once logging began, the species, diameter class, and other data pertaining to each tree went into another record. In this manner, a close estimate of inventory on each compartment could be prepared, modified by growth and insect-caused mortality. The unique data from BMEF would later be analyzed at the Berkeley Station to form the basis for sampling methods that became widely used



U.S. Forest Service, Pacific Southwest Research Station



U.S. Forest Service, Pacific Southwest Research Station

Figure 49—View of buildings at California Forest and Range Experiment Station Blacks Mountain Branch, Lassen County, California.

in the future. Additionally, BMEF was subdivided into 100 compartments and an intensive road system (46 miles) was constructed. Built between 1935 and 1938, this road system was laid out so that a road bordered every compartment, and was the first in the West designed specifically for truck hauling of logs. The compartment system was installed for purposes of logging convenience and for inventory record-keeping. As far as possible, roads were located to allow trucks to run downhill with their loads. The CCC provided all labor and a large part of the equipment operation for BMEF. Besides this first in western logging methods, BMEF also was the first to use its own equipment, and eventually its own crews, to conduct its logging on a scale not tried elsewhere by the Forest Service (Berg 1990, Gordon 1982, USDA FS 1938a).

Management, silviculture, and insect control for interior ponderosa had been studied since 1910. However, the initial objective of the BMEF program was to develop these theories into a system of management and to test, demonstrate, and improve this system through continuous operation of a timber tract on a commercial scale (Berg 1990). Consequently, in the first part of the 1930s, experimental timber harvests at BMEF were primarily conducted for insect control in hopes of advancing and testing an insect risk-rating system that identified large, old ponderosa pines at risk of being killed by the western pine beetle. By 1936, the “California Pine-Risk System”³⁶ came into being and essentially classified ponderosa pine as

³⁶ Kenneth “Ken” A. Salman and J.W. “Jack” Bongberg of the Entomology Laboratory at Berkeley developed this system of tree classification from research conducted in the late 1920s by Duncan Dunning. Salman and Bongberg’s work was published in a 1942 article “Logging High Risk Trees to Control Insects in the Pine Stands of Northeastern California,” that appeared in the *Journal of Forestry* (Berg 1990, Gordon 1982, Salman and Bongberg 1942, Wickman 2005).

**Each year,
CCC enrollees,
entomologists, and
foresters joined battle
with the beetle for
California's pines.**

to vigor. The rating system resulted in a silvicultural approach (selective treatment) to managing western pine beetles instead of the direct control method (mid-1920s to mid-1930s) that amounted to felling the obviously attacked trees, peeling their bark with axes to expose and kill insect broods by means of sunlight, dry air, and in some cases, burning the bark (Gordon 1982, Wickman 2005). In 1937, the basic experiment to test and verify the California Pine-Risk System was started at BMEF. Each year, CCC enrollees, entomologists, and foresters joined battle with the beetle for California's pines, and conducted light insect-control salvage logging on cutover lands at BMEF. By the fifth season, selective stand treatment seemed to have beaten the insects to the punch. During that time, damage on the lightly cut areas was only a small fraction of that in older uncut timber stands (Dunning 1941). Thereafter, it was demonstrated at BMEF that small cuts could be made to reduce the annual rate of tree killing and sanitation-salvage began to be widely adopted in ponderosa pine regions. The California Pine-Risk System of insect control was soon used for both ponderosa pine and Jeffrey pine stands in eastern California. In 1939 and 1940, large-scale applications were made elsewhere in California, and the word began to spread of its success. The California System was the first insect risk-rating system of its kind to be developed and applied, and it continues to be used widely today (Gordon 1982; Salman and Bongberg 1942; USDA FS 1938a, 1940a, 1941a; Wickman 2005).

The California Pine-Risk System was not the only research conducted at BMEF in the 1930s. In the second half of the decade, CFRES chief of pine management Duncan Dunning used BMEF for an ambitious study of stand growth and development as well. In February 1937, Dunning outlined a plan of development for sustained yield research at BMEF. In this planning document, the outspoken Dunning severely criticized current forestry practices. Public forest practices, in his opinion, had been scaled down to the standards of lumbering needs. Furthermore, he wrote:

Only a spirit of optimism can support beliefs that, somehow, growth will be very much more rapid than records indicate: that mere fire protection will insure future merchantable stands; that economic selective culling will incidentally result in some semblance of forestry; or that any other cutting practice will approach forestry, if essentially subjugated to the aim of unreasonable profit for an inefficient custodian [Gordon 1982: 67].

Dunning recommended an unheard-of 140-year rotation (the period from regeneration to final harvest). Apparently, Regional Forester Show and his timber management officer T.D. Woodbury could not swallow Dunning's statements and

opinions. They made little effort to assist CFRES in getting finances for this forest management research at BMEF³⁷ (Gordon 1982).

Nonetheless, starting in 1938, and each year for the next 10 years, plots were installed at BMEF (Halls Flat) to test cutting prescriptions, ranging from commercial clearcut, to various intensities of partial cutting, to no harvest. The Forest Service did not ordinarily engage in actual logging when timber was sold, but in this case, it wanted to control all woods operations in connection with this feasibility test of sustained yield timber production. Previous research had shown that the usual practice of cutting most of the timber in a single operation resulted in long-deferred second cut with consequent interruptions of employment and business. It was hoped that lighter, more frequent logging with better timing and selection of trees would result in more rapid growth and reseedling, and would reduce serious insect damage at the same time (Dunning 1938, USDA FS 1938a).

The approach of World War II curtailed this and other research at BMEF, but by this time, BMEF research projects had led to two more “firsts.” The experimental forest was the first to show that light salvage cutting was no more expensive than heavier cutting. And BMEF was the first to help design and construct the first unmanned, rapidly portable log loader—the Le Tourneau industrial crane. It handled overmature pine timber—the key to the success of “light salvage cutting” that revolutionized subsequent logging practice (USDA FS 1982).

Feather River Branch Station/Nursery and Experimental Forest—

The Feather River Branch Station and the Feather River Experimental Forest (FREF) had varying histories during the 1930s. The Feather River Branch Station was first established on the Plumas National Forest in 1912. From then until 1926, District 5 had supervised research and located a nursery there. When the California station was established, it assumed supervision of the Feather River Experiment Station and nursery from District 5, and renamed it the Feather River Branch Station/Nursery, but it had no assigned staff (Fowells 1983).

In 1933, the Feather River Branch Station/Nursery included a superintendent’s residence, staff house, office and laboratory, warehouse, and nursery, and also a training school for Region 5 personnel (fig. 50). In 1934, the Feather River Branch Station/Nursery was renovated, and forestation and nursery studies began here once again. Following the renovation, the nursery produced small amounts of ponderosa and Jeffrey pine planting stock for use in the national forest planting programs. But

³⁷ Dunning was a central figure in pine forest management and a prolific publisher on the subject. Some regarded him as the “keenest observer and best naturalist at the station.” However, there seemed to be a “deep-seated friction” between him and Director Kotok and probably Regional Forester Show as well (Connors 2006: Section 8, 8).



California Forest and Range Experiment Station

Figure 50—Office building for California Forest and Range Experiment Station Feather River Branch, Quincy, California.

in late 1937, following discussions between CFRES and Region 5, a decision was made that the nursery would no longer produce experimental planting stock. The remaining stock on hand was used on the Plumas National Forest. Thereafter, the station/nursery participated in a number of smaller reforestation studies. In 1938, a poplar hybrid developed by the Northeastern Station was tested at the nursery and destroyed after early survival and growth were measured. In the same year, a large and complicated study comparing seed sizes, seedling sizes, and transplant sizes of ponderosa and Jeffrey pine was started and carried on at the nursery until the 1960s. And, in 1940, the station/nursery cooperated in a study of Scotch pine. After the initial survival and growth were determined, the planting was destroyed during World War II to make room for other studies (Fowells 1983).

By contrast, little research work was conducted at FREF, which was approved on June 27, 1933, and located 10 miles east of Quincy, California, in the drainages of Willow Creek and Thompson Creek tributaries of the North Fork of the Feather River on the Plumas. As established, FREF contained 3,970 acres of which 83 percent was mixed conifers (ponderosa and sugar pine, Douglas-fir, white fir, and incense-cedar). Under the direction of Duncan Dunning, FREF was set up to study the same five pine forest management research objectives that Dunning listed for research at Blacks Mountain, but in mixed-conifer timber in sites of medium

quality. Additionally, Walter Lowdermilk and then Charles Kraebel were to conduct some water management research at the FREF. Unluckily, the FREF contained a great number of mining claims, the existence of which made the establishment of research installations therein impossible. The mining claim situation would not be resolved until the mid-1950s, but, as it turned out, no forestry research would ever be conducted at FREF (Fowells 1983; USDA FS 1937d, 1940b).

Stanislaus Branch and Experimental Forest—

As at the Feather River Branch/Nursery, forestry research at the Stanislaus Branch (fig. 51) began long before the founding of the California station. Scattered harvest cutting plots, in what would become the Stanislaus-Tuolumne Experimental Forest in 1943, were established and monitored by District 5 personnel from approximately 1909 to 1924. They were started to study the growth of residual stands, growth characteristics of regenerated timber stands, and decay of logging slash. Other plots were important for “methods of cutting” experiments, which were periodically remeasured and results analyzed until the 1930s (Conners 2006). However, until the CFRES took over the research program from District 5 in 1926, no permanent facilities existed in the area.

Some sources indicate that the Stanislaus Branch Station had a 30-acre experimental area set aside, perhaps associated with a potential nursery site, whereas other references indicate that a larger area was assigned to the California station



U.S. Forest Service, Pacific Southwest Research Station

Figure 51—Building No. 4, caretaker's cottage at California Forest and Range Experiment Station, Stanislaus Branch, Pine Crest, California, 1935.

Staff constructed and climbed 80- to 120-foot wooden ladders that reached the crowns of individual sugar, ponderosa, and Jeffrey pines, as well as a white fir.

for research purposes. Nonetheless, the Stanislaus Branch Station seemed to evolve slowly and informally from 1927 to 1929 in response to the need to supervise a research program that determined desirable silvicultural practices in part of California's pine region. The first building constructed at this time was a caretaker's cottage in the Cow Creek area. Additional facilities eventually included a two-room office-laboratory and a garage-storage building. Thereafter, 12 new harvest cutting plots were established up to 1930, but vegetation was charted intensively on only six plots. For the next 28 years, staff counted all cones on pines and firs on these six plots. Silviculturalist Duncan Dunning and other scientists conducted research in this area that focused on the development of harvesting methods for old-growth stands that could provide for regeneration of sugar pine, Jeffrey pine, and ponderosa pine. To determine factors influencing mortality and survival of seedlings, five "site factor" stations were constructed between 1931 and 1934 in a small 30-acre experimental area. These site factor stations were established to monitor conditions related to seedling establishment. Beginning in 1932–1933, records were kept for 30 years at one site, 19 years at another, and 11 years at three other sites. These data were used in the definitive work on seed and cone production³⁸ (Berg 1990, Conners 2006, Fowells 1978, USDA FS 1937d).

With the advent of the New Deal emergency programs (ECW, PWA, and CCC), funds and labor became available to increase facilities at the Stanislaus Branch Station. In 1936, Harry Fowells,³⁹ a research scientist, was nominally placed in charge of the Branch Station, a position he held through 1953. From the 1933–1937 period, a staff house, an office-laboratory, a dormitory, and large garage-warehouse were constructed. These facilities housed staff that seasonally came to the Stanislaus facility to conduct research studies on seed production or cone development, to remeasure harvest cutting plots, or to check on the site factor stations. To find out why cone crops were so periodic, Fowells and staff also constructed and climbed 80- to 120-foot wooden ladders that reached the crowns of individual sugar, ponderosa, and Jeffrey pines, as well as a white fir. But as already noted, as early as 1931, CFRES had sought an experimental forest on the Stanislaus National Forest near the Branch Station's center of work there. Silviculture scientist Duncan Dunning drove this effort and in 1935 proposed the development of an experimental forest on

³⁸ Harry A. Fowells and Gilbert H. Schubert summarized 28 years of seed production of sugar pine, ponderosa pine, and white fir and interpreted this information for application to cutting practices and seed collection in USDA Technical Bulletin 1150 *Seed Crops of Forest Trees in the Pine Region of California* (Fowells and Schubert 1956).

³⁹ Harry Fowells was accepted to the doctoral program at the University of California at Berkeley in 1930, and given a research assistantship. Instead, Fowells accepted a full-time job at CFRES, "an offer too good to turn down" at the time. Eventually, he found time to complete graduate courses and earned his Ph.D. in 1958 (PSW 2001b).

which to apply the theories emerging from detailed research on the experimental plots at the Stanislaus Branch Station, but he was turned down (Fowells 1978). In 1940, Dunning renewed his effort for an experimental forest area on the Stanislaus National Forest, whose objectives would cover the same five pine forest management research objectives that Dunning listed for research at BMEF and FREF, but in a totally different type, namely sugar pine timber in sites of high quality (USDA FS 1940b). In light of the new U-1, U-2, and U-2A Regulations (1938) that replaced the L-20 Regulation, allowing experimental forests and ranges to be set aside for long-term research, Dunning pointed out that the new experimental forest would also serve as a public relations asset to recreation management. But a formal designation creating an experimental forest near Pinecrest, California, a very popular recreation area, would not come until late 1943,⁴⁰ when the Stanislaus-Tuolumne Experimental Forest was finally created (Conners 2006, Fowells 1978).

Redwood region silvicultural investigations—

The function of the CFRES redwood management division was to develop and demonstrate the best possible system of management for the forest lands of the redwood region. This involved the determination, through experimentation, of sound practices that would provide continuously the greatest quantity of desirable timber products. Along with this sustained-yield research program, the California station needed background knowledge regarding redwood cutover areas, results of planting timber and related resources, logging methods, costs and damages, and other information relating to the proper management of redwood timber lands (Talbot 1940). Prior to the New Deal, CFRES redwood regional studies had revealed that planting could not restore stands on logged areas that had already been subjected to the destructive clearcut logging and slash-burning methods of the day. These investigations also indicated that redwoods reproduced well from seed under proper conditions, and it appeared feasible to leave seed trees as a rule rather than to attempt planting, and that selective logging with tractors was possible and afforded greater returns to the operator (Silcox 1934, Stuart 1933).

To further test these and other research questions, Hubert Person, who was assigned to investigate forest management issues associated with California's redwood region, desired the acquisition of areas suitable for redwood experimental

⁴⁰ In December 1943, two tracts were formally set aside for long-term database studies. One tract was on the South Fork of the Stanislaus River and a larger tract was on the lower slopes of Dodge Ridge, south of the North Fork of the Tuolumne River. These tracts were selected because they were typical of mixed-conifer stands of the Sierra Nevada, specifically those of high site quality on mid-elevation west slopes in the Sierra Nevada range (Berg 1990).

Successful planting was possible at moderate cost if newly logged areas were planted promptly and care taken in choice of stock.

forests to acquire this information.⁴¹ With the coming of the New Deal, considerable discussion took place at CFRES regarding this need, and also among Region 5 officials, who wished to acquire land for a new Redwood National Forest. For instance, in a 1933 memorandum to Director Kotok, Hubert Person openly discussed three areas that he considered suitable for experimental forest status. He recommended areas at Caspar Creek near Fort Bragg, California, at Van Duzen River, a major tributary of the Eel River southeast of Eureka, California, and at Weott, also southeast of Eureka. Although nothing came of Person's recommendation at this time, the California station did not give up pursuing the issue. Then during 1935–1936, Region 5 finally convinced the National Forest Reservation Commission to establish purchase area boundaries for two redwood areas in California, a Northern Redwood Purchase Unit (NRPU) in Del Norte County and a Southern Redwood Purchase Unit (SRPU) in Mendocino County. Thereafter, Region 5 began slowly acquiring redwood lands within these broad zones to form the nucleus of a much larger Redwood National Forest. Naturally, CFRES was also involved in the transactions and negotiations, with Hubert Person pushing the idea to set aside 2,300 acres in the NRPU either for scientific purposes as an experimental forest, or as a research natural area (RNA) (Boe 1983, Conners 1995, Silcox 1936).

Meanwhile, Hubert Person continued the redwood research program that he had begun in 1931 that included general research in the areas of planting, condition of cutover land, redwood logging, and establishment of natural reproduction. By 1937, Person's program included planting studies, natural reproduction studies on selectively logged areas, tree measurements for construction of volume tables, logging studies, and slash disposal in cooperation with the California Redwood Association.⁴² Among the important publications Person produced was *Commercial Planting on Redwood Cut-Over Lands* (Person 1937), which concluded that successful planting was possible at moderate cost if newly logged areas were planted promptly and care taken in choice of stock. William E. Hallin and Person also published widely on tractor and selective logging methodology and costs associated with the redwood region while R.C. Wilson traced the history of early day logging operations in the Santa Cruz redwood region (Aitro 1977). However, Person realized that any future redwood studies and investigations could only be facilitated on fully

⁴¹ At this time, there was only a scattering of redwoods within the boundaries of California's national forests, and they were chiefly on the Monterey division of the Santa Barbara National Forest, which in 1936 was renamed the Los Padres National Forest (Godfrey 2005).

⁴² The California Redwood Association was founded in 1916.

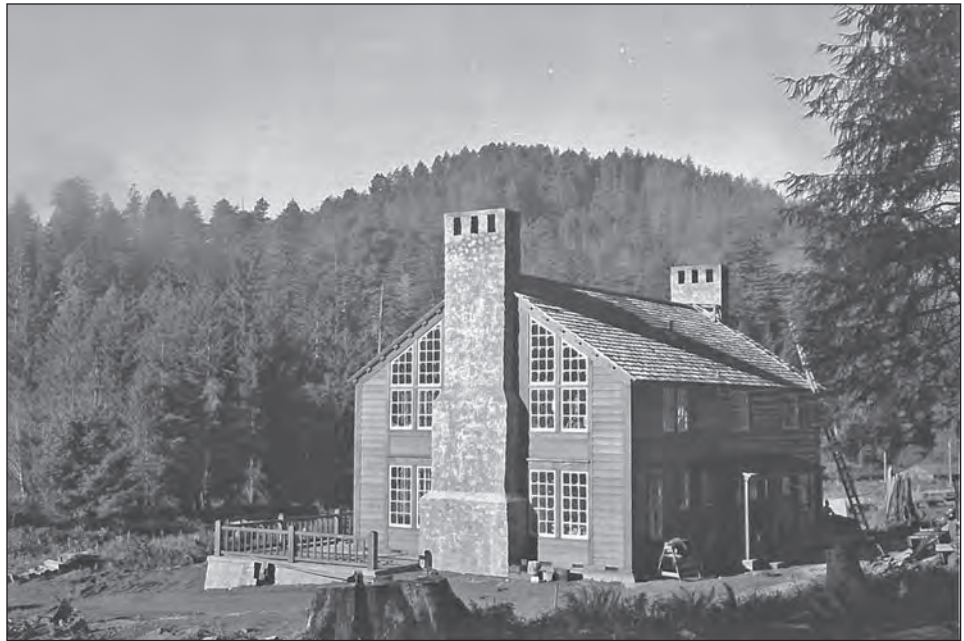
controlled lands located within an experimental forest. Once again, in 1939, he pushed for a redwood experimental forest in his report *Problem Analysis for Silvicultural Investigations in the Redwood Region* (Person 1939). His paper realized the need for an experimental forest, and suggested one in each of the northern and southern redwood zones.⁴³ Finally, in late 1939 and early 1940, after prolonged and involved transactions, the Forest Service completed the purchase of substantial acreage for the NRPU and made it part of the Trinity National Forest. Of this acreage, with the support of Acting Chief Earle Clapp, the Forest Service designated 14,500 acres of redwood timberland north of the lower Klamath River in Del Norte County as an experimental forest⁴⁴ (Boe 1983, Conners 1995).

Redwood (Yurok) Branch and Experimental Forest—

On January 14, 1940, Regional Forester Show and Director Kotok approved the designation of the Redwood Branch and Experimental Forest 4 miles north of the town of Klamath, Del Norte County. The purpose of the experimental forest was to develop and demonstrate the best possible system of management for the forest lands of the redwood region, which included studies related to tree selection, natural reproduction, logging, slash disposal, and yield. Plans for buildings at the Redwood Branch Station got started immediately. By using CCC labor from a nearby camp to clear the site, and WPA project funding, CFRES constructed a two-story multipurpose headquarters building with interior panels constructed from the principal tree species in the area. The building, complete with fireplaces throughout (someone may have thought that CCC crews would be around for awhile to cut firewood), was finished just before World War II altogether interrupted research there. Studies on coastal redwood silviculture and techniques for regeneration and management would not restart at the Redwood Experimental Forest, also known as the Yurok Branch and Experiment Station (fig. 52), until the mid-1950s (Boe 1983, Conners 1995, USDA FS 1940b).

⁴³ By this date, the environmental and stand differences between the two units were evident to most foresters.

⁴⁴ At this time, tax delinquency made many private landowners anxious to sell their redwood holdings for federal government cash. Apparently, 50 percent of the private cutover land in NRPU was in arrears and could be purchased at bargain basement prices (Conners 1995). Acting Chief Earle Clapp strongly supported this and similar purchases. In a letter to Regional Forester Show dated May 31, 1940, Clapp stated: "The remaining old-growth redwood stands of California and possibly also the remainder of the old-growth pine stands constitute one of these problems [raised by the Joint Congressional Committee on Forestry]....In the past the Forest Service has in the main let liquidation of the old-growth timber run its course, without concrete, aggressive attempts to stop it. The time has come, however, when in my judgment we should submit through appropriate channels whatever specific recommendations may be necessary to get on top and control in the public interest such problems" (Clapp 1940: 1–2).



U.S. Forest Service, Pacific Southwest Research Station

Figure 52—California Forest and Range Experiment Station, Yurok Experimental Forest, Requa, California.

Forest fire protection—

Adequate protection from fire was the first requisite to sound management of the land resources of the pine and redwood regions of California. Without it, no form of management, whether it be for timber production, livestock forage, conservation and storage of water, or for recreational values, could succeed. The purpose of fire research at CFRES was to substitute quantitative and scientific data for fire-control lore on fire behavior, damage, and the effectiveness of different planning and suppression methods and facilities for fire-control lore. Fire research at CFRES augmented the knowledge already gained from the combined experiences of fire-control personnel (Talbot 1940). California Station effort was in line with the objectives of the *Copeland Report*, in which Director Edward Kotok, who by this time was a nationally recognized expert in fire research, reviewed the fire situation in the Nation and the objectives of fire control, including organization, spread of attack, economic considerations, and limitation of fire damage (Aitro 1977).

In spite of 20 years of constant attempts to better fire protection performance that began when District 5 Forester Coert DuBois published his *Systematic Fire Protection in the California Forests* (DuBois 1914), at the beginning of the New Deal, fire risks in the state were still a major burden of every national forest administrator. Finally, in 1930, fire research had become a formal section at the station, and with Region 5 cooperation, the Shasta Experimental Fire Forest (SEFF) was

created that year (fig. 53). However, CFRES fire research at SEFF and publications by Kotok and Show on fire protection, such as *The Determination of Hour Control for Adequate Protection in the Major Cover Types of California Pine Region* (Show and Kotok 1930), offered eventual hope. By the onset of the New Deal, facilities at SEFF included a central staff house and laboratory in the town of Mount Shasta and a combination office-laboratory at Pilgrim Creek, 25 miles distant. An area of several thousand acres of dense chaparral tributary to the Pilgrim Creek center had also been set aside for experimental brushland fire work; it was an area representative of over a million acres of high-quality timberland captured by brush as a result of fire or logging followed by fire (USDA FS 1937d). The SEFF provided Kotok and Show the opportunity to test the concepts of their 1930 *Hour and Control* publication (Cermak 2005). At SEFF, the most acute fire problems of the California region (detection, organization planning, fire behavior, and firebreak development) continued to be studied. This forest fire protection effort greatly benefited from the New Deal's alphabet agencies, especially the CCC. By the end of the New Deal years, fire research in California was on good footing.

For instance, in the past, CFRES had given considerable attention to forest fire detection problems. Studies included the development of singular techniques for visibility maps and the selection of lookout points (fig. 54). The station's fire research staff led by George Gowen investigated the radius of vision of lookouts under varying conditions (sun, haze, smoke conditions, and seasons). During the New Deal, CFRES staff continued forest fire visibility work. In 1934, with the aid of the CCC, research staff set carefully controlled fires at SEFF and observed them under a wide variety of conditions (Silcox 1934), and completed their research just in time to permit Region 5 to use the data gathered. With this new information, and under station direction, Region 5 completely revamped its lookout system⁴⁵ using available CCC labor (USDA FS 1937d).

This action created a domino effect of additional work. Revision of California's lookout system brought forth the necessity for review of the communication and road transportation systems of the national forests. Therefore, CFRES began testing the adequacy of Region 5's communication system. Completing its communication/transportation study in 1935–1936, CFRES revealed many weaknesses in the location and type of construction of Region 5's telephone lines, as well as other

The most acute fire problems of the California region (detection, organization planning, fire behavior, and firebreak development) continued to be studied.

⁴⁵ The number of lookouts went from about 100 to 200, and some of the "old standby lookouts were abandoned often with tears because of sentimental attachment" (Show 1965: 85).



U.S. Forest Service, Pacific Southwest Research Station

Figure 53—Laboratory and office, California Forest and Range Experiment Station, Mount Shasta Branch, Mount Shasta, California, 1942.



U.S. Forest Service

Figure 54—Metal lookout towers replaced many early wood platform lookouts, such as this one on the Mendocino National Forest.

problems.⁴⁶ The CFRES study showed that 400 miles of telephone lines should be reconstructed, 1,330 miles abandoned, and 3,243 miles of new line built (Silcox 1935a, USDA FS 1937d). Again, the presence of the CCC enrollees helped in many ways. Their work included the construction of new telephone lines as well as foot, horse, and motor-truck trails. These various physical improvements for fire control were finished in 1936, giving Region 5 a foundation never before available for fire performance efficiency (USDA FS 1937d). The research and construction activity also provided material for Director Kotok and Regional Forester Show's publication *Planning, Constructing, and Operating Forest-Fire Lookout Systems in California* (Show and Kotok 1937).

Besides the research in detection and organization planning, CFRES and Region 5 also undertook fire behavior research in the New Deal years. Fire behavior became an important research area after the devastating 1932 Matilija Fire on the Santa Barbara National Forest that burned close to 220,000 acres, and occupied much of the time of station fire research staff, such as George M. Gowen and J.R. Curry at SEFF thereafter⁴⁷ (Cermak 2005). Fire behavior studies were necessary in order to forecast fire danger, to permit determination of size of crews and speed of attack requirements, and to promote development in fire suppression tactics and strategies. Advances in the knowledge of how various factors, such as wind, slope, moisture content, size and arrangement of fuels, and degrees of compaction, significantly improved fire suppression efficiency. Toward this end, again with the help of the CCC, in 1937, the station began studying this problem through the observation of approximately 300 test fires at SEFF. Station fire research staff analyzed these factors with the aim of integrating them into a series of indexes expressing the chance of fires starting, rapidity of spread, and the type of organization needed to

**They voted
unanimously for a new
fire suppression policy
of "immediate control"
by 10 a.m.**

⁴⁶ Many trunk lines were seriously overloaded and dependable service suffered. Furthermore, in some cases, Forest Service lines had been tied to farmer lines, and service was tricky and uncertain because of interference on such party lines (Show 1965).

⁴⁷ In 1935, responsibility for fire research at the station was shifted from George M. Gowen to J.R. Curry. Gowen had moved over to a Region 5 administration position. Curry led CFRES during the next critical phase of fire research at CFRES that began after a fire research conference held at Pasadena attended by 10 Forest Service experiment station directors and an equal number of regional foresters. They voted unanimously for a new fire suppression policy of "immediate control" by 10 a.m. After the Pasadena conference, Chief Silcox in a circular letter dated May 7, 1935, outlined this policy (Loveridge 1944). This "new" policy had the same objective as Show and Kotok's minimum-damage theory, which they espoused in USDA Circular 358, *Fire and the Forest* (Show and Kotok 1925). It had looked closely at historical damage done by recurring fires in California's pine region (Gisborne 1942, Loveridge 1944).

Person-caused fires in flash-fuels and brush zones presented the dominant Southern California fire problem.

cope with current fire danger. Then, a coordinating committee of Region 5 and station personnel attempted the first fire danger rating (FDR) for four of California's national forests. By 1939, the rating system they developed was expanded to the remaining national forests⁴⁸ (USDA FS 1937d, 1939a).

As indicated above, Region 5 worked closely with the station in fire management studies—a collaboration that eventually led to several landmark publications and helped cement the working relationship between researchers at the station and fire specialists in Region 5. The station's first important publication, *Region 5: Fire Control Handbook* (USDA FS 1937b) provided a working tool for fire control people based on fire research results at SEFF and actual practical experience. Two other significant publications came at this time. The first was *Principles of Forest-Fire Detection on the National Forests of Northern California* (USDA FS 1937a), which included the results of large-scale fire tests at SEFF. The second publication was *A Planning Basis for Adequate Fire Control on the Southern California National Forests* (USDA FS 1941c). It stated that “person-caused fires in flash-fuels and brush zones presented the dominant Southern California fire problem.” It also indicated the objective of southern California fire control should be to hold losses in individual watersheds to an endurable maximum acreage burn for any fire⁴⁹ (Arnold 1949, Cermak 2005, Show and Kotok 1938, Show et al. 1941, USDA FS 1940a).

Finally, there was the subject of firebreak development and maintenance. It was during the CCC period with its large pools of humanpower, that the firebreak, known as the Ponderosa Way, was built (fig. 55). This continuous fireline, or fuelbreak between timber and brush, stretched over 800 miles along the west front of the Sierra Nevada⁵⁰ and was perhaps the most publicized single CCC project in

⁴⁸ Apparently, by prearrangement, perhaps at the Pasadena Fire Research Conference, the development of fire-danger rating systems was left to Forest Service Regions 1 and 6. However, Charles C. Buck (CFRES fire research) and George Gowen (at the time in Region 5 administration) developed a fire-danger system to meet the unique needs of Region 5. They also set up a grid of weather observation stations in the state, and the Fire Weather Service of the United States Weather Bureau played an important part through continued active participation in the development of the fire-danger rating system (Wilson 1984).

⁴⁹ Thereafter, Region 5 used the results of the latter study for many public relations pieces, including one article entitled “Put It Out.” This article admonished smokers by blaming them for 43 percent of all human-caused forest and brush fires in the state and may have led to the Smokey Bear “antismoking” campaigns of the future (Godfrey 2005).

⁵⁰ In an attempt to aid in cutting firebreaks, CFRES developed a power brush saw that operated with a 1-1/2-horsepower gasoline motor to cut through dense brush and in stands of small samplings. The saw was developed by E.A. Morrow, a mechanic who had been in the Army Air Force overseas in World War I. Morrow's power brush cutter, a horizontal circular saw mounted ahead of a wheel, and maneuvered like a wheelbarrow, weighed 100 pounds, which probably limited its usefulness (Fowells 1983, Silcox 1934).



Figure 55—Ponderosa Way constructed by the Civilian Conservation Corps near Grass Valley, California, 1934.

California. A.E. Wieslander of the California Station and C.E. Dunston of Region 5 worked together to outline the route of the firebreak (Cermak 2005; Show 1963; Silcox 1934, 1935a). One major problem in firebreak maintenance tackled by the station alone was sterilization of the soil along the right-of-way to keep vegetation down. In an era not cognizant of the environmental hazards associated with unrestrained and unwise chemical usage, the station's solution depended on simple treatments of diesel oil and a variety of arsenic compounds to hinder the growth of annuals on the truck trail and firebreak. N.D. Bruce, along with C.A. Abell, led the way in this research on methods of killing sprouting stumps and eradicating dense perennial shrubs, such as bear clover, and sterilizing soil with chemicals against annual vegetation on firebreaks (Aitro 1977). Thereafter, weed and brush control became a research area within the station's forest management research program that eventually turned to developmental research in cooperation with the University of California College of Agriculture on herbicidal chemicals that would prove more effective, if not just as hazardous (USDA FS 1937d, 1939a, 1940a).

By 1941 and the approach of World War II, CFRES fundamental investigations in fire management, which included determining the physical relationships between the manner in which fires start and spread and the variables that influence them, including fuel, weather, and topography (USDA FS 1940b), had produced a healthy body of fire management literature. Related aspects of fire management, such as designing national forest transportation plans to meet fire control problems in

California, redesigning telephone communication systems, or the complex problem of selecting and distributing lookouts for maximum efficiency in fire control, found publication, thanks to CFRES fire scientists such as A.A. Brown, Charles C. Buck, George Gowen, and Regional Forester S.B. Show. Other CFRES staff, such as John R. Curry and W.L. Fons, looked at the relationship between forest fire-danger rating and fire control planning and its application to California as well as various aspects of fire behavior. Still others such as C.A. Abell and P.D. Hanson⁵¹ concerned themselves with determining the desirable size of suppression crews in various parts of California, among other subjects (Aitro 1977). In 1941, CFRES fire research knowledge was gathered into one publication, *A Forest Fire Protection Problem Analysis for California*, (Buck et al. 1941), a lengthy fundamental analysis of 77 problems in fire management that confronted the protection agencies of the state of California. It covered four basic fields in fire research: fire prevention, presuppression, suppression, and fire effects. Of course, CFRES fire research staff knew it would be impractical to attack each of the 77 problems at the same time, so CFRES selected eight problems as having the highest priority for research in the near future, which will be discussed in chapters to come (Buck et al. 1941). Nonetheless, reductions in both regular and emergency personnel, such as CCC labor because of World War II, resulted in a definite reduction in the rate of productive research in fire management (USDA FS 1942a), and fire research almost came to a halt as most of the limited staff was assigned to projects of interest to the military (Wilson 1984).

Forest Products

Forest products research began in the California region with the establishment of the Forest Service in 1905. With the founding of the California station, most of the earlier products activities in subjects such as wood preservation, marine piling, and air-seasoning of lumber gradually were closed out or transferred to the Forest Products Laboratory (FPL) in Madison, Wisconsin. This shift had been in pursuance of Director Kotok's policy that all lines of station research contribute directly to the major station objective of advancing the better management of forest lands. Following the policy shift up to about 1936–1937, regular research projects centered on east-side logging studies conducted mostly by M.R. Brundage of the CFRES products division. These studies demonstrated to the regional lumber industry that cutting of trees below specified diameters cost more in direct expenditures than the total returns from the lumber produced. They also improved log-grading rules for

⁵¹ In 1938, P.D. Hanson, Forest Supervisor of the Lassen National Forest, was asked to head up Region 5's fire planning projects (Wilson 1984).

the pine region, and led to the publication of a manual of procedure for logging and milling studies. In spite of some hopeful signs, station staff believed the picture was still dark. Although some large operators were enlightened by the station's evidence, the majority of the lumber industry apparently were unable to abandon the traditional notion that maximum realization per acre during the first cut was the most profitable practice (USDA FS 1937d).

The regular wood products research program at CFRES, however, was at times interrupted by several special projects.⁵² One such project of significance involved a logging and lumber industry study in Eldorado County pursued in cooperation with the University of California and the Giannini Foundation. Much like the Tennessee Valley Authority (TVA), but on a smaller scale, the objective of this project was the permanent socioeconomic betterment for Eldorado County through proper coordination of industry, agriculture, and forestry, and hinged on maintaining a permanent lumber manufacturing plant in the town of Diamond Springs. The CFRES viewed the Eldorado County investigation as the perfect setup for applying silvicultural treatment to areas that had not been properly cut under private management during the previous 15 years, as recommended by the 1933 *Copeland Report* (USDA FS 1934: January, September). A year later, C.L. Hill, A.E. Wieslander, and University of California professor David Weeks published the results of this study (Weeks et al. 1934), which described the complex problems arising out of the economic and social structure of El Dorado County and its land utilization (Aitro 1977, USDA FS 1937d). Their research was so well received, that Eldorado County officials formed a land committee to push forward a regional plan based on the report's recommendations. Moreover, CFRES expanded this land-use research to a whole series of Mother Lode counties, running northward from El Dorado to the Feather River (USDA FS 1934: January, September; 1935: May, September; 1937d).

Important changes at CFRES occurred in wood products in the mid-1930s. Until 1937, wood products research had been largely confined to working out the economics of lumber production and its integration with management practices. Brundage's ongoing logging and milling study exemplified this work, as well as various cooperative projects with Region 5 Division of Timber Management and private industry associations, such as the California Redwood Association. In 1938, C.L. Hill complained that the demands for work by his Division of Products far exceeded the capacity of the division's limited personnel, so much so that Hill wrote Director Kotok informing him that no new comprehensive projects could

The majority of the lumber industry apparently were unable to abandon the traditional notion that maximum realization per acre during the first cut was the most profitable practice.

⁵² The FPL often requested cooperative work of the CFRES, and published jointly. For instance, in 1934, CFRES and the FPL published data on the properties of western white-fir and their relation to uses of the wood in a technical bulletin (Silcox 1934).

As the war approached, increased demands for lumber and other forest products owing to the national defense program placed new burdens on wood utilization research.

be undertaken until his division could clean up a backlog of manuscript commitments, especially Brundage's logging and milling study report, which had yet to be completely written. At the same time, Hill wished to reorganize the work of wood products research and to shift personnel from practical lumber production studies and forest management studies to accommodate a different line of work—utilization studies. In particular, Hill wanted to explore the consumption of lower grade materials from species harvested within the region itself, such as white fir, incense-cedar, and Douglas-fir—a development Hill linked to the rapid development of tractor and truck logging in parts of California and the work at the Blacks Mountain Experimental Forest on different cutting systems. In Hill's opinion, California forests offered a large production potential for harvesting low-grade lumber, and an even larger production potential from species left in the woods. This low-grade lumber situation constituted not only inefficient utilization, in Hill's assessment, but complicated future Region 5 timber management plans. In mid-1939, a Washington office General Integrated Inspection (GII) agreed with Hill's reorganization plan but left the task to his successor. Hill, who had been in charge of products for 20 years, was transferred to the station director's office, probably in anticipation of a Forestry Omnibus Bill being introduced into Congress.⁵³ Simultaneously, L.N. Ericksen was made the new director (Hill 1939; USDA FS 1939a, 1940a).

In 1940, based upon the GII, the wood products division gave more consideration to utilization problems. When CFRES divisions were asked to provide a short summary of the scope, problems, and objectives of their work for the Forestry Omnibus Bill, L.N. Ericksen readily pointed out that his division's objective was more efficient utilization of forest products for construction and industrial uses; that the division acted in an advisory capacity on wood-utilization problems within the region; and that the work of the products division was closely integrated with that of the pine and redwood divisions of the station (Talbot 1940). To approach these problems, Ericksen planned to conduct a survey on a number of utilization problems in the coming year. However, attention toward this end was delayed because of the mounting interest in the defense program of the Nation and impending worldwide conflict. As the war approached, increased demands for lumber and other forest products owing to the national defense program placed new burdens on wood

⁵³ C.L. Hill, who had held various positions in the Forest Service related to forest products, announced his retirement in January 1941. Since reporting as a technical assistant on the Sierra National Forest in 1912, Hill's California experience in both District 5 and the California Station included timber surveys, management plans, experimental plantings, insect-damage surveys, wood technology, protection of wooden piling against marine borers, air seasoning of lumber, extraction of heptanes from Jeffrey pine, and forest economics, particularly land utilization in relation to forestry (Talbot 1941).

utilization research, as wood products research faced new and increasing responsibilities (USDA FS 1940a, 1941a).

Forest Influences

Besides forest products research, forest influence fact-finding also provides an interesting story because in California, the problems of water supply, floods, and erosion control were very important.⁵⁴ The relation of forests and other vegetation to watershed conditions had caught the attention of foresters, engineers, and others since floods and droughts caused substantial losses in America. The perennial question raised was whether or not vegetation, such as forests, exerted a beneficial influence on watersheds and helped prevent such losses to human developments. By the early 1930s, two sides of the debate emerged. One group held that vegetation conserves water supplies and its management is so important in flood protection that it should have complete protection from any form of depletion. The other group maintained that vegetation might accentuate water shortages through its consumption of this valuable fluid, that it had a dubious value in watershed protection, and that the removal of vegetation rather than its protection would constitute good watershed management (USDA FS 1937c, Wilm 1946). Early on, the Forest Service appeared to side with the first group, as protecting watersheds was stated as one of the main reasons for public management of forested lands, especially in the Western States.⁵⁵ Alongside this academic debate, major changes pertaining to erosion

⁵⁴ Forest influences constituted the first new project undertaken by the California station after its establishment in 1926. Prior to that time, E.N. Munns pioneered forest influences work in California, and his report *Erosion and Flood Problems in California* for the California State Board of Forestry (Munns 1923) led the way.

⁵⁵ Because of a lack of thorough knowledge on the matter, in 1909, the Forest Service embarked on a quantitative watershed experiment in southern Colorado near Wagon Wheel Gap, partially to shed light on the debate. In 1921, the experiment resulted in a report by Carlos G. Bates and A.J. Henry that was considered a classic in watershed literature at the time (Bates and Henry 1921, Forsling 1978, Price 1976, Wilm 1946). The Wagon Wheel Gap Experiment was a milestone in watershed management investigation and brought to light a number of facts on streamflow-forest relations in Western mountain states, and showed that areas did exist where the removal of forest cover did not cause damage, but even benefited water yields. In 1932, W.G. Hoyt and H.C. Troxell reanalyzed the Wagon Wheel Gap data along with additional information from two southern California watersheds in Los Angeles County—one of which had been denuded by fire. They concluded that indeed there were increases in water yield induced by denudation, but the occurrence of severe floods and damage from sediment during the years immediately after could not be overlooked (Hoyt and Troxell 1934). In 1933, W.C. Lowdermilk analyzed the Hoyt-Troxell report in an article for the *Journal of Forestry*, pointing out contradictions and conflicting evidence (Lowdermilk 1933). Nonetheless, Lowdermilk called for further research. His article, along with similar articles from 1932 to 1935 on water conservation, aspects of soil erosion and floods, and watershed protection by him and Clarence Forsling, Scott Leavitt, and Edward N. Munns, respectively, added to the debate. They developed the thesis that the protective benefits of vegetation were worth more than any costs incurred through water consumption, and that well-vegetated areas produced maximum yields of useable, silt-free water. Nevertheless, the debate continued (Aitro 1977, Storey 1982, Wilm 1946).

streamflow investigations were taking place between the Forest Service and the newly formed Soil Conservation Service or SCS. It was decided in 1935 that the SCS should direct its scope of research to lands primarily agricultural in character, whereas the Forest Service research program was to relate to forest and range lands, including the influence of plant cover on runoff, streamflow, flood control, soil-erosion control, and climate. The Forest Service program would be carried out as part of the activities of the regional forest experiment stations (Silcox 1935a), a position that was bolstered when Forest Service Chief Silcox set up a Division of Forest Influences in 1937 (USDA FS 1937c). Influences research got fully underway thereafter at seven regional forest experiment stations (USDA FS 1937c).

By 1937, forest influences research at CFRES was geographically distributed in the following manner. In southern California, the San Dimas Experimental Forest was the major center of research with limited watershed studies conducted at the Devil Canyon Branch. In the San Joaquin Valley, forest influences research occurred at the Kings River Branch Station along with some work by P.B. Rowe, on the hydrology of the Sierra Nevada foothills conducted at a watercycle installation at Northfork, California (Aitro 1977). Erosion control and reforestation of smelter-fume denuded areas and research on erosion in foothill brush type in the Sacramento Valley were carried out at limited facilities at Kennett,⁵⁶ and Redding, California, respectively. Finally, limited work on foothill brush type was also done at the University of California using its plots, lysimeters, and tank installation (USDA FS 1937d).

San Dimas Experimental Forest—

The 17,000-acre San Dimas Experimental Forest, the only such forest in southern California, was established in early 1934. Lying along the front range of the San Gabriel Mountains, it became an outdoor hydrologic laboratory to document and quantify the water cycle in these semiarid steep lands and to answer watershed, erosion, and other questions. Prior to its establishment 30 miles northeast of Los Angeles on the northern edge of the Los Angeles Basin near Glendora, California, Station Director Kotok and others had recognized the need for an experimental

⁵⁶ One of the first areas considered for revegetation/erosion control was the denuded “smelter fume” area (75,000 acres) along the Sacramento River in the vicinity of the former copper-producing town of Kennett, California, in Shasta County, which is now submerged by a reservoir. E.N. Munns originally started this erosion and reforestation project in 1921, and in 1934, CFRES revived work at Kennett using CWA labor. Over 1.2 million willow cuttings were planted in the gullies, and 800 acres were sown chiefly to ponderosa, Jeffrey pine, incense-cedar and, black oak. The CFRES terminated the project when emergency labor became unavailable (USDA FS 1934, 1935, 1937b).

forest in this part of California since 1926. However, CFRES could do nothing toward that end until May of 1932, when Kotok, Charles J. Kraeble, and Walter C. Lowdermilk of the station's research staff evaluated several potential sites. A year or so later, in an establishment report dated November 8, 1933, they officially recommended San Dimas as "eminently suitable" for the station's needs. They decided on San Dimas for several reasons. The type of cover, topography, and geologic structure of the two major watersheds selected (Big Dalton and San Dimas Canyons) were typical of southern California's chaparral region. Both watersheds were accessible by means of mountain roads. There was a minimum amount of development in the area, and flood control dams on the two key canyons (Dalton and San Dimas) furnished outside controls for all experimental data collected on smaller drainages. Finally, the experimental forest was especially suited for forest influences research because the San Dimas Water Company had maintained detailed records of runoff supply for irrigation purposes from this region for fully 20 years (Berg 1990, Dunn et al. 1988, Storey 1982).

Although Chief Forester Silcox did not officially set aside SDEF until March 28, 1934, in January, Director Kotok sent J. Donald Sinclair⁵⁷ to SDEF as the scientist-in-charge prior to being formally named director. Sinclair's mission was to get research work started at SDEF during the heady early days of the New Deal, and perhaps to address an urgent erosion control situation in southern California.⁵⁸ Prior to his arrival, Walter Lowdermilk had developed the original working plan and experimental procedures for SDEF. Sinclair's task was to supervise the construction of the necessary research facilities at SDEF, which was a major undertaking made possible first by State Emergency Relief Administration (SERA) labor

⁵⁷ Sinclair joined the Forest Service as a silviculturalist after graduation from the University of California with an M.S. in 1929. Two years later, he transferred to CFRES, where he worked with watershed specialist Lowdermilk (Robinson 1980).

⁵⁸ Erosion control work became more urgent after the disastrous La Crescenta-Montrose flood, which on January 1, 1934, killed 44 people and damaged 483 homes. The flood was more mud than water, and a CFRES study indicated that the source of the flood turned out to be a 4,000-acre fire-denuded watershed above Pickens Canyon, which carried off 50,000 cubic yards of eroded debris per square mile, whereas the runoff from nearby San Dimas Canyon, a few miles distant, carried only 56 cubic yards per square mile of eroded material. This study demonstrated to Forest Service scientists the value of forest cover and the economic wisdom of safeguarding it (Cermak 2005, Silcox 1934). Afterward, a flood-control survey of the Los Angeles River watershed was undertaken that resulted in the establishment of a remedial program, which included a Forest Service operation within the Arroyo Seco subdrainage, most of which was on the Angeles National Forest. This operation involved fire control, vegetative-cover improvement, road improvement for erosion prevention, and mountain-channel improvement. A similar operation to prevent damage by erosion, sedimentation, and possible floods from an 8,000-acre burn was undertaken on the San Bernardino National Forest (USDA FS 1941b).

and then by Depression-era CWA, WPA, and CCC labor programs in the 1930s. It was a perfect example of the aid given to CFRES by such emergency organizations (Robinson 1980, Storey 1982).

San Dimas Experimental Forest was formally dedicated on June 15, 1935. The initial broad objectives of the work undertaken at SDEF were twofold: to learn what happens to rain falling on brush-covered watersheds in terms of water yields and losses and how water and soil movement is influenced by watershed features such as vegetation, soil, and geology; and to apply this information in the management of watersheds to increase yields of good water⁵⁹ and decrease water flows and erosion (Sinclair 1960). However, research activity was postponed for 5 years, until all construction was completed. (fig. 56) Therefore, the primary activity at the experimental forest in its first few years was equipping it with necessary facilities, such as roads, trails, telephone lines, shelter cabins, field headquarters, and experimental equipment for hydrologic and other phases of its research program. To measure precipitation, 320 rain gauges, one of the largest and most concentrated networks of rain gauges in the world, were placed on contour trails to measure rainfall and its variations in the rugged mountains. To measure streamflow, 17 stream gauging stations (fig. 57) were built to measure runoff from watersheds of 35 to 8,400 acres (seven of the smaller watersheds were equipped with basins to measure sediment). To measure climate, six climatological stations were established to supply a continuous measurement and recording of air temperature, humidity, wind velocity and direction, evaporation of free-water surfaces, and soil temperatures. To measure runoff and erosion, 22 plots, each 1/40-acre, were established in three groups at elevations of 1,500, 2,700, and 4,900 feet.⁶⁰ Each group was representative of a different type of site and vegetation and equipped for measurement of surface runoff and erosion. Finally, to study the effect of vegetation on the percolation of water through the soil and on water losses through transpiration and evaporation,

⁵⁹ The sole source of water supply for southern California at the beginning of the New Deal was precipitation, making water an extremely valuable resource. In fact, since 1865, the cost of water in southern California had risen from \$900 a second-foot of continuous flow to over \$300,000 per second-foot. As a result, in southern California, all feasible means of recovering greater portions of precipitation were explored. In the face of continued shortages of water supply, the question of whether transpiration of noncommercial chaparral forest cover represented a water loss that might be recovered by systematic destruction of this mantle of vegetation by fire needed an answer (Lowdermilk and Hamilton 1933).

⁶⁰ The group at 4,900 feet was burned over by a wildfire in 1938 that moved out of San Antonio Canyon and burned about 430 acres in the San Dimas Experimental Forest. Thereafter, CFRES used the opportunity to provide quantitative measurements of the effect of fire on runoff and erosion (Storey 1982).

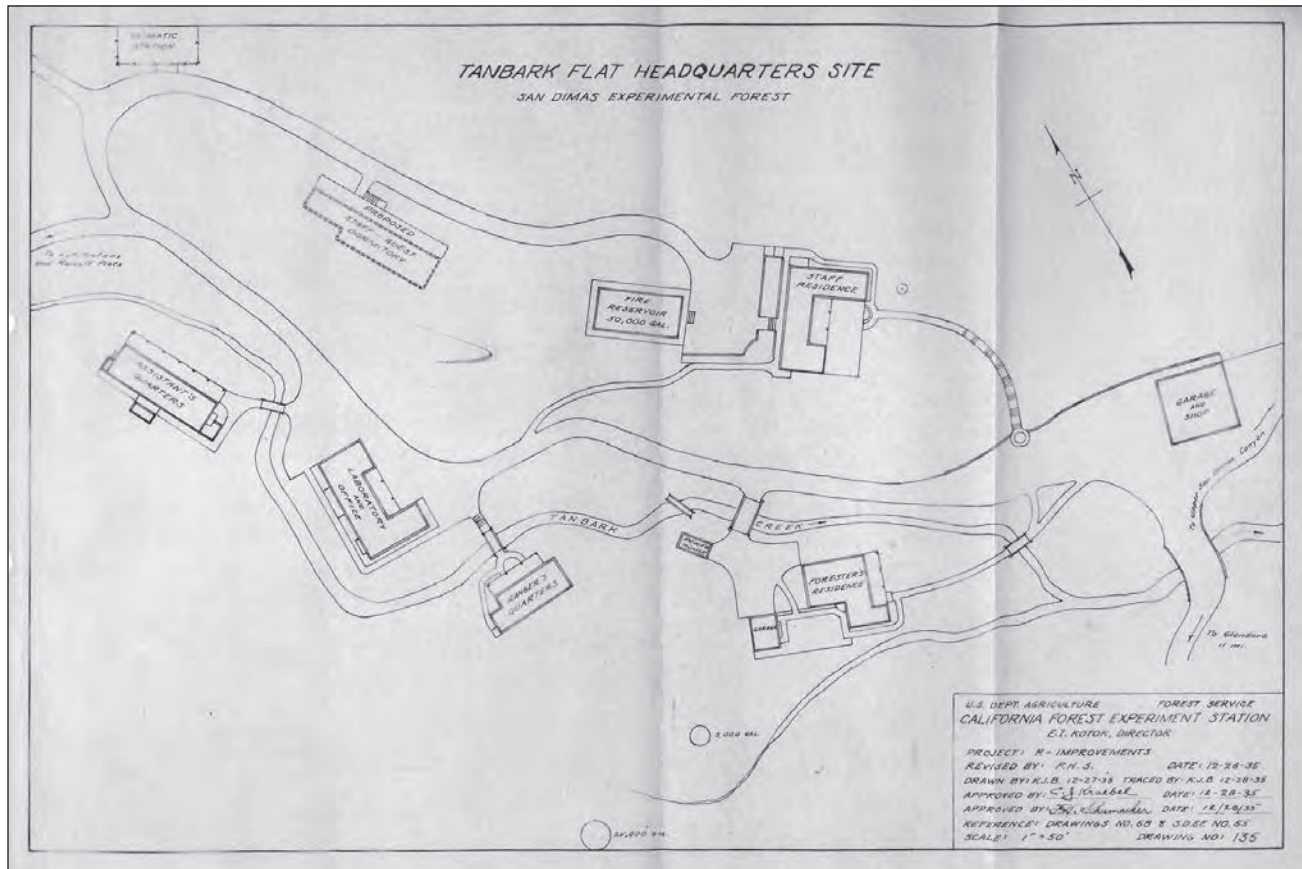


Figure 56—Site map of California Forest and Range Experiment Station, Tanbark Flats Headquarters, San Dimas Experimental Forest, 1935.



Figure 57—Water gauging station, c. 1940.

one of the largest lysimeter installations (128 in all) in the world was constructed to compare the influence of different native plant species on water yields and losses. These lysimeters, which were constructed between 1935 and 1937 at Tanbark Flats, consisted of tanks of various sizes and shapes, which in 1937 were filled with a uniform soil. To allow the soil to settle, the lysimeters remained bare from 1937 to 1940. Thereafter, various types of native vegetation were grown under observation and with detailed measurements of the water cycle (Dunn et al. 1988, Robinson 1980, Sinclair 1960, Storey 1982).

By 1940, the SDEF had all its facilities completed. They included a technician's residence, offices, laboratories, warehouses, shelter cabins, flumes and weirs, gauging and climatic stations, and lysimeters (fig. 58). As soon as some of these installations were completed, SDEF staff began its major long-time effort—the day-to-day accurate record collection of baseline data pertaining to precipitation, streamflow, climatic factors, erosion, and plant growth from all facilities. Fortunately for CFRES, in the 1930s, CCC enrollees helped in this tremendous task. For instance, during the first 6 years of operation, 114 storms were recorded at the SDEF, or an average of 19 a year. For each storm, enrollees had to cover about 100 miles of trails to note the readings of each rain gauge. Then there was the constant need to develop new instruments and techniques. For example, in March 1938, a record-breaking storm and flood⁶¹ caused so much damage at SDEF to the original gauging stations, that they were extensively rebuilt and modified into what was called then the “San Dimas Flume.”⁶² Then there were also problems with the design and performance

⁶¹ The tremendous disaster of March 1938 pointed again to the enormous importance of the station's program of research in watershed management, streamflow, and erosion control in the chaparral forests. During a 5-day period, about 19 inches of rain fell upon SDEF, causing a great deal of damage to the experimental forest. All damages were soon repaired and SDEF was reasonably rehabilitated within a short period of time because of the station's close working relationship with the WPA (USDA FS 1939a). Meanwhile, federal agencies (Forest Service, SCS, and the Bureau of Agricultural Economics), along with the state of California, began a series of flood control surveys in the Los Angeles basin to determine measures necessary to prevent and control abnormal erosion and retard flood runoff in the interest of flood control and water conservation. Staff members of CFRES were detailed to these interagency flood control surveys authorized by the 1936 Omnibus Flood Control Act (USDA FS 1939a, 1940a, 1941b).

⁶² This new approach consisted of a large concrete flume with capacities adequate for expected maximum flows, a smaller flume of steel set in concrete and placed downstream in tandem with the larger flume to measure intermediate flow stages, and a 90-degree V-notch weir to measure small clear-water flows.



U.S. Forest Service, Pacific Southwest Research Station

Figure 58—Office and laboratory building of California Forest and Range Experiment Station, Tanbark Flats, San Dimas Experimental Forest, 1935.

of rain gauges within the rugged San Dimas mountain terrain, and the lysimeter complex that also needed to be worked out. Nonetheless, with all facilities completed, studies at the experimental forest got underway. Thereafter initial investigations covered a whole range of engineering, ecology, hydrology, climatic, and soil fields of work that met SDEF's stated research objectives (Dunn et al. 1988, Storey 1982, USDA FS 1940b).

Donald Sinclair, as the SDEF Director, naturally published articles on watershed management research, focusing on the research program investigating rainfall, geology, streamflow, soils, and vegetation on the watershed. Wendell E. Davis, Everett L. Hamilton, H.G. Wilm, and Herbert Storey covered watershed precipitation research. On the other hand, throughout the 1930s Charles Kraebel published extensively on erosion control, especially in regard to the serious problem of erosion resulting from motor traffic and road building in mountainous areas, and suggested a variety of preventive and corrective measures to refine location, alignment, bridges, tunnels, retaining walls, and drainage of new roads, and improve drainage and treatment of fill slopes on already existing roads. But it was Director Kotok who took the lead in championing the forest influences studies being investigated at SDEF. Throughout the late 1930s, Director Kotok attended a number of water conservation conferences trying to distinguish between the cosmic forces, which

shaped and controlled geologic processes, and people's power to develop and protect the natural forces at work in watersheds. He often discussed the significance of plant life in a watershed and described the activities of humankind that affected vegetation unfavorably such as range overuse, fires, logging, and unregulated agriculture, and clarified the forester's function to develop and protect the natural forces at work (Aitro 1977).

Kings River Branch Station—

Forest influences research in the San Joaquin Valley in central California began in 1937, when the Kings River Branch Station was approved on the Sierra National Forest. The Kings River Branch Station consisted of two units. The first unit was the Big Creek Unit, which initially comprised several hundred acres of woodland-grass forest at elevations that ranged from 500 to 3,500 feet. In late 1935, WPA workers began construction work on this set of small experimental watersheds. Five years later, the installation here included a headquarters bunkhouse, office, small dams, water measuring devices, and shelter cabins. (fig. 59) The purpose of study at the Big Creek Unit was to investigate the relation of forest cover to streamflow in the Kings River watershed (fig. 60). Studies dealt with precipitation, runoff, groundwater, and erosion in relation to topography, geology, soil, vegetation, and fauna in two specific areas—a 200-acre foothill woodland site and a 1,500-acre fir forest (USDA FS 1935: December, 1937d, 1940b). (fig. 61)

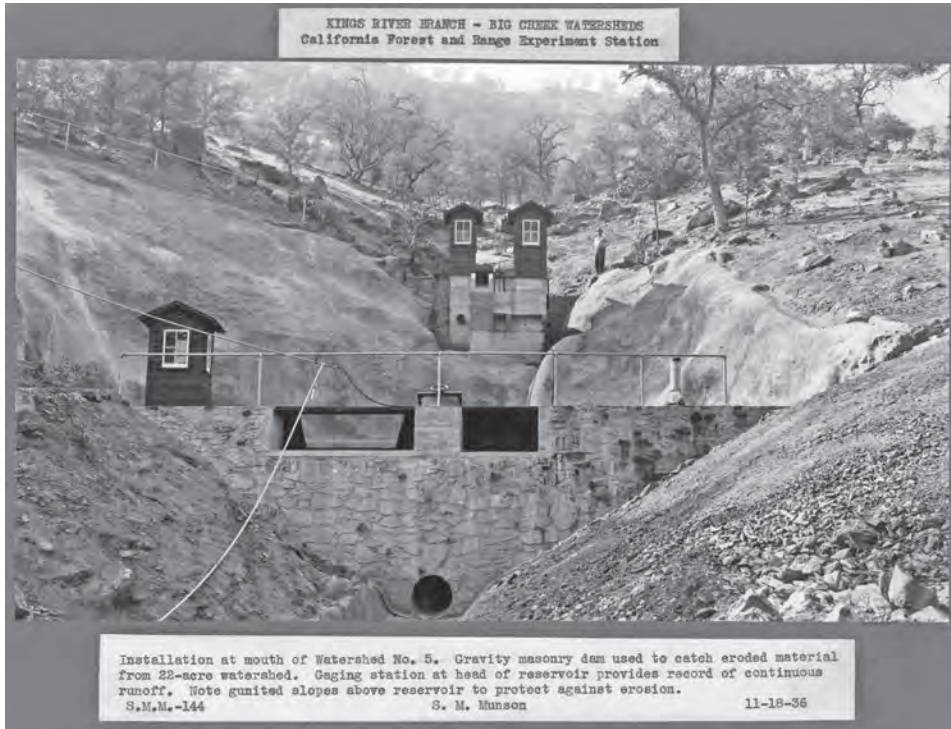
The Teakettle Unit also was created to investigate watershed issues, especially after the passage of the 1936 Flood Control Act and the Federal Soil Conservation and Domestic Allotment Act,⁶³ and after California state agencies began exploring how the Central Valley of California's water supply might be increased through management of the Sierra Nevada watersheds (Kraebel and Kellogg 1938). The snow zone of state of California lay here on the west side of the Sierra Nevada and along the Cascade Ranges above 3,500 feet, and although they are only 12 percent of the state's land area, these areas produced about 50 percent of the state's total streamflow. Given its importance, CFRES began preliminary studies of watershed management techniques for these high-elevation timberlands. Research was aimed at problems of snow accumulation and melt under various cutting practices in the steep topography of this mountainous region (Berg 1990, USDA FS 1977b).

⁶³ The 1936 Flood Control Act (49 Stat. 1519) authorized public works for flood control and particularly authorized investigations by the Secretary of Agriculture with respect to watersheds and measures for runoff and waterflow retardation (Silcox 1936). The Flood Control Act recognized that downstream engineering must be supplemented by upstream measures for retardation of runoff and control of erosion on watersheds, and the Federal Soil Conservation and Domestic Allotment Act made possible the actual job of controlling streams at the source, which included 450 million acres of national forests (Kraebel and Kellogg 1938).



U.S. Forest Service, Pacific Southwest Research Station

Figure 59—Headquarters of California Forest and Range Experiment Station, San Dimas Experimental Forest, Glendora, California.



U.S. Forest Service, Pacific Southwest Research Station

Figure 60—Gravity masonry dam used to catch eroded material from California Forest and Range Experiment Station Kings River Branch-Big Creek watersheds, 1936.



U.S. Forest Service, Pacific Southwest Research Station

Figure 61—Boat-and-cable ferry at California Forest and Range Experiment Station, Kings River Branch Station, 1938.

Toward this end, in 1938, five drainages on the Teakettle Creek watershed, located on the north fork of the Kings River in the Sierra National Forest east of Fresno, California, between Yosemite and King's Canyon National Parks, were selected for long-term watershed management studies. This acreage contained old-growth forests (primarily mixed-conifer—red fir, and Jeffrey pine with some lodgepole pine). The CCC built stream gauging stations and sediment basins here, and by the end of the year, calibration studies were begun on what was considered the Teakettle RNA.⁶⁴ The research program's objective was to determine methods of managing watersheds in representative fir and fir-pine types of the Sierra Nevada (tributary to the San Joaquin Valley) of the maximum beneficial yield of water consistent with satisfactory control of floods and erosion and with other legitimate uses of the forest. But by early 1939, because of a limitation of personnel, little could be done at this Kings River Branch unit except for the maintenance of records from the pine-fir unit at Teakettle Creek, and from the important foothills area. The research program continued until about 1940, when a lack of funds forced its closure. However, prior to its closure, a bunkhouse cabin, dry laboratory, and a small garage were built for research scientists visiting there (Berg 1990; USDA FS 1937d, 1939a, 1955a, 1977b) (fig. 62).

⁶⁴ The Teakettle RNA later was officially designated as part of the Teakettle Experimental Forest, which was established in 1958.



U.S. Forest Service, Pacific Southwest Research Station

Figure 62—Teakettle station building, California Forest and Range Experiment Station, Kings River Branch, Sanger, California.

Range Research

Range research had been established at the station in 1931, followed by a year of orientation work and surveys to develop improved yardsticks for range condition measurement.⁶⁵ Prior to the New Deal, range management in California had drawn upon the findings of systematic research in other Forest Service regions, which were then applied in California. But the broad problem of sustaining the most profitable range use was especially vexing in this region of the country. Simply put, range research facts developed elsewhere in the West did not fit well in California whose range-forage cover was highly unstable both in plant ingredients and yield

Range research facts developed elsewhere in the West did not fit well in California.

⁶⁵ Since the founding of the Forest Service in 1905, forage resources and grazing on California's national forests had declined significantly because of a number of factors. However, relief and recovery came to the livestock industry with the introduction of CCC labor and NIRA funding, which allowed for range improvement projects, such as the construction of drift fences, stock driveways, erosion control dams, stock bridges and trails, holding corrals; the development of springs, windmills, wells, reservoirs and water tanks; the reseeding of the range; the eradication of poisonous plants; and rodent control. Overgrazing conditions on California's national forests eventually were reversed, in part because of these improvements, but more likely as the result of abundant rainfall over the next few years. Save for the above work, and some administrative improvements during the New Deal, Regional Forester Show and his forest supervisors demonstrated very little interest in grazing matters. Acting on this instinct, in 1938, Show turned all Region 5 range research over to CFRES (Godfrey 2005).

of forage. California's range conditions necessitated new approaches and techniques by which to measure the effects of different range treatments. This was the broad problem that fell to CFRES and a number of cooperating agencies.

To meet California's unique range situation, CFRES initially divided its research program to cover five ecological regions—central valley and adjacent foothills, east-side (of Sierra Nevada) region, west-side timbered region, north coastal area, and south coastal area. Both cattle and sheep range problems were found in all of these regions. (Nonetheless, in the end, no detailed studies of sheep range management were undertaken in the New Deal years because of a lack of staff and funding.) But by 1941, CFRES' range research program had investigated only the first two ecological regions—the Sierra Nevada foothills of the San Joaquin Valley and the cutover mountain ranges of the east side, which included the Shasta, Modoc, Lassen, Plumas, and Tahoe National Forests (USDA FS 1937d, 1940a). To investigate these ecological regions, CFRES set up two experimental ranges—the San Joaquin Experimental Range (SJER) and the Burgess Springs Experimental Range (BSER). However, with mounting demands for meat and wool caused by the outbreak of World War II, research at these two ranges was somewhat curtailed.

San Joaquin Experimental Range—

In 1933, Murrell W. Talbot (fig. 63) led the range management team at CFRES. Under Talbot's supervision, range survey work continued in the San Joaquin Valley, a project now linked to the *Copeland Report*, which recommended a survey of forage resources and conditions being conducted throughout the Western States. The CFRES reconnaissance work assembled information on the broader aspects of the current use and condition of some 10 million acres of grazing lands in California, chiefly in the foothills below national forest lands and national parks, and almost entirely in private ownership. Passage of NIRA and CWA in early 1933 gave CFRES and Talbot sufficient funding to continue and complete the first phase of the foothill-range survey of the San Joaquin Valley⁶⁶ (USDA FS 1934: January, February, March, April). Interest in and enthusiasm for establishing an experimental range research area in the San Joaquin foothills mounted when CFRES range reconnaissance work revealed the serious problem of range use and watershed protection in the Sierra foothills adjoining the San Joaquin Valley in central California. Besides facilitating the solution to the many evident important foothill-range problems, a new experimental range offered the opportunity for closer contact with the

A new experimental range offered the opportunity for closer contact with the livestock industry.

⁶⁶ In conjunction with this project, a range bibliography with California information was brought up to date with the aid of CWA workers. This work was incorporated into Frederic G. Renner's 1938 classified index to range research covering the 1800s through 1935 (Renner 1938).



U.S. Forest Service, Pacific Southwest Research Station

Figure 63—Murrell W. Talbot, range management expert and California Forest and Range Experiment Station's "unofficial" second director (1941–1944).

livestock industry, for correlation with Region 5 range management issues, and for cooperation with related CFRES erosion streamflow studies (Silcox 1934).

In March 1934, this expectation was fulfilled, when the Forest Service used PWA funding to purchase approximately 3,500 acres of typical foothill land in O'Neals, California, north of Fresno for an experimental range. This land purchase became SJER's core area to be used to learn how to better manage San Joaquin Valley grazing lands (fig. 64). Thereafter, from 1934 to 1938, the Forest Service periodically added land to SJER under the Weeks Act until its holdings reached 5,000 acres.⁶⁷ San Joaquin Experimental Range was California's first range research station. The first task on the new experimental range was to develop basic information underlying sound range management in San Joaquin Valley's Sierra

⁶⁷ Open woodland dominated by oaks (blue and interior live oaks) and digger pines with scattered shrubs and a nearly continuous cover of herbaceous plants (grasses and various legumes) covered most of the San Joaquin Experimental Range. Perennials—primarily rushes—were found in the bottomlands. An RNA of approximately 73 acres was eventually established on a small portion of the range and has remained ungrazed since 1934. Two smaller ungrazed areas (6 and 10 acres, respectively), and numerous other small enclosures (less than one acre), were also set aside for range research over time as well.



U.S. Forest Service, Pacific Southwest Research Station

Figure 64—Building overview of California Forest and Range Experiment Station, San Joaquin Experimental Range, 1939.

foothills. Furthermore, it was originally conceived as a cooperative interdisciplinary research center to identify cost-effective methods of commercial livestock production in the annual grass-oak-pine woodlands, while maintaining the integrity of the ecosystem. Livestock on the range were used in experiments to evaluate the relationships among livestock, grazing, plants, and other animals (fig. 65).

During the summer of 1934 and under the supervision of the Sierra National Forest, construction immediately began on a work center for the new experimental range.⁶⁸ Meanwhile, Talbot's range research team began the second phase of its foothill-range survey—to survey a representative cross section of range forage plants in the valley by major vegetative types as blocked out by A.E. Wieslander's cover type map. (fig. 66) Additionally, Director Kotok and CFRES staff met with an advisory committee of Madera County stockmen and other landowners. Together, they reviewed research plans for experiments to be undertaken on SJER. At the end of this meeting, they gave general approval for SJER's main lines of work,

⁶⁸ During the initial building period, a caretaker's residence, garage, and office was built. By November, a 70-man CCC winter camp, also under the supervision of the Sierra National Forest, was established on the experimental range for the purpose of building an extensive pasture fence and other general work such as water development and other range improvements. Thereafter, in cooperation with Region 5, a crew of CCC workers was used to make a detailed topographic survey of the selected site. By 1940, the San Joaquin Experimental Forest consisted of a superintendent's house, technician's residence, offices, laboratories, greenhouse, warehouse, equipment shed, barn, corrals, and water developments (USDA FS 1940b).



U.S. Forest Service, Pacific Southwest Research Station

Figure 65—Typical cattle grazing scene at California Forest and Range Experiment Station, San Joaquin Experimental Range, 1935.



U.S. Forest Service, Pacific Southwest Research Station

Figure 66—Scientist examining range land at San Joaquin Experimental Range.

which included investigating the question of insufficient forage production in the critical early winter period (USDA FS 1934: March, April, September, November, December).

One of the most puzzling questions that SJER needed to answer was when exactly did new feed seasonally appear on California's foothill ranges. To answer this question and related ones, SJER collected forage data from approximately 800 temporary plots located at intervals over the 3,500 acres of SJER rangeland.

SJER was nicknamed the “rattlesnake ranch” because more than 200 snakes were killed during the spring of 1935.

This forage inventory was needed to provide for future comparisons of pastures treated in different ways in future experiments. To make this assessment, six grazing-capacity pastures were constructed by early 1935 and used for measuring the results of different intensities of grazing use. The pastures were arranged in duplicate and stocked at three rates: 10, 15, and 20 acres per cow. Following completion of these and additional experimental pastures, Jesse W. Nelson, who, for the past 15 years, had been in charge of District and then Region 5’s Division of Range Management, was reassigned to the CFRES and to SJER as its senior range examiner. Nelson’s first action was to purchase and introduce 70 head of two-year-old Hereford heifers onto these pastures for a controlled cooperative grazing project with the University of California. Under Nelson, CFRES’ experimental range soon became a full-fledged ranching operation. In 1936, the first season of controlled grazing took place at SJER. The University of California owned and ran the cattle herd while SJER’s staff managed range and wildlife conditions, which included thwarting coyote raids on the young herd and rounding up rattlesnakes⁶⁹ (USDA FS 1935: February, April, May, September, November, December; 1937d). In 1938, SJER sold the first cattle from the project, and they topped the San Francisco meat market.⁷⁰ For SJER, this was an encouraging start on the problem of maximum utilization in producing beef to meet market demands (USDA FS 1939b).

Meanwhile, in 1936, the Forest Service Branch of Research (BR) released *The Western Range* (USDA FS 1936), which bluntly stated that rangelands in the Western States were seriously deteriorating, and which Earle Clapp proudly saw as significant as the *Copeland Report*. The CFRES staff contributed to *The Western Range*, which placed an especially heavy load on CFRES staff time demands. They used San Bencito County as a key sample of California’s range problems (USDA FS 1937d). But with *The Western Range* project out of the way, SJER range researchers began making available SJER’s initial research results, starting first with the 1935 “Forage Inventory” study.⁷¹ The inventory study represented the first attempt, by any agency, to actually measure the composition of the complex foothill vegetation of California (Silcox 1936; USDA FS 1935: September, 1937d).

⁶⁹ SJER was nicknamed the “rattlesnake ranch” because more than 200 snakes were killed during the spring of 1935.

⁷⁰ In the 2 years on SJER’s range, each cattle herd was given supplemental feeding each summer and 49 days prior to sale. By 1941, CFRES cooperative cattle breeding herds were maintained yearlong on annual plants growing on California foothill ranges. With supplemental feeding at critical times, calf production per breeding cow averaged 98 pounds heavier, and cows earned \$6 per cow more than without such feeding (USDA FS 1941b).

⁷¹ The forage inventory found over 80 species of importance on SJER’s 1,120 temporary plots, which were distributed throughout 11 experimental pastures.

Several CFRES publications soon followed the 1936 forage inventory study. Some CFRES findings criticized the rule-of-thumb approach to range management, which failed to supply adequate information for averting continued range depletion. That approach, according to CFRES investigations, led to harmful practices, including too many animals on the range, poor balance between classes of animals and type of range, improper seasonal use, and promiscuous light burning. Another article⁷² outlined a program for range rehabilitation built around the multiple-use principle involving livestock production, watershed protection, wildlife, recreation, and timber production (Aitro 1977, Watts et al. 1936). Additionally, August L. Hormay,⁷³ in a series of publications, summarized and described the problems in past and present grazing use in several key San Joaquin Valley counties (Madera, Merced, and San Benito). They aided in defining and solving some of the more important problems connected with the maintenance of California's range resources (Aitro 1977). However, Arthur W. Sampson and Aaron Gordon wrote arguably the most significant publication to come out of SJER research in the late 1930s. In *Composition of Common California Foothill Plants as a Factor in Range Management*, Gordon and Sampson (1939) reported on the chemical characteristics of certain range plants. *Composition of Common California Foothill Plants* provided important information on plant succession, classification, and economic value of particular range plants. This information was important to perfect more dependable methods of estimating the carrying capacity of the San Joaquin Valley range. Authors of articles of similar nature and related subjects included Jay R. Bentley, H.H. Biswell, H.R. Guilbert, August L. Hormay, M.W. Talbot, and Kenneth A. Wagnon (Aitro 1977, Sanderson and Duncan 1985).

By the approach of World War II, cooperating agencies at SJER involved in foothill range research included several USDA agencies (Bureau of Plant Industry, Soil Conservation Service), the Department of the Interior's Biological Survey, the University of California, California Division of Fish and Game, and California livestock associations and community groups. Besides the cooperative controlled grazing projects, which involved investigations of grazing capacity and forage

CFRES findings criticized the rule-of-thumb approach to range management, which failed to supply adequate information for averting continued range depletion.

⁷² Interestingly, M.W. Talbot, (CFRES head of range research), Lyle F. Watts, Charles Connaughton (future Region 5 Forester, 1955–1967), and others authored *The Management of Range Lands* (Aitro 1977, Watts et al. 1936).

⁷³ August "Gus" Ludwig Hormay (1907–1999) graduated from the University of California, Berkeley, in 1929 with a forestry degree, and in 1931 went to work for the CFRES as a junior range examiner. As later chapters will note, August Hormay's 35 years of research and experimentation for the station led him to develop a theory of rest-rotation that asserted that proper livestock grazing management allowed the range to "rest" in cycles. This concept of grazing proved sound, and was adopted throughout the West. Hormay's papers are in Merrill G. Burlingame Special Collections, Montana State University, Bozeman, Montana.

utilization, other cooperative studies took place at SJER during the 1930s. They included artificial revegetation and reseeding, testing of new range plants, rodent forage consumption, and the role foothill woodland-grass cover played in the regulation of stream runoff and erosion. One significant topic, for which SJER enlisted the help of the USDA Biological Survey and CCC recruits, was the first of many bird studies. The SJER was a natural habitat of valley quail,⁷⁴ and by the late 1930s, SJER began a cooperative study with Region 5, the Division of Zoology of the University of California, and the Biological Survey on quail management (food habit and hunting recovery studies) (USDA FS 1937d, 1939a, 1940a, 1941a).

Burgess Spring Experimental Range—

The key research question in the northern California region, California's second range ecological region, centered on the proper management of east-side pineland range, and involved questions such as what was the value of the range, what effect did cattle grazing have upon pine regeneration, and what was grazing's relationship to other major land uses on the Shasta, Modoc, Lassen, Plumas, and Tahoe National Forests? To facilitate this work, in September 1935, the California station established the Burgess Springs Experimental Range, an outpost area of the nearby Blacks Mountain Experimental Forest. The BSER, located 16 miles east of BMEF headquarters, encompassed an area of approximately 1,280 acres. By the end of the year, the CCC completed the physical construction work needed here, which included a number of livestock enclosures, a game and rodent enclosure, and a few other improvements of lesser importance.

In its first year, studying range management on cutover ponderosa pine lands began at Burgess Springs. Initial investigations studied the damage to tree reproduction by cattle, paying particular attention to the effect of grazing on the survival of pine seedlings. By the late 1930s, research at BSER determined that cattle caused very little damage to pine reproduction in the northeastern California region. By 1940–1941, range research work at BSER was refocused. After many field visits and office consultations with Region 5 administration, it was decided to complete an analysis of broader range problems confronting Region 5's east-side ranges. They included plant succession and cattle carrying capacity⁷⁵ of cutover pine land,

⁷⁴ Henry S. Fitch and Ben Glading were the principal scientists who cared out studies on quail that frequented the San Joaquin Experimental Range, as well as other birds such as the horned owl, at this time.

⁷⁵ At this time, sheep were excluded from cutover lands in some east-side national forests. However, there was pressure from the livestock industry to establish an experimental sheep station somewhere in the north end of the Sacramento Valley to answer similar questions regarding sheep management (Hill 1939, Talbot 1940).

season of range use, utilization standards, fluctuations in forage production, livestock control and management, artificial and natural revegetation and erosion control, livestock grazing versus wildlife, and livestock grazing versus timber production. Essentially, this reorientation modernized the CFRES range research program in this part of California, and put it on a long-range basis (USDA FS 1935: April, September, November; 1937d, 1939a, 1940b, 1941a).

Forest Economics

Like range research, forest economics research,⁷⁶ the science of production, distribution and consumption of forest wealth, hit its stride during the New Deal years, largely because preparations of portions of the *Copeland Report* fell particularly within the field of forest economics (Stuart 1933). In California, no longer did forest economics research center just on the forest survey mapping project.⁷⁷ Instead, it included the analysis of the financial and social aspects of forest-land use, and was seen as a yardstick that gauged whether technical developments and recommended practices were feasible and could be applied in forestry. In a sense, forest economics worked for all the other divisions. But in another sense, all other divisions worked for forest economics, as their recommendations would sooner or later have to stand the test of economic analysis (Talbot 1940).

As the 1930s progressed, the CFRES forest economic research program transitioned from conducting a few specific studies⁷⁸ into a well-rounded comprehensive attack on California's forest economic problems. This changeover accelerated after 1936, when economics was designated as a full-fledged station division, and staffed

In California, no longer did forest economics research center just on the forest survey mapping project.

⁷⁶ One of the earliest pieces of research conducted in California pertaining to economics was a study conducted by C. Stowell Smith, who was Chief of Products in District 5, a position he held from 1908 to 1917. In 1914, Stowell authorized a study entitled "The Lumber Industry in California," which was intended for official publication, but was sidetracked by World War I research problems (USDA FS 1937b).

⁷⁷ Mapping of forest-cover types in California continued in cooperation with Region 5 staff, the U.S. Geological Survey, and the National Park Service. In 1933–1935, several maps covering over 4 million acres were completed, which proved useful to a large variety of agencies, universities, private firms, and individuals (Silcox 1935a, Stuart 1933). By 1937, CFRES field type mapping covered 29 of the total of 72 million acres in California. These maps were seen as indispensable to the timber-inventory phase of the survey yet to come (Silcox 1936, USDA FS 1937a). By 1940, a skeleton staff was still working on the forest survey, and their energies were being used in interpreting and preparing for dissemination the data already collected (Talbot 1940).

⁷⁸ One such investigation was a forest-insurance study completed in 1934 for the sugar pine, ponderosa pine, and redwood regions of California that concluded that there was no reason why forest-fire insurance could not operate successfully in these regions (Silcox 1934). Another study demonstrated the financial disadvantages of cutting smaller trees, and compared the conservation values of selective or partial cutting to indiscriminate clearcutting (Silcox 1935a, USDA FS 1937a).

Researchers set out to work out a stable coordinated form of forest utilization based upon sustained-yield forest management for the foothill lands where forestry played a key element in the local economy.

in part with wood products personnel (CFRES 1937: 27, USDA FS 1937d). The CFRES economics research concentrated on two economic questions: forestland ownership and the relation of taxation and public finance to land use. Regarding the former, CFRES, with the cooperation of the Giannini Foundation, assumed control of the land-use research in five counties in the Sierra foothills, begun by the wood products division in the early 1930s. The CFRES economics division was interested in the possibility of stabilizing local communities that were partly dependent on the adjoining public and private forest resources. Researchers set out to work out a stable coordinated form of forest utilization based upon sustained-yield forest management for the foothill lands where forestry played a key element in the local economy. Regarding the latter problem, CFRES began a somewhat similar study of the relationship between taxation and public finance and land use in four south-central Sierras counties (Silcox 1936, USDA FS 1937c). Economic investigations, such as these, reflected Chief Silcox's view that there was a social obligation inherent in forest-land management (USDA FS 1937a).

Economist H.R. Josephson,⁷⁹ who joined the CFRES wood products division in 1934 after graduate work at the University of California, Berkeley, published several articles in the late 1930s that discussed the desirability of sustained-yield forest management, and the need to consider economic trends in planning, including taxation policies, to realize the highest monetary and social returns from the use of forest resources. In several significant publications, Josephson also discussed the competitive and supplementary relationships between forestry and agriculture, the intensity of forest-land use, and policies of best use in order to realize productive forests, profitable and stable industries, and permanent forest employment (Aitro 1977). Simultaneously, Station Director Kotok, in a 1938 paper entitled *Some Economic Problems in Pacific Coast Forestry*, examined another important economic question being discussed at the time by a new breed of economists calling themselves forest economists (Kotok 1938). They, along with lumbermen and foresters, posed the question of whether the Pacific Northwest would go through the same cycle of forest resource exploitation that had occurred in New England, the Great Lakes region, and the South. Kotok concluded that the Pacific Coast States had not reached the final stages of forest exploitation as had these other regions. He did believe, however, that there were adverse symptoms evident in many spots.

⁷⁹ In 1940, Josephson left the station, when he was appointed to the faculty of the Department of Forestry, University of California College of Agriculture (Oakland Tribune 1940).

Beyond the value of timber and lumber products and associated aspects, Kotok pointed out that forests also played an additional economic role in recreational use, in livestock grazing, and in watershed protection, which he and others considered paramount and the first requisite in forest management. In conclusion, Kotok stated that the best economic development for California's forests was a "multiple land use plan" that integrated "timber, forage, wildlife, water, hydroelectric energy and recreational opportunities" as the "wealth which could insure stable and permanent communities" (Kotok 1938). Kotok and Josephson looked forward to researching specific studies, such as comparing the relative income from forest or grazing use, or financial comparisons of liquidation and sustained yield in industrial forest enterprises. But World War II interrupted those plans.

Wildlife and Recreation Research

The year 1936 was a turning point in wildlife research, as it had been for economic research. Prior to the 1930s, the Forest Service had increasingly realized the inter-relations of wildlife resources with economic, recreational, and other forest uses. Many in the agency believed there was a need to research them and instigate sound planning based on the study of the subject. That opportunity came on June 1, 1936, when the Forest Service organized a separate division of wildlife management and 83 specialists for wildlife assignments in the regional offices, with 63 of them trained in colleges and universities (1936: 32–33; Silcox 1936, USDA FS 1937c). The CFRES would not get a wildlife research specialist for some time to come. Instead, this research continued to be conducted by the Bureau of Biological Survey (BBS).

As noted in the previous chapter, biologist E.E. Horn of the BBS had begun cooperative wildlife investigations with the CFRES in 1928. In the 1930s, Horn continued these investigations, which were of practical service to forest and range management. By this time, BBS stationed Horn in residence at the San Joaquin Experimental Range. Along with WPA help, Horn investigated the influence of wildlife on SJER's rangeland, namely the food habits of rodents and the function of rattlesnakes as predators influencing rodent populations. At about the same time, CFRES, in cooperation with Region 5, initiated a study on the Los Padres National Forest pertaining to coyote-deer predation. In northern California, wildlife research continued on the perpetual problem of rodent and rabbit attacks and pine regeneration, but found no active deterrents at this time (USDA FS 1939a, 1940a, 1941a). Finally, the BBS developed a new wildlife manual that helped forest officers to administer wildlife resources on the national forests in cooperation with the states

(USDA FS 1941b), but it would not be until after World War II that the Forest Service realized it needed to conduct its own wildlife research programs if the organization was to better understand the management of this resource.

Much the same could be said for recreational research efforts. From the moment President Roosevelt took office until the outbreak of World War II, recreation issues began to dominate many of Region 5's activities, and the administration increasingly focused its attention on recreational management. For instance, in 1936, Regional Forester Show initiated a recreation inventory that rated each of California's national forests on their suitability for recreational use. According to Show, this was the first such program completed anywhere in the country⁸⁰ (Show 1965). However, many recreational questions regarding mixing camping and summer resort home areas, or calculating canyon capacity for camping units, went unresolved. Furthermore, the Forest Service had no clear idea of how unrestricted summer and winter recreational use by visitors and by sightseers affected the national forests, and would not until Forest Service recreational research programs began after World War II (Camp, n.d.). However, recreational research would not become a research function at CFRES until the early 1960s.

Other USDA Agency Research

From the very beginning, the California station's investigational program was closely coordinated with that of Region 5, the administrative branch of the Forest Service in California. Regional Forester S.B. Show highly valued the CFRES work and liberally supported it because the station's research program affected Region 5's work directly. Therefore, CFRES research was mutually beneficial to both organizations. While Region 5 subsidized the station in building its work stations on experimental forests, Region 5 benefited by learning the results of up-to-date and very practical research in timber and range management (Show 1965). Cooperative projects between Region 5 and the station have been identified already in this narrative, and need not be repeated. Cooperative studies in California that also continued

⁸⁰ Before World War II, California Region 5 was able to provide the public with lists of all the national forests by name and location, together with thumbnail sketches of special recreational features and types of accommodations available. Each national forest had simple facilities for the visitor's convenience, such as stoves or grates, tables, good drinking water, and sanitary facilities at all improved campgrounds and picnic grounds. It had simple shelters, bathhouses, playfields, and nature trails at some of the more popular ones. There were even parking areas, ski shelters, runs, and jumps, and some toboggan slides at winter sports areas. Besides supporting good recreational design, Chief Silcox also instructed his regional foresters to lend greater attention to the "social" functions of the forest in their recreation programs (Godfrey 2005, USDA FS 1941b).

with three USDA agencies, the Bureau of Plant Industry, Soils, and Agricultural Engineering (BPISAE), Bureau of Entomology and Plant Quarantine (BEPQ),⁸¹ and BBS are briefly discussed below.⁸²

Forest Pathology and Entomology Research

At the start of the New Deal period, white pine blister rust was the most immediate menacing tree disease on national forests throughout the country. The disease had been found 50 miles north of the California-Oregon border, and many feared that the disease would soon reach California's sugar pine region, the most valuable timber species of the state. To control any spread of the disease into these valuable stands, the Forest Service continued to eradicate the alternate host plants of the disease—shrubs of the genus *Ribes*—from the forest. The BPISAE recommended this treatment. By 1935, close to 120,000 acres of sugar pine in California and Oregon were treated in this way, and a year later, total treated areas reached 187,000 acres. However, the Forest Service estimated that 1.1 million acres needed protection—a worrisome situation. The Forest Service annual report for that year indicated that serious losses in future timber production could be averted only by concentrated work during the next 2 years. However, although progress was made in the war on white pine blister rust by mobilizing and using emergency labor of CCC and WPA crews, the effort was inadequate, and the disease became established in northern California and continued to spread (Silcox 1934, 1935a, 1936; Stuart 1933; USDA FS 1937c, 1938b, 1939b, 1940d, 1941b).

In regard to insect control, CFRES staff did very little basic research on the biological factors concerned in forest insect infestations in Region 5 during the New Deal period.⁸³ Essentially, CFRES left this activity to cooperative work with senior entomologist J.M. Miller at BEPQ's Forest Insect Laboratory located on the Berkeley campus. From 1933 to 1935, major insect infestations continued to plague the Sierra, Stanislaus, Modoc, and Shasta National Forests. To combat them, California Region 5 conducted insect-control work as recommended by BEPQ with the help of CCC labor and in cooperation with private owners of adjoining infested

⁸¹ Effective July 1, 1934, the Bureau of Plant Quarantine was consolidated with the Bureau of Entomology in the Department of Agriculture by the Agricultural Appropriation Act of March 26, 1934.

⁸² In 1939, the Bureau of Biological Survey was transferred from the Department of Agriculture to the Department of the Interior as part of the Fish and Wildlife Service.

⁸³ At this time, Hubert Person and Harry A. Fowells conducted the only direct CFRES insect control work. Person wrote on the insect enemies of redwoods (Person 1933), and Harry A. Fowells investigated the cutworm damage to seedlings to California pine stands (Fowells 1940) (Aitro 1977).

Destructive outbreaks of beetles continued, but they appeared to be localized attacks.

areas. Despite their industrious efforts, emergency labor only marginally stemmed the tide of bark beetle epidemics on some national forests as new epidemics developed elsewhere. But, in 1936–1937, in contrast to reports on the situation from previous years, there appeared to be a return to normal conditions on most of California’s national forests. Destructive outbreaks of beetles continued, but they appeared to be localized attacks (Silcox 1934, 1935a, 1936; Stuart 1933; USDA FS 1937c, 1941b).

Even so, in 1937–1938, funds from both the Forest Service and BEPQ were used to establish two new forest insect laboratories in California because they feared that renewed extensive bark beetle infestations could still cause severe losses of high-value trees in the Sierra Nevada. Their mission was to continue to gather seasonal information on the causes and extent of these outbreaks. One field laboratory was located at Hat Creek Ranger Station on the Lassen National Forest in eastern Shasta County, and was designated to conduct forest insect research in northern California. Kenneth A. Salman was placed in charge of the Hat Creek Field Laboratory. The second insect research station, the Miami Field Laboratory, was placed on the Sierra National Forest. John E. Patterson directed it. Both laboratories were built during the summer and fall of 1937 by CCC crews, and were in operation by the summer of 1938. The Hat Creek and the Miami Field Laboratories, along with the Hackamore Field Laboratory, which had been established at an earlier date on the Modoc National Forest,⁸⁴ conducted biological research to obtain better knowledge regarding the problem of insect control, development and testing of insect control methods, and classification of pine stands according to insect hazards as a basis for utilization of expected losses. Besides these laboratories, BEPQ added personnel to its main office and laboratory on the Berkeley campus. By early 1939, BEPQ began an annual detection survey program in California. This program supplied information on current insect conditions in the more important commercial and recreational forest areas of the California region. But priorities of the war program soon cut funding for the Berkeley Laboratory, and the war effort soon eliminated a number of projects there and at the Hat Creek, Miami and Hackamore laboratories as well (Hall et al., n.d.; Tilden 1983; USDA BEPQ 1939; Wickman 2005).

⁸⁴ In the early 1930s, “a rather crude station” was built at Hackamore in the Modoc National Forest. “It consisted of small cabins and a small lab and rearing building for study of the western pine. A.S. West, Jr., Jack Whiteside, and Jack Bongberg worked there under Salman. The buildings at this site were the temporary type, probably because it was not at a convenient location” (Wickman 2005).

Prelude to War

During the New Deal years, the vigorous research roots of CFRES were nurtured from seed in 1926 to a full-body research organization that worked cooperatively with many federal, state, and private institutions to fulfill the research needs of Region 5. By the approach of war, CFRES had eight major lines of work (silviculture [pine and redwood], wood products, range, economics, fire, influences, genetics, and forest survey), with the personnel, funding, facilities, and experimental forests to match most of their research needs. But, World War II retrenchment would nibble the station's domestic research program to the bone.

This Page Left Blank Intentionally

Chapter 5: 1941–1945, Off to War

“The fact that we are at war makes it necessary that all the work of the Department of Agriculture be reviewed in the light of the new situation.... Every activity now must be measured by the contribution it can make to a victorious conclusion of the war,” declared Agricultural Secretary Claude R. Wickard on December 11, 1941, 4 days after Pearl Harbor. When Wickard asked how the Forest Service, along with the rest of the Department of Agriculture, could help the defense effort, Acting Chief of the Forest Service Earle H. Clapp was prepared. Clapp had already begun shifting employees from less essential work to activities that contributed directly to national defense. Normal Forest Service business was pruned down to the barest minimum consistent with the discharge of the agency’s irreducible obligation to protect and maintain the country’s national forests. In general, during the war, the Forest Service national defense program included making timber, range, and other resources available for war without destructive depletion of them, providing direct aid to combat defense, supplying specialized equipment, services, and skills to the military, and aiding civilian defense and anti-FC activities (USDA FS 1945).

Under the leadership of Regional Forester S.B. Show, Region 5, effectively and efficiently handled the majority of these Forest Service defense and war activities in California. Region 5’s wartime program was a multifaceted one that included locating critical raw materials and strategic metals on California’s national forests; manning the Aircraft Warning System (AWS); preventing fires caused either by enemy sabotage, by friendly forces, or by natural events; and by increasing timber production for defense purposes (Godfrey 2005). The California Forest and Range Experiment Station (CFRES) did its part by undertaking research to find the best and largest possible uses of wood and wood products to further the war effort (USDA FS 1945). Although the Forest Service in general directed research toward national defense, the agency also aimed to establish and maintain a healthier and more prosperous national economy after peace was reestablished (USDA FS 1941b). The CFRES, under the leadership of Acting Director Murrell W. Talbot, or “Tally,” was tasked with the wartime research mission in California.

Wartime Retrenchment

From the outbreak of World War II, transfers of key personnel to other USDA and Forest Service assignments seriously affected the CFRES research program. For instance, by late 1942, L.N. Ericksen from the wood products division had transferred to the Washington office, physiologist Nicholas T. Mirov from the Institute of Forest Genetics (IFG) had gone to the Southern Station for a short time,

N.D. Bruce was on loan to the Forest Products Laboratory (FPL),¹ and C.L. Abell was transferred to Region 5. At the same time, other personnel simply resigned from working at CFRES to go into various war industries, and others were drafted. Still others, frustrated by their mundane tasks of keeping and maintaining records and data at the station, and impatient to contribute to the war effort in a more active role, were given military furlough to enter the armed services. By September 1942, they included men like R.K. Blanchard, L.W. Hill, D.M. Ilch, D.H. Rogers, and A. Simontachhi. W.E. Hallin left for the United States Army Air Corps, and C.H. Gleason and B.M. Kirk applied for commissions. Still others were reassigned to Selective Service work in connection with the conscientious objector camps run by the Civilian Public Service (CPS).² Although these personnel losses were distributed among all of the CFRES divisions, they hurt forest products and influences the most, eventually forcing these programs to close by the end of the year. In addition to the loss of key professional and technical personnel, CFRES could no longer take advantage of New Deal emergency program labor as it had in the 1930s. In the heyday of the New Deal, CFRES had approximately 700 Works Progress Administration (WPA) and State Emergency Relief Administration (SERA) enrollees working at the Berkeley Station, the IFG, and the San Dimas Experimental Forest (SDEF). By the end of 1942, only 42 remained (USDA FS 1945). Fortunately for the CFRES, in mid-1941, the CPS established a camp at Tanbark Flat on the SDEF. The 90 or so conscientious objectors there took up some of the work previously done there by New Deal emergency laborers. A CPS side camp was also assigned to the field research station at the San Joaquin Experimental Range (SJER) (Price 1948, USDA FS 1945). The CFRES budget fared no better. According to one report, as the war progressed, CFRES' dependency on CPS funds, which could be discontinued any time during the war years, was "breathtaking" (Loveridge and Dutton 1946).

Because of the loss of personnel and research funds, the research program naturally suffered during the war years. Prior to retrenchment, the station's program, which was developed in close cooperation between the station and Region 5,

¹ In World War II, the laboratory was called upon to lay aside long-range research in order to devote its resources to war-related problems. Unlike the California station, with the outbreak of war, FPL's budget, personnel, and operations grew quickly. Within a short time, the FPL's budget grew from \$600,000 to \$2.5 million; personnel increased from 175 in 1940 to 700 in 1944 with many projects on a three-shift basis. National defense research activities of the FPL were many and it was acclaimed as a "real wartime star" (Godfrey 1990, Steen 1998).

² The Selective Training and Service Act of 1940, approved September 16, 1940, provided in part that "any person who, by reason or religious training and belief, was conscientiously opposed to participation in war in any form, whose claim was sustained by the local draft board, should be assigned to non-combatant services." On February 6, 1941, President Roosevelt authorized the Director of Selective Service to designate work for conscientious objectors and establish camps from which to carry on such work (Price 1948).

was an accomplished one. However, by 1944, personnel loss and diminished financial resources caused CFRES to completely drop, or to continue on a maintenance basis only, many of its research lines. Among those dropped completely were all silvical and site factor observations (except simple weather records), stand and tree growth records, utilization studies in connection with harvesting, regional redwood (see “Scientific and Common Names” section) research, further statistical analysis of fire data, studies on the use of water and chemicals in fire suppression, fire behavior and speed and strength of attack research, periodic insect and disease control investigations, and periodic records and data for genetics studies. The budget for the Forest Resources Survey, or FRS, was slashed by 50 percent, and the products budget was cut 19 percent with no work being done because the one man assigned to the work spent most of his time on other jobs. The forest influences budget was slashed by 45 percent. All influences work now was concentrated at SDEF because CPS labor was available there. Because of the war, R.H. Weidman was the only regular staff member to remain at IFG, and project work at the institute for a time was slowed down to a maintenance basis only (Loveridge and Dutton 1946).

War Research Program, 1941–1945

In the turmoil of the first month following Congress’ declaration of war on December 9, 1941, Acting Director Talbot and CFRES staff scrambled to find the station’s niche in the war effort and to gear up for defense activities. Silviculture research pushed vague forest management ideas for California’s pine and redwood regions. The forest products division meekly offered consultation services to local industries and to the FPL. Range research simply had no wartime program offerings, while economics, working with the western pine and redwood associations, began to maintain charts and statistics of lumber production, orders, and shipments. Meanwhile, fire research contributed limited resources to urban fire defense, and influences research studied the establishment of ground cover for mud and dust control, erosion control, and landscaping planting for new military facilities. Genetics offered to test the quantity and quality of naval stores in western pine, or survey native plants for possible products during the war crisis. Finally, forest survey staff made an effort to use aerial photographs for activities of value to wartime and postwar planning (USDA FS 1945).

Although disorganization reigned at first, by January 1942, a clear wartime program had begun to emerge. And by June of that year, CFRES found its stride in contributing to the war effort. In fact, former Station Director E.I. Kotok, who now was an Assistant Chief in the Washington office, took the time to “give his best

By June of that year, CFRES found its stride in contributing to the war effort.

CFRES-related publications were of material value in getting ranchers to see the advantages of moderate grazing on annual-type ranges in California.

to the gang for a good job under way” (USDA FS 1945). Because CFRES worked so closely with Region 5 during World War II, in many instances, separation of their individual organization contributions in the war job was virtually impossible. Nonetheless, CFRES research was reoriented to fighting America’s enemies and provided valuable assistance in the following general defense and war activities.

Assistance to Farm Families in Producing Feed for Freedom

After the Pearl Harbor attack, President Roosevelt appointed the War Production Board (WPB) to coordinate procurement programs for the armed forces and to allocate materials between civilian and military needs. The WPB provided assistance to farm families, fostered cooperation with livestock owners in production campaigns, and helped resolve many farm labor problems. The California Station, along with Region 5,³ worked closely with the WPB’s “Food for Freedom” program. Russell W. Beeson from Region 5 was assigned to this task, but represented the station as well. The contributions of CFRES focused on assisting the Agricultural Adjustment Administration (AAA) in its efforts to meet livestock and meat production goals during the war years by improving range utilization. The station also conducted studies on ways to increase forage production on mountain meadows through reseeding trials, and to increase livestock production through better understanding of forage competition between deer and cattle in northeastern California. In the latter case, the California station reestablished bitterbrush on burned-over range to make more forage available for livestock production (USDA FS 1945). Although during the war years CFRES publications were limited, August Hormay and J.R. Bentley managed to publish several short research articles on standards for judging the degree of forage utilization on California annual-type ranges and the distribution, forage value, enemies, growth pattern, reproduction, and methods of estimating grazing use of bitterbrush (Aitro 1977). The AAA and the Soil Conservation Service (SCS) reported that these CFRES-related publications were of material value in getting ranchers to see the advantages of moderate grazing on annual-type ranges in California (USDA FS 1945). By mid-1943, CFRES shifted away from this war work back to its normal domestic range research program, which is discussed in a later section.

Locating and Servicing New Defense Industrial Plants

One underestimated benefit provided by the California Station during the first months of World War II was the technical advice it gave to the defense industry about controlling erosion during the construction of important industrial plants. For

³ For a description of Region 5’s war effort, see Godfrey 2005.

instance, the station supplied 10,000 shrubs and reseeded trees for erosion control for the huge new magnesium plant built near Palo Alto by the Permanente Metals Corporation. During World War II, this magnesium plant turned out 1 million pounds of the chemicals used as the flammable agent in America's military incendiary bombs⁴ (USDA FS 1945).

Providing Strategic and Critical Raw Materials

The California Station staff made numerous major contributions to providing strategic and critical raw materials during the war by working closely with the lumber branches of the WPB and the Office of Price Administration (OPA). One major aim of the CFRES wartime program was to conduct fact-finding surveys for these war agencies that controlled the Nation's lumber production. Requirements, production, and supplies (RPS) of forest products, a war-connected program, was carried out by the station and financed for the most part by the WPB during World War II. The CFRES met this goal in several ways. First, CFRES staff gathered data on supply and demand for all types of timber and on any shortages in California that might be developing. For instance, each quarter, CFRES provided the WPB and OPA with a comprehensive appraisal of the factors affecting lumber production for both the pine and redwood regions. These appraisals included a report of production to date, a forecast of expected production, an analysis of manpower problems, and an examination of equipment, weather, and other difficulties. The fall reports were expanded to include a summary of log inventories available for winter milling. Tabulated lumber production statistics included shipments, orders, and production for the lumber industry by pine and redwood regions, along with indices of labor and transportation trends. Finally, the station kept the WPA and the OPA informed on a number of other war-related statistics, such as California's fuel situation, in terms of demand for coal, oil, and fuel wood for farms and cities, especially for winter use. These inventories, surveys, statistical calculations, and similar data gathering became a routine contribution of CFRES to the war effort (USDA FS 1943).

One key element of CFRES' information mission additionally involved reporting critical special situations. For instance, in the early part of the war, there was an extraordinary demand for heavy beams, posts, and pilings for the many new harbor facilities needed by the military. To meet research data needs regarding piling

The CFRES wartime program was to conduct fact-finding surveys for these war agencies that controlled the Nation's lumber production.

⁴ The Permanente magnesium plant was dismantled in 1947.

The WPA continually sought CFRES advice on various timber and lumber operators' equipment needs [and] on plant expansion requirements.

demands, in 1942, the Challenge Experimental Forest (CEF) on the Plumas National Forest was designated for experimentation in this research area. At CEF, CFRES surveyed and established sample plots in the CEF's second-growth pine in order to initiate piling research as quickly as possible. The station also studied piling production methods, costs, wastes, and relationship to second-growth stands, and reported the results to the AAA. The station also reported on the production, consumption, and supply of wood piling in California, and consulted with the Maritime Commission on marine piling preservation. In 1943, a CEF timber sale provided 35,000 linear feet of piling for the war effort⁵ (USDA FS 1945). Later that year, the CFRES wood products division summarized its findings in a publication designed to inform landowners about the methods of selling piling stumpage in order to encourage such sales (USDA FS 1945). Another special report appraised California's wooden agricultural container situation. Because of war-caused wood shortages, sawmills, box factories, trade associations, and consumers of fresh fruits and vegetables demanded information on shook (a set of components ready for assembly into a box, cask, or crate) production. The CFRES provided this supply-and-demand information to them and to all concerned federal and state agencies, such as the state Agricultural War Board. The station also produced for the WPB a singular report describing the number, kind, location, holding capacity, and present conditions of all California dry-kiln facilities⁶ (USDA FS 1945).

Throughout the war years, CFRES carried out those consultant and research services to these and other war agencies, and most local, regional, and district offices of the various war agencies concerned with California lumber production knew to ask the station for factual information. For instance, the WPA continually sought CFRES advice on various timber and lumber operators' equipment needs, on plant expansion requirements, and on probable production of individual operations. Or, for example, the War Manpower Commission (WMC) relied on CFRES to analyze its bimonthly reports of current and anticipated employment in selected

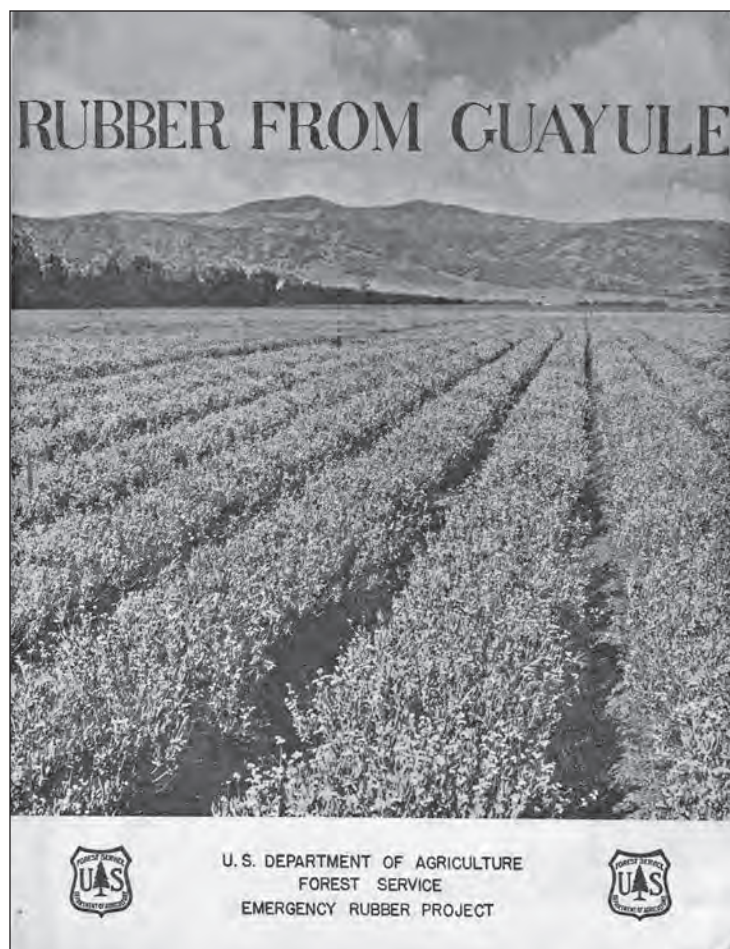
⁵ With the exception of the Blacks Mountain Experiment Forest (BMEF), all other experimental forests were essentially shut down during World War II. However, BMEF contributed to the war effort by continuing to test methods of controlling insect losses through proper selective logging practices. Improved cutting practices helped to provide more timber from BMEF plots, and as a byproduct of this research, BMEF seasonally provided 10 million board feet of Douglas-fir (see "Scientific and Common Names" section) for veneer and made several million board feet of ponderosa pine available for the war (USDA FS 1945).

⁶ After World War II, the FPL gave priority to kiln-drying research to provide properly cured lumber for new home construction, which the National Housing Authority predicted would reach nearly 3 million by the end of 1947 (Steen 1998).

California lumbering and logging operations. Finally, OPA consulted with the station on food rationing problems in the lumber industry and repeatedly sought advice on the effect of the various lumber, log, and stumpage price ceilings. Other agencies even used CFRES economic data and periodic reports as evidence in legal cases submitted by labor and management (USDA FS 1943).

Finding Substitutes for Unobtainable Imported Raw Materials

With the Japanese invasion of Indochina in 1940–1941, the United States was cut off from natural rubber supplies, and a substitute source was needed immediately. In the battle to find substitutes for imported raw materials such as rubber, attention was immediately drawn to the guayule plant as a substitute for the imported raw natural rubber. With the outbreak of war, the Forest Service began an emergency Guayule Rubber Project (fig. 67) without delay, and in February 1942, Region 5 was delegated to oversee the exploration of cultivating and processing of the guayule



U.S. Forest Service, Pacific Southwest Region

Figure 67—Work on the Guayule Rubber Project was but one California Forest and Range Experiment Station contribution to the World War II effort.

CFRES explored other rubber substitute sources.

plant through grinding, washing, and flotation (Godfrey 2005). Acting Station Director Talbot believed that CFRES' genetics division and its highly trained specialists were eminently qualified to contribute to the Guayule Rubber Project. So in April 1942, Talbot heavily lobbied Clarence Forsling, head of the Forest Service Branch of Research (BR), to assign the California Station to the project (USDA FS 1945). In September 1942, Talbot transferred A.E. Wieslander and three "flood control men" to the Guayule Rubber Project and CFRES began conducting limited research. The CFRES participation included determining the suitability of various farming areas for guayule production, supplying basic climatological and water cycle soils data, and compiling a statewide map showing locations of potential guayule plantation sites. (USDA FS 1945). Meanwhile, CFRES explored other rubber substitute sources. For instance, CFRES, in cooperation with the University of California and Stanford, studied Indian hemp as a rubber and fiber source. Preliminary studies indicated that 100 to 200 pounds of rubber could be produced per acre from this common weed, and 500 to 1,000 pounds of fiber could be expected from this cannabis plant. Additionally, the station began researching varieties of rabbitbrush as a possible rubber source. But by April 1943, CFRES scientists determined from extraction tests that rabbitbrush did not constitute a feasible rubber source for the present emergency (USDA FS 1945).

In the meantime, the CFRES genetics division focused one of its wartime investigations on the genus *Garrya* as a practical source of an alkaloid, *garryine*, to be used as a substitute for quinine in the treatment of intermittent fevers such as malaria. Scientists, such as Nicholas T. Mirov (fig. 68), worked closely with the University of California Medical School and College of Pharmacy in this *Garrya* bush study. As late as April 1943, testing showed sufficient promise to continue the project, but within months, problems surfaced. By October 1943, CFRES dropped the project from its wartime research program when John Hopkins Medical School discovered that six of the *Garrya* species being tested had no alkaloid similar to quinine. Meanwhile, Mirov worked on several other war projects, such as obtaining rotenone,⁷ a toxic crystalline substance used at the time as an insecticide, from new sources. To meet the critical shortage and urgent need for this material, Mirov tried to extract it from the seeds of native species of *Amorpha fruticosa*, or desert false indigo. Initial tests of this shrub yielded rotenone, but other species, such as *A. californica* did not. By October 1943, studies of *Amorpha* gave little promise of positive results, and the project was terminated (USDA FS 1945).

⁷ Rotenone was used for the control of insects on leafy vegetables and fruits, and for the control of vermin on humans and livestock. It was later used to poison "trash" fish populations.



U.S. Forest Service, Pacific Southwest Research Station

Figure 68—Nicholas T. Mirov, prominent California Forest and Range Experiment Station scientist and the first plant physiologist appointed by the U.S. Forest Service.

By late 1942, another essential raw material needed in the war was cork. Therefore, CFRES worked closely with the FPL in investigating possible sources of Douglas-fir and white fir bark as cork substitutes. The CFRES reported on the major producers of these species in California, and the station contacted various cork industry leaders to determine cork requirements. In cooperation with Region 5, CFRES also initiated plans for experimental cork-oak planting in California with the ultimate objective of providing for a postwar planting program of some 100,000 acres of cork oak. Station participation involved seed collection, experimental planting, genetics research, determining characteristics of suitable planting sites, and the use of station nurseries at Devil Canyon, Placerville, and Berkeley. Research included methods of identifying superior cork-producing strains, seed storage and treatment, vegetative propagation, site selection, and the exploration of site requirements. From existing records and other sources, CFRES also compiled specific locations of approximately 2,000 cork oak trees old enough to be

potential sources of acorns. By December 1942, acorn collection was organized and acorns were being gathered throughout the state, and by March 1943, propagation work was underway for the 1943–1944 planting season both at the Placerville and Devil Canyon nurseries. Direct seeding experiments also took place on the Cleveland and Los Padres National Forests, and Region 5 planned to plant 60,000 cork oak seedlings at Placerville and 40,000 at Devils Canyon during the winter of 1943–1944. However, by 1944, the impending end of the war prompted the decision that although this project was a good war risk when needed for national defense, its value in peacetime was questionable when harvesting costs and time were considered. Simply put, it took too much station effort in comparison to other needed work and the project was dropped⁸ (Loveridge and Dutton 1946, USDA FS 1945).

Locating, Acquiring, Servicing, and Assisting New Military Establishments in Defense Operations

Because of fears that a Japanese air attack on California's coastal military and industrial installations was imminent,⁹ disguising them to blend in with their surroundings was vital. Therefore, CFRES, in cooperation with the University of California and Stanford University, initiated camouflage research pertaining to the use of natural grasses, shrubs, and vines for overhead cover. The CFRES also worked with the Western Defense Command (WDC) to develop camouflage techniques for nearby permanent military facilities. They included the Oakland bomber base and the California State Guard encampment at Berkeley, as well as other strategic military facilities in California, such as Hunter Liggett Military Reservation within the Los Padres National Forest, and the Fort Rosecrans Coast Artillery Corps at Point Loma near San Diego. In response to United States Army Corps of Engineers' requests for trees, shrubs, and other plants for windbreak and camouflage purposes, CFRES turned over 11,775 plants to the Army from the station's Berkeley native

⁸ By January 1944, CFRES established 10 small test plots and three larger plantations in selected locations throughout the state to test suitability of site, kind of stock, and various treatments. But because of labor shortages and transportation restrictions, it was not possible to use all of the nursery stock grown to date for experiments. With the cooperation of the University of California, CFRES' primary cooperator, 75,000 of the seedlings were distributed to landowners.

⁹ With the declaration of war in December 1941, the City of San Francisco anticipated a Japanese aircraft attack. Spooked by a "sighting" of a formation of enemy aircraft 100 miles off the coast approaching the Golden Gate Bridge, civil defense sirens sounded and the city went dark, searchlight beams prodded the clear sky overhead, and sailors, soldiers, and marines rushed to their battle stations (Godfrey 2005).

plant nursery for use at Camp Knight and elsewhere.¹⁰ In addition, 43,535 plants from the Devil Canyon nursery, including both potted and bare root stock of some 90 species, were sent to other installations. The largest request for stock came from Camp Haan Army Service Depot,¹¹ but requests from the Victorville Army Flying School and Fort Rosecrans were fulfilled as well. The station also assisted with camouflage planting and dust control at Mills Airfield, formerly San Francisco Municipal Airport, which had been militarized. As a result of CFRES' early camouflage recommendations in 1942, installations along the Pacific Coast were more effectively hidden from the enemy (USDA FS 1945). Throughout the war, CFRES continued this type of camouflage research mission. In April 1943, in cooperation with Region 5 and other USDA agencies, CFRES prepared a list of plants available in California nurseries for camouflage purposes and made recommendations as to their use in hiding gun placements, covering soil scars, and in dust control through the establishment of windbreaks and adequate ground cover. Additionally, the Devils Canyon nursery was given the mission of raising 25,000 trees and shrubs for future camouflage planting at military establishments (USDA FS 1945).

Besides providing data on suitable native plants and planting techniques, CFRES staff assisted with instruction at Army camouflage training camps, and more importantly, at the request of Region 5 Office of Civil Defense (OCD), they organized lectures on camouflage planning at the University of California Extension Division. Herbert A. Jensen gave these lectures, the purpose of which was to train architects, engineers, and landscape designers for OCD's industrial camouflage program and to explain air-photograph interpretation. The lectures were so successful that by late 1942 the California Station and SDEF were giving similar training courses to WDC military and naval intelligence groups as well (USDA FS 1945).

CFRES prepared a list of plants available in California nurseries for camouflage purposes.

¹⁰ Camp John T. Knight was the name of the cantonment area of what became the Oakland Army Base, but was part of the overall San Francisco Port of Embarcation. This name was officially used from 1942 until it was fully incorporated into the Oakland Army Base in 1946.

¹¹ In January 1941, Camp Haan started out as a coastal artillery antiaircraft replacement training center adjacent to March Army Air Field. However, in March 1942, it was reorganized as an Army Service depot, and in late 1942, it became a prisoner of war camp housing Italian and then German prisoners of war. Later in the war, it became a debarkation hospital receiving wounded from the Pacific theater of operation. At its peak, Camp Haan had a population of 80,000 people. It closed in August 1946.

Making the Home Front Strong and Other Civilian Defense Activities

Finally, CFRES worked with Region 5's OCD in the development of a coordinated fire protection plan that included fire prevention, presuppression, and fire suppression action for the 250-square-mile East Bay Hills area of Contra Costa and Alameda Counties. This area contained highly inflammable forest, brush, and grass cover, and constituted a serious threat to war industries and municipalities located therein. In late June 1942, Charles C. Buck and C.A. Abell worked closely with the WDC. The WDC anticipated a Japanese aerial incendiary attack on the area for several reasons. The East Bay Hills area was traversed by major railroad and highway routes and by all of the electric power and communication trunk lines serving the East Bay area. The area also contained numerous antiaircraft batteries as well as other military installations. In the end, CFRES research resulted in a small publication used by the military that recommended fire prevention, detection, and dispatching techniques for 15 agencies involved in protecting war industries from aerial incendiary attack or saboteur-caused fires. By October 1942, Region 5's OCD East Bay San Francisco Hills coordinated fire protection plan was completed, and extensive hazard reduction and fireline construction was underway. Firefighting tools for 1,000 men were purchased or borrowed, and a dispatch action plan was agreed upon. Furthermore, California station staff took OCD training courses, and were placed on active civilian defense assignments. Station staff also trained in firefighting techniques and became classified for use in the event of fire emergency (Aitro 1977, USDA FS 1945).

One highly confidential project conducted by CFRES at this time involved fire warfare research. Early in the war years, Region 5 and CFRES, in cooperation with the United States Army Air Force and the Chemical Warfare Service, began research on incendiary bombing experiments at March Army Air Field, near Riverside, California. However, by October of 1942, work on the possible use of forest fires as a potential offensive-defensive tactical weapon was shifted to the Eastern Defense Command, where it was tested by the Army as a military weapon in repelling enemy invasion along the east coast (USDA FS 1945).

Domestic Research Program, 1941–1945

The impact of war conditions, reflected in the heavy reduction in funds and manpower, meant a redirection of effort and curtailment of numerous projects in CFRES' long-range domestic research program. Acting Station Director M.W. Talbot attempted to protect major past research investments as far as possible by continuing the most vital work, or keeping such projects at the minimum maintenance level (USDA FS 1943).

Forest Management

In the area of forest management, CFRES continued to conduct limited domestic research in three important areas from 1941 to 1945. The first research area was silvics. During the early part of the war, most of the genetics projects were carried on at a maintenance level, with almost three-fourths of the division effort being devoted to such wartime assignments as the analysis of native plants for rubber, quinine, rotenone, tannin, and fiber; the analysis of plants for camouflage use by infrared photography, as well as other camouflage assignments; research with cork oak; or teaching war geography to army personnel. However, by 1943, the genetics division was able to continue some of its pioneering work on hybridization. By repeated crossings of different species they produced diverse individual seed and pollen-parent trees. In short, several of these pine hybrids were “new trees” and apparently superior ones under testing conditions. Researchers believed that extensive use of these superior tree types would be required for the reforestation of California’s brush fields and burned-over, or denuded lands, so the further these experiments could be pushed along during wartime, the better off they would be in the postwar period. By the end of the war, Francis Righter, chief of the genetics division, also hoped to produce a reference handbook that depicted the growth, hardiness, silvicultural values, and other characteristics of the institute’s pines¹² (USDA FS 1943).

At the beginning of 1944, Palmer Stockwell replaced his colleague Francis Righter as genetics division chief. While Stockwell continued various wartime assignments started by Righter, Stockwell was also able to redirect more and more of his staff effort back to genetic problems, especially hybridization. By March 1945, the tree-breeding program began to pick up loose ends of earlier experiments that had lapsed during the war, to write up accumulated data and findings, and to restore balance to the program by advancing those phases of work on pollination that had fallen behind, but on which successful breeding depended. Stockwell looked forward to the postwar era, which he and his staff hoped would include intensified systematic testing of pines to determine which pairs of species would hybridize, and hybrid character (USDA FS 1944).

The tree-breeding program began to pick up loose ends of earlier experiments that had lapsed during the war.

¹² In 1947, Francis Righter co-authored an article entitled “Hybrid Forest Trees” with Palmer Stockwell for the *USDA Yearbook of Agriculture* 1943–1947 (Stockwell and Righter 1947), which discussed research progress and use of hybrids produced at the Institute of Forest Genetics. A year later, CFRES produced *Tree Breeding at the Institute of Forest Genetics* (USDA FS 1948b).

Dunning stressed getting the station's forest research findings into application.

The second area of domestic California forest management research conducted at CFRES during the war involved aspects of pine region research at Blacks Mountain Experimental Forest (BMEF).¹³ At BMEF, CFRES' chief of pine management, Duncan Dunning, continued to accumulate information on the management and silvicultural practices needed to insure adequate wood crops from ponderosa pine lands at low cost. The BMEF logging office and research operations were carried on successfully by men ineligible for military duty because of age and physical condition and a few women. Experimental cutting methods, or sustained yield logging, continued to demonstrate that light salvage or sanitation cutting was no more expensive than heavier cutting. Furthermore, Duncan and the CFRES staff believed that by making a series of variable cuts properly timed and placed, instead of a single progressive heavy cut, it was possible to harvest highly susceptible trees prior to bark beetle attack, accomplish natural restocking, release advance growth, prevent brush invasion, and provide logs of certain quality grades as needed. During the war, Dunning concentrated CFRES forest management resources on this effort, which left little time for other domestic projects, or for maintaining the station's long-term projects. For instance, a lack of funds and technical personnel made it necessary to defer 5-year measurements due on the 1939 series of the Methods of Cutting (MOC) study at BMEF. Nonetheless, Dunning stressed getting the station's forest research findings into application, and he spent some effort on forecasting statewide forest growth and demands in the post-World War II era. As the war approached its end, interest in better management of both private and public forest land intensified. This interest accelerated when some realized that there would be a postwar shortage of lumber for civilian use, and that after the war, few undeveloped logging areas remained available to California's many sawmills. Meanwhile, this abnormal wartime market resulted in stimulating cutting of red and white fir, and the station began to field requests for assistance in developing marking rules for these species. The division's plans in the postwar period were to continue ponderosa pine cutting at BMEF, to conduct logging and insect control experiments, to prepare revised growth estimates for California as a section of the Forest Resource Survey, and to analyze accumulated records as a basis for revision of marking and cutting practices for postwar forestry programs (USDA FS 1943, 1944).

¹³ Unfortunately by 1943, other projects were closed down completely, including the station's entire redwood program following Hubert Person's transfer to the Pacific Northwest Station on a special war job.

Forest fire protection was the third component of the CFRES domestic forest management research program. During World War II, fire research at the station nearly came to a halt because most of the limited staff was assigned to projects of military interest (Wilson and Davis 1988). Nonetheless, throughout the war, the CFRES fire research division, under the leadership of Charles C. Buck, continued to devote available personnel and research effort to the field of fire-danger rating systems and large-fire behavior. Laboratory and wind tunnel studies of fuel characteristics, along with scale-model fires, added new information on the effects of different fuel combinations on fire spread. For the first time, fuel temperature was recognized to be one of the more important factors affecting both ease of ignition of forest fuels, and the rate of spread of surface fires. Wind velocity, temperature, and fuel moisture were also studied. By the beginning of 1944, new findings from these studies were blended with the results of past work to provide the basis for a complete revision of California's fire-danger rating system for its national forests and for areas protected by the state. The new system combined the effects of wind velocity, indicator-stick moisture content, seasonal development of herbs and shrubs, relative humidity, temperature, and slope into a single index of potential fire spread rate. This forest protection management tool required less field time and promised to add considerable significance to Region 5's fire-danger measurements. In the field of large-fire behavior, CFRES worked closely with Region 5, to whom it gave considerable assistance in scouting fires, in predicting probable changes in fire danger, and in helping plan suppression strategy. The value of these observations to CFRES staff in interpretation of laboratory research data and close collaboration with Region 5 on "actual" versus "theoretical" fires was immeasurable. Finally, CFRES gained considerable knowledge by participating in and developing the coordinated fire protection plan for Region 5's OCD East Bay San Francisco Hills project¹⁴ (USDA FS 1943).

Despite these gains, in 1944, the fire research division was forced to retrench even more. With its staff reduced to two men (Buck and Abell), the fire division shifted primary emphasis from established projects that contributed to the basic long-term domestic research program to extension and training activities and to assistance to Region 5 in solving immediately pressing fire problems. The station and Region 5 felt that more could be contributed toward better fire control practice

During World War II, fire research at the station nearly came to a halt because most of the limited staff was assigned to projects of military interest.

¹⁴ Lessons learned about organizing a giant task force of fire control agencies, fire research, federal civil defense, and private industry from the East Bay Hills project would be applied in the post-World War II years to projects such as FIRESTOP, which will be discussed in the next chapter.

Because of the need for increased wartime meat production, domestic range research at CFRES did not stand still during the war.

by this emphasis rather than by attempting to carry on the station's regular research program. The Shasta Experimental Fire Forest (SEFF) was therefore closed as an active research center, and fire behavior research was limited to laboratory studies of fire ignition and spread conducted by CPS personnel at San Dimas. Thereafter, the station concentrated on intensive application of established fire-danger-rating procedures to the administration and supervision of fire-control activities. Besides fire behavior studies, other key projects suspended included analysis of fire report data used to establish objectives for regionwide application in fire-control practice and research on effective use of manpower and equipment resources in suppressing large fires, on regional and local detection problems and lookout efficiency, on the use of herbicides in maintaining firebreaks and rights-of-way, on use of water and chemicals in fire suppression, and on the relationship of weather elements to fires (USDA FS 1944).

Because of the need for increased wartime meat production, domestic range research at CFRES did not stand still during the war. The purpose of range research in this period was to obtain the greatest production of meat, hides, wool, and other products from both livestock and game animals, without impairing future production or damaging the range. Information was needed on numerous phases of practical management, including proper intensity and season of grazing, methods of artificial reseeding, brush removal, erosion control, water spreading, and similar practices for a large variety of forage types in California. Range investigations centered on the annual-type ranges in the foothills of the San Joaquin Valley at the San Joaquin Experimental Range (SJER) and on perennial-type summer ranges in the mountains of northeastern California at the Burgess Springs Experimental Range (BSER) (USDA FS 1944).

During the war years, Jay R. Bentley was the project leader at SJER (USDA FS 1943, 1944). He oversaw the continuance of domestic research at SJER, although necessarily on a reduced level, which added to the store of facts needed for the "blueprints" of many postwar range development programs. At the beginning of World War II, CFRES published SJER current findings on range research in a major collection of papers edited by C.B. Hutchinson and E.I. Kotok, entitled *The San Joaquin Experimental Range* (1942). Major contributors to the publication included M.W. Talbot, J.W. Nelson, and noted University of California grazing expert Arthur W. Sampson. *The San Joaquin Experimental Range* described the facilities, soils, climate, and vegetation, and the range organization and management at SJER itself, and then covered studies and experiments in the SJER program. Then the publication covered the subject of annual type forage, discussed its

characteristic growth and behavior, and reported on experiments dealing with grazing for maximum yield, maintenance, and improvement. Next, it turned to a discussion of a variety of research projects that investigated artificial reseeding, rainfall runoff and erosion, and the chemical composition of important range plants. Finally, to a lesser extent, it addressed wildlife relations at SJER (Aitro 1977). Significant new findings continued to emerge from the cooperative experiments reported on in *The San Joaquin Experimental Range*. For instance, significant projects under Bentley's leadership included the study of artificial reseeding of several promising forage species and of grazing intensity in foothill ranges, which demonstrated that moderate grazing of annual-type range was better than lighter or heavier grazing. At the same time, August Hormay, project leader for mountain range investigations at the BSER investigated the grazing value of cutover pine timberland for cattle in the mountain ranges, along with utilization of browse and artificial reseeding of bitterbrush (USDA FS 1943, 1944).

Although progress was made in grazing research, during the first 2 years of the war, the CFRES division of forest influences was all but shut down, except for maintaining the records at the SDEF, which was done by conscientious objectors from a Civilian Public Service (CPS) camp located at Glendora. Furthermore, the planting stock of the Devil Canyon nursery had been disposed of in filling orders from various military posts. Even the station's Berkeley plant nursery stock, comprising several thousand potted shrubs, was distributed to military centers in the San Francisco Bay area. Further curtailment in the division of forest influences came in 1943 when the Devil Canyon Branch Station was closed for the duration of the war. The CFRES also turned over its Kings River Branch Station at Trimmer, California, to the Sierra National Forest under a cooperative agreement whereby the forest staff continued to collect certain minimum hydrologic data in return for the use of CFRES buildings (USDA FS 1943). The year 1944 proved even more devastating to the program. Installations on the Big Creek watersheds at the Kings River Branch and those at North Fork and Bass Lake work centers continued to be operated on a maintenance basis with the collection of statistics from the Sierra Forest and the North Fork CPS camp. However, no further records were kept at the Teakettle Creek watersheds at the Kings River Branch, or at the Berkeley installations. The loss of personnel who joined the military or transferred to high-priority war projects continued, thrusting an increasing burden on the remaining staff. As with other station divisions, this situation retarded the analysis of data, caused the suspension of important phases of research, and reduced several projects to a maintenance basis. C.J. Kraebel, as chief of the division, kept the influences division

During the first 2 years of the war, the CFRES division of forest influences was all but shut down.

The regular division of products program remained suspended throughout the war.

afloat by centering the division's work largely at San Dimas and by cooperating with the fire research division and Region 5 in a fire damage appraisal study¹⁵ (USDA FS 1944).

Forest products fared little better. With its one staff member, Hereford Garland, devoting practically all of his time to wartime requirements and supply surveys such as stumpage and log prices in California by species, the regular division of products program remained suspended throughout the war. Garland hoped, however, that the establishment of a full-fledged forest products utilization unit of three or four technicians after World War II would mean that he could begin a program of needed wood studies. Of special interest to him was the problem of efficient utilization of second-growth pine stands, and demand for California softwoods, such as white and red fir that had been accentuated by the wartime demands for all kinds of forest products. A study of waste wood in California was also needed as part of the Forest Service's reappraisal of America's timber situation in the post-war period. There was also a complete suspension of any forest economics work because of a lack of funds and the full-time assignment of Edward C. Crafts to wood requirements and supplies work. For the time being, the problem of how to make forestry pay in financial terms was set aside. The Forest Resources Survey was virtually closed down, and its three-member staff was reassigned to war jobs. George F. Burks continued full-time on timber supply surveys, studies, and reports for the WPB, WMC, and OPA, while Herbert A. Jensen spent almost all of his time at the University of California teaching aerial photograph interpretation to military students. A.E. Wieslander, on the other hand, divided most of his time between the Guayule Emergency Rubber Project and postwar planning (Aitro 1977; USDA FS 1943, 1944).

Naturally, because most of the station's domestic research program was suspended or reduced owing to the war, cooperative work with other agencies was limited as well except as outlined above with Region 5 and the University of California's departments and divisions. Cooperation with other federal, state, and community agencies continued to the degree permitted by conditions. Cooperative studies with the Bureau of Entomology and Plant Quarantine (BEPQ) continued because they were vital to the solution of several forest management problems, especially at BMEF. However, the station found it necessary to suspend

¹⁵ This cooperative project aimed at developing a uniform system for appraising damages from fire on the four southern California watershed forests. The immediate purpose of this project was to establish a sound basis upon which to determine the damages that would result from fire in a given drainage. Later this data would be used to establish justifiable levels of protection for areas primarily valuable as watersheds, and to determine the best distribution of available protection resources among local administrative units.

any cooperative work with the Fish and Wildlife Service until after the war. One essential cooperative work project with a federal agency involved the Civilian Public Service. The CPS gave substantial assistance to the station's domestic research programs at SDEF, IFG, SJER, and the Kings River and Feather River Branch Stations. The excellent and valuable service rendered by these conscientious objectors made possible the maintenance of several important research projects at these facilities, which would have otherwise been more seriously curtailed or closed entirely during World War II (USDA FS 1943, 1944).

General Integrated Inspection Report (1944–1946) and the End of the War

Meanwhile, CFRES underwent its first thorough and systematic Washington office (WO) inspection—a General Integrating Inspection (GII) conducted by Assistant Chief E.W. Loveridge and Chief of the Grazing Division, W.L. Dutton. The GII began in the summer of 1944 with a followup completed in December 1946.¹⁶ The Loveridge-Dutton GII covered not just the CFRES research program, but also the station's interaction with Region 5.

In general, the Loveridge-Dutton GII found that the integration between the station and Region 5 was “outstanding” as far as planning went. The GII stated: “The research program is, or was prior to retrenchment, a very impressive one.” However, the station was subjected to “considerable criticism” by the GII because many felt that the station should have done more to publicize the excellent results of past CFRES studies and findings of scientists such as Duncan Dunning and others,¹⁷ and to see that his silvicultural research findings were implemented in Region 5.

¹⁶ The GII constituted the primary instrument for program control by the WO over each region and station and was a long-range planning tool. Ideally, the GII was carefully planned to supply the WO with the type of information necessary for an overall appraisal of progress at a region or station. Upon arrival, inspectors contacted the regional forester or station director and worked out a schedule to cover the area desired by the inspectors. At the conclusion of the inspection, a full report covering all aspects surveyed, plus recommendations for necessary changes in program or action emphasis, was submitted to the WO. However, prior to completion of the GII report, the regional forester or station director was given a chance to review the findings and submit a rebuttal on controversial points. If possible, a conference was held between the inspectors and region/station officials, at which time, final recommendations were reviewed and corrective action agreed upon. Thereafter, the chief forester signed off on the inspection, which was bound and placed in an inspection report library for both current and historical reference (Godfrey 2005).

¹⁷ Loveridge and Dutton went on to say, “A most urgent need in this connection is to obtain in published form the excellent results of the years of research by Dunning. Failure to carry through this top-priority project at an early date would, in our judgment, be very serious” (Loveridge and Dutton 1946: R-6).

Concerning the status of the “skeletonized” research program, the Loveridge-Dutton GII was kinder.

Loveridge and Dutton emphasized this point by declaring, “If we consider integration as carrying through to the point where Administration aggressively adopts or seriously accepts trial Research findings, then we believe there is room for a lot of improvement in R-5. In timber, range, and fire we are convinced that the quality of management and administration could be stepped up substantially by more aggressive use of principles developed by Research...[However,] we share with earlier inspectors full appreciation of the fine quality of research work done to date.” [Emphasis in the original.] Loveridge and Dutton advocated that the station put forward more news releases about its research and its overall programs to the general public. They realized, however, that the more fundamental problem at the California Station was a lack of leadership under Acting Director Murrell Talbot. To overcome this disadvantage, they advised that the WO appoint a director without further delay (Loveridge and Dutton 1946).

Concerning the status of the “skeletonized” research program, the Loveridge-Dutton GII was kinder. First, they acknowledged the serious financial handicap under which the station had operated during the war years, asserting: “In view of the importance of Research to conservation in this Region every reasonable and permissible step should and will be taken both locally and by the Chief’s Office to strengthen the Station’s financial base,” and continued “Under these circumstances it is remarkable that the morale of the Station force has been held as high as it seemingly is.” Loveridge and Dutton promised that on their return to Washington they would see what possibly could be done to have appropriations increased as soon as possible. They also suggested that Region 5 help out the station financially to the extent it seemed justifiable to do. In particular, the Loveridge-Dutton GII suggested that Region 5 help to finance physical improvements at BMEF because station studies conducted there touched several important phases of Region 5’s timber management work. The GII report stated “certainly something should be done about the ‘Rag Row’—the tent, trailer and shack settlement back in the woods occupied, during our visit, by three technicians and their families plus four loggers and their families with five children, and only one toilet and one shower to serve them”¹⁸ (Loveridge and Dutton 1946).

Although they were impressed by the first results of the sanitation-salvage cuttings at BMEF and reduction in losses from the western pine beetle—Loveridge and Dutton expressed the hope that Region 5 would extend the technique over much

¹⁸ Two years later, conditions at BMEF had not changed. The Blacks Mountain logging camp was still a makeshift affair because of the problem of finding financing for capital improvements, such as cottages to house crewmen and their families (Loveridge and Dutton 1946).

of the region before the next pine beetle cycle again reached a highly destructive stage (Loveridge and Dutton 1946)—Loveridge and Dutton lamented the fact that just when interest in redwood conservation was running high following years of destructive logging, research work at the Yurok Experimental Forest was discontinued because of a lack of funds. They asserted that “a very urgent need still exists for research in this type and it is regretted that funds and personnel deficiencies so far have caused the Station to be unable to do much on this.” They also supported establishing an additional experimental forest under the station, a proposed “Middle Fork” Stanislaus Experimental Forest (Loveridge and Dutton 1946). The inspectors also offered their insights on regeneration studies. They believed that additional planting research was urgently needed, and felt that the value of such research was strikingly illustrated by the results obtained by the station in cooperation with Region 5 on experimental plots at Feather River, by the work in the Shasta brush fields, and by the “fascinating” studies at the Institute of Forest Genetics (Loveridge and Dutton 1946).

In the area of range management, the Loveridge-Dutton GII commented that Region 5 had profited from the experiment studies carried on by CFRES, but that Region 5 needed to more fully utilize the station’s range management findings. Furthermore, the Loveridge-Dutton GII stated that aside from preliminary investigation with bitterbrush at BMEF, and nursery and range tests for adaptability at SJER, both the station and Region 5 had not gone far enough with reseeding work (Loveridge and Dutton 1946). Water management did not escape the purview of the Loveridge-Dutton GII either. The investigators expected that the station could find more opportunities than it had to volunteer to participate in this field (Loveridge and Dutton 1946). Finally, on the subject of fire research,¹⁹ Loveridge and Dutton praised the station’s accomplishments, articulating that the projects underway at San Dimas were “very impressive” and that the “program has been and apparently continues to be very capably handled considering the small amount of R. [research] funds available. Research and Administration have worked together with unusual closeness over the years with the result that fire research findings are usually put into effect promptly” (Loveridge and Dutton 1946: FC-3).

Additional planting research was urgently needed.

¹⁹ Their only criticism of the fire research program was that Region 5 rangers, supervisors, and other field men in California, both federal and state, seemed to make little use of the fire-danger rating or meter system. Region 5 and the station corrected this over the next 2 years (Loveridge and Dutton 1946). Pertaining to this last item, Loveridge and Dutton noted that with critical changes in California state forestry and increased closeness of relations between Region 5 and the State Forester’s Office, the state of California was making use of the station’s fire research findings, especially the fire-danger rating system (Loveridge and Dutton 1946).

If anything, the Loveridge-Dutton GII did stimulate one quick result. In February 1945, Stephen B. Wyckoff was appointed as the third director of the California Forest and Range Experiment Station at Berkeley—a position he would hold for almost a decade. Stephen Wyckoff was not a stranger to the directorship, or to California. Wyckoff was a graduate of the University of California and had served as Director of the Pacific Northwest Forest and Range Experiment Station in Portland, Oregon, since 1938. With the surrender of Japan and the close of the war, postwar challenges for the California station fell upon the shoulders of Director Wyckoff, who was recognized as an outstanding conservationist, particularly in the West. He believed the station's mission was to develop, through research, the techniques of use and management to give California's 87 million acres of wildland permanent value (Wyckoff 1949).

Chapter 6: 1946–1962, Golden State of Research

In 1943, Lyle Ford Watts replaced Earle Clapp as Chief of the Forest Service and served from the last turbulent years of the war until 1952. Watts soon selected Edward I. Kotok, first director of the California Forest and Range Experiment Station (CFRES), to be his assistant chief for research.¹ Kotok's immediate challenge was helping the Forest Service meet the Nation's forestry needs during the chaotic postwar years. California, perhaps more than any other state, exemplified the unsettled state of affairs in the Nation after World War II. The migration to the Golden State after the war transformed California. From 1940 to 1945, the state's population increased from 6.9 million to 9.2 million, but only a decade later, the state had grown to more than 13 million people. Expanding economic opportunity matched California's growth in population. A postwar boom in manufacturing followed the war years, and the state's salubrious climate, available space, established factories, and science-oriented universities all combined to broaden the economy even further. The state's farm economy kept pace with manufacturing, and California continued to be the West's leading farm state. Southern California—and in particular cities like Los Angeles and San Diego—became the favored destination for the vast majority of the people moving to the state, although secondary cities elsewhere in the state, such as Oakland, Stockton, and Fresno, grew as well. California's burgeoning economic and population growth led to three interrelated consequences—increased suburbanization, transportation needs, and recreation needs (Godfrey 2005).

Explosive growth in manufacturing, farming, and population brought about sharply rising pressure on California's natural resources. For instance, increasing demands for agricultural lands and expansion of industry, as well as the larger population, focused attention on the availability of water supplies. In many instances, industrial plants were being located in agricultural areas where they competed with farmers for groundwater. Many communities grew so fast that by 1948 domestic water supplies were no longer adequate, especially in dry years. Thus, there arose a great need for expanded research pertaining to the influence of vegetative cover on water yield and soil stability. The increasing population and the need for water ultimately led to one of the most controversial questions faced by the Forest Service

¹ Clarence Forsling, who held that post, moved to the Department of the Interior in 1944 to be Director of the newly established Grazing Service. Forsling served as Director of the Grazing Service from 1944 to 1946; and then became a member of the program staff of the Secretary of the Interior from 1946 to 1953, when he retired.

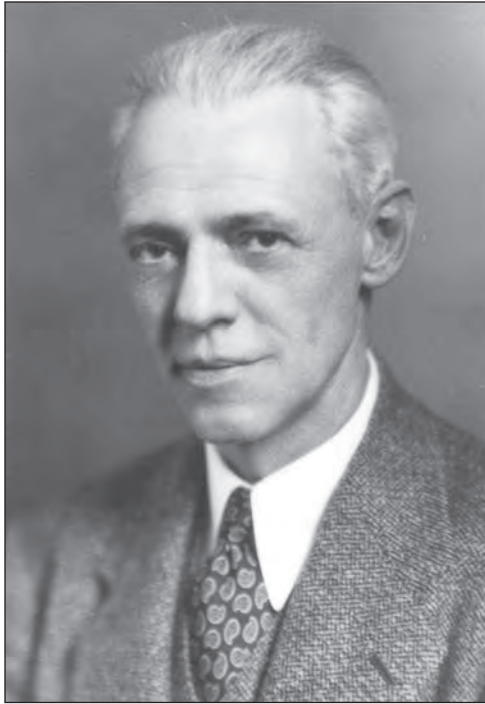
in California: Should the millions of acres of land covered by brush, which was primarily useful as watershed, be removed and converted to rangeland? The nature of the problem begged for a well-rounded program of study involving range, fire, and watershed research. Increased pressure on California's timber resources came at the same time. Lessening timber reserves in other parts of the country, coupled with increasing local demands, raised California's lumber production to the highest point in its history. By species, the heaviest production was in ponderosa pine, Douglas-fir, and redwood (See "Scientific and Common Names" section). Such demands, met primarily at this time from old-growth timber resources, pointed sharply to the need to develop and apply intensive forest management methods, to convert old-growth stands to managed growing forests, and to attain regeneration on forest lands of good site quality. Additionally, many realized that California's commercial forests contained more merchantable Douglas-fir than any other species. However, much of it was old, large, and contained decay. The conversion of these stands to managed growing forests would be a difficult and challenging problem. But many felt that these stands, if wisely handled, could become a permanent forest area of great productivity, contributing materially to the state's annual timber production (USDA FS 1948a, 1949).

Finally, the growing economy and increased pressure on California's natural resources—which other parts of the Nation felt to a lesser degree—affected all aspects of forestry research. The CFRES and Region 5 were fully aware of these new problems, and after World War II gave immediate attention to their resolution. While practically every part of the California station's long-time research program supplied useful information and answers, recently appointed Station Director Stephen B. Wyckoff ² (fig. 69) had to come to terms with difficult decisions on how best to use the station's limited postwar resources to accomplish the greatest good (USDA FS CFRES 1948a).

Stephen B. Wyckoff and Postwar Station Financial Problems

During the station's great period of expansion in the early 1930s, the California station had operated continuously with the help of emergency programs such as the Civilian Conservation Corps (CCC) and the Works Progress Administration

² Stephen B. Wyckoff joined the USDA in 1919 when he was named as an assistant plant pathologist in the Bureau of Plant Industry and was put in charge of the blister rust control work in western pine regions. In 1936, he transferred to the Forest Service and was appointed director of the Northern Rocky Mountain Forest and Range Experiment Station in Missoula, Montana. Two years later, he was named as Director of the Pacific Northwest Forest and Range Experiment Station in Portland, Oregon (Journal of Forestry 1945).



U.S. Forest Service, Pacific Southwest
Research Station

Figure 69—Stephen B. Wyckoff, third director of the California Forest and Range Experiment Station (1945–1954). He addressed the postwar financial challenges and oversaw the station's move from Hilgard Hall to Mulford Hall on the Berkeley campus to be closer to the School of Forestry.

(WPA), to name a few. Depression-era funding of this kind supported a considerable number of subprofessional workers in offices and the field and paid salaries for technical staff supervising emergency workers. The labor and materials derived from these programs essentially maintained the station's experimental forest system. However, World War II forced the station to curtail many experimental forest activities. Fortunately, during the war years, the station was able to depend on the Civilian Public Service's (CPS) conscientious objector camps to continue work on two experimental forests, the San Dimas Experimental Forest (SDEF), and the San Joaquin Experimental Range (SJER).

But the year 1946 brought several changes in the scope and direction of the CFRES. Some of these changes aided the station's program by strengthening research in a few divisions, but others hampered research programs. For instance, early in the year, the forest economics division was formally reorganized under A.E. Wieslander to include the work of the Forest Resources Survey or FRS.³ This merging of related activities into one administrative division brought greater strength and more effective assignment of staff members at CFRES, and prevented

³ As noted in previous chapters, the McSweeney-McNary Forest Research Act of 1928 authorized the FRS, but in California it had been shut down during World War II because its three-member staff was redirected to war jobs.

Director Wyckoff continued on this prudent course of completing some projects, making satisfactory headway on others, and not embarking on any new research programs.

duplication of efforts. In 1946, forest management, range, and influences research were also strengthened as additional funds became available after the war. However, owing to increased costs of travel and steady rise in cost of all supplies, materials, and equipment after the war, these research funds no longer went as far as in the prewar years (USDA FS 1946). In fact, after the war ended, Director Wyckoff scrambled to keep CFRES financially afloat.

Another change was the termination of the CPS program. This reordering raised a serious financial policy question: How to continue the station's research program and maintain the experimental forests? Director Wyckoff appeared to have three choices: to close down these experimental centers, to use much of the time of the station's highly skilled technical workers for low-grade maintenance work, or to curtail several station activities until funding opportunities presented themselves (USDA FS 1946). Wyckoff chose the last solution. During the next year, he slowed down station activities by bringing past projects to a close and seeking publication of project results. For example, the fire research division completed all fieldwork, analysis, and interpretation of data for a fire damage appraisal study on four southern California national forests. The range research division completed two major field projects at SJER and the Burgess Springs Experimental Range (BSER) that had been underway for a number of years. While the forest influences division made progress in analysis and interpretation of a large volume of data and manuscripts based on its work, the division of flood control surveys⁴ also completed a backlog of unfinished surveys in southern California. Finally, the 1947 field season marked the end of 11 consecutive years of experimental logging on the Blacks Mountain Experimental Forest (BMEF). As suggested by the 1946 Loveridge-Dutton General Integrating Inspection, work was then begun on the compilation of the Blacks Mountain data for publication. Thanks to those remedial actions, the station sustained itself during the difficult financial years following the war (USDA FS 1947). During 1948, Director Wyckoff continued on this prudent course of completing some projects, making satisfactory headway on others, and not embarking on any new research programs. In doing so, he kept the station going against a

⁴ Following the disastrous 1938 floods in southern California, the station created a Division of Flood Control Surveys in 1940–1941. This division worked jointly with the Soil Conservation Service (SCS) and the Bureau of Agricultural Economics (BAE) on flood control investigations. Its mission was to determine flood causes and prospective flood damages in watersheds, and to recommend a definite remedial program for execution on mountain and valley lands in southern California. Among some of its initial projects were the Santa Maria, Santa Ynez, and Santa Ana River Surveys. However, their work was suspended once World War II broke out (USDA FS 1941a).

background of a fast-growing economy, rapidly increasing population, and new demands on the state's timber, water, and land resources. Wyckoff staved off a financial crisis and soon turned to increasing cooperative funding from federal, state, and private institutions to rescue the station (USDA FS 1947).

New Headquarters and Station Reappraisal

While confronting the station's financial future, Director Wyckoff also grappled with space problems on the University of California campus. Following the war, there was an educational boom throughout the California education system, including Berkeley's College of Agriculture and its School of Forestry. In 1939, under the leadership of noted professor Walter Mulford, the school's original Division of Forestry grew into a full-fledged Department of Forestry. A School of Forestry was established in 1946, with Mulford as its first dean,⁵ and it offered a Master of Forestry degree. Until 1939, enrollment at the Division of Forestry had been modest, but with the development of the Department of Forestry, and then the establishment of the School of Forestry, enrollment soared and the number of bachelor and master degrees awarded increased dramatically. In 1947, a new forestry sciences building was constructed on campus and dedicated in Mulford's honor. Because of the close ties between the School of Forestry and CFRES, the station moved from its former headquarters at Hilgard Hall to the new forestry science building. For the next 11 years, CFRES comfortably occupied part of Mulford Hall. These years at Mulford Hall nurtured rapport and cooperative relations with university administrators, forestry faculty, and CFRES researchers. A side benefit of CFRES's location on the Berkeley campus was the ability of station staff to increase their formal education. This action was in line with post-World War II Forest Service policy, which encouraged researchers to return to graduate school for advanced training. Between 1947 and 1950, nine station staff enrolled in advanced university degree programs. This educational opportunity, and the informal contacts with faculty members on various phases of official work, combined with the active cooperation between the station and the university, made the relationship a fruitful one (Aitro 1977, Steen 1998, USDA FS 1949a).

In the interim, congressional requests also made demands on the time and resources of Director Wyckoff and station staff. In 1949, the Senate Committee on Appropriations requested that the Forest Service provide it with a complete analysis

A side benefit of CFRES's location on the Berkeley campus was the ability of station staff to increase their formal education.

⁵ Walter Mulford retired in 1947 knowing that since 1914, when he first taught at Berkeley, professional forestry had advanced remarkably. The School of Forestry made many significant contributions to forestry research during Mulford's tenure through faculty members Joseph Kittredge, Arthur W. Sampson, and F.S. Baker.

Cooperative relationships gave breadth to the station's programs.

of its research program by January 1950 (USDA FS 1950). The Senate Committee was uncertain about the Forest Service research program—how it was organized, plans for the future, and the place of state and local agencies in bearing some of the costs of needed research. To meet these congressional concerns, Assistant Chief for Research Edward Kotok requested that each Forest Service experiment station director reappraise its research program and report back on four specific inquiries: How did the station meet its federal responsibility for research, how did the station select research problems, how did the station carry out research, and finally, what additional field facilities were needed by each station to undertake its principal lines of research? (Harper 1978, USDA FS 1950).

In July 1949, Wyckoff complied with Kotok's request.⁶ In his reappraisal of the California station, Wyckoff described how the station could provide sufficient large-scale forest research to meet the state's needs. Besides describing how the station operated under a cooperative agreement with the University of California that dated back to October 1926, Wyckoff explained its cooperative relations and frequent close contacts with the USDA and other federal agencies, with the California State Department of Natural Resources through its Division of Forestry, and with other universities, research foundations, industrial and agricultural associations, private industrial concerns, and even governments of several foreign countries. These cooperative relationships gave breadth to the station's programs. In describing how the station selected research problems, Wyckoff noted that during its history, several national comprehensive reviews of forestry, such as the *Cope-land Report* (1933), the Western Range Survey (1936), and the Joint Congressional Committee Report (1941), had kept the California station properly oriented. However, Wyckoff also pointed out that the station's research programs were constantly adjusting to new developments through frequent contacts with Region 5 administration, as well as with land management organizations, industrial agencies, scientific bodies, and education institutions. Cooperation and guidance came in varying degrees from these groups. The University of California and its various divisions

⁶ In 1951, CFRES wrote an extension to their 1949 report under the same title "Reappraisal of Research Program of the California Forest and Range Experiment Station" (USDA FS 1951c). In the extended report, Station Director Wyckoff was concerned mainly with cooperative aspects of the program, especially pertaining to two questions: utilizing cooperative contributions from state and local sources for operating the field research program, and prospects prevailing in California for recommended legislation to facilitate such cooperative contributions from state and local sources (USDA FS 1951c). Information from CFRES and other stations were incorporated into *Cooperation in Forest and Range Management Research*, which Assistant Chief of Research V.L. Harper sent to Congressman Jamie Lloyd Whitten, Chairman of the Subcommittee on Agricultural Appropriation. This formed the basis of the 1956 Whitten amendment to the Granger-Thye Act of 1950, authorizing the Forest Service to collect funds from partners for performing work that is the responsibility of the partner (USDA FS 1951b).

were concerned with services fundamental to forestry, providing advice regarding soil technology, plant nutrition, animal husbandry, and botany; timber owners and lumber industry representatives from groups such as the California Redwood Association (CRA), the Western Pine Association, and the California Forest Protection Association (CFPA) maintained close relations with the station through their agents, conferences, and field visits to branch stations. Ultimately, though, problems that were selected for station study were mainly practical, applied, or operational in nature and were devised to meet urgent requirements of national forests and other land management agencies. According to Wyckoff, expediciencies of various kinds necessarily entered into choice of research problems, particularly the availability of funds and specialist personnel for a research project. Director Wyckoff described the station's available resources, which included the headquarters office at Berkeley, the convenient campus laboratory facilities, facilities secured elsewhere through cooperation with other research organizations, and the station's field facilities consisting of three research centers,⁷ experimental forests and ranges, and numerous small study areas located primarily on national forest land outside of the experimental forests and ranges. Meanwhile, over the next 5 years, Wyckoff sought two additions to the station's field facilities operations. One was the addition of approximately 8,800 acres to the Stanislaus Experimental Forest (SEF) for forest management research and for possible future use in range and watershed management research. The other was the reactivation of the Yurok Redwood Experimental Forest, which was ideally located in the redwood region for the study of this species (USDA FS 1949b).

Assistant Chief of Research Kotok incorporated many of the California station's ideas into *The Forest Research Program and Summary* (Harper 1978, USDA FS 1950), which he placed before Congress along with a request for increased Forest Service research appropriations. In this request, the Forest Service sought support for a five-year research plan for "orderly development" of much-needed facilities and for additional funds for timber, range, and water resources research. In hindsight, Kotok's request before Congress was modest. But congressional leaders

Expediciencies of various kinds necessarily entered into choice of research problems, particularly the availability of funds and specialist personnel for a research project.

⁷ The concept of establishing Forest Service research centers began in California under Station Director Edward Kotok with three research centers maintained with some year-round personnel. They were the San Dimas Experimental Station, the Institute of Forest Genetics, and the San Joaquin Experimental Range (Harper 1978, Storey 1975). The concept spread to the rest of the Nation after World War II, especially in the Southwestern and Southern Stations. The policy of conducting research from regional headquarters alleviated the problem of wasting funds and time traveling to field projects from a central station headquarters. Furthermore, the research centers benefited researcher's families, who frequently complained that husbands and fathers spent too much time away from their homes in travel (Harper 1978).

quickly rejected it, largely because they lacked confidence in Kotok's research leadership. To some, his answers and manner in congressional hearings seemed too "academic," "glib," and "unsatisfactory," with one congressman stating that there was "little justification to increase funding for a program hampered by weak leadership." Kotok, who was inspired by Gifford Pinchot to join the Forest Service and whose experience in forest research dated back to 1911, was simply not attuned to the congressional culture that was trying to make postwar economic readjustments. When Congress rejected his appropriation request, Edward Kotok decided to retire as research chief. Verne L. Harper succeeded him (Steen 1998). For the next 15 years, Harper (fig. 70) guided and shaped Forest Service research, putting him second in longevity and influence to the redoubtable Earle Clapp.

National Forestry Research: The Verne L. Harper Era

Verne Lester Harper's Forest Service career spanned nearly 40 years. He earned his B.S. and M.S. in forestry from the University of California in 1926–1927, at the very same time the CFRES was established on campus. After graduation, Harper joined the Forest Service and was detailed to Florida to conduct naval stores research, eventually serving as forest management division chief (1935–1936) at the Southern Forest Experiment Station in New Orleans. In 1937, the Forest Service promoted Harper to Division Chief of Forest Management Research in Washington, D.C., a position he held until 1944. During that time, Harper earned his Ph.D. in forest economics from Duke University. At the conclusion of World War II, Harper moved to Philadelphia to head the Northeastern Forest Experiment Station. He stayed in Philadelphia until 1950, when he became Deputy Chief of Research upon Edward Kotok's retirement (Clepper 1971).



Courtesy of the Forest History Society, Durham, NC

Figure 70—Verne L. Harper, (back row, second from right), Division Chief of Forest Management Research (1937–1944) and Deputy Chief of Research (1950–1965).

“Les” Harper was an innovator in regional research planning and management. As Deputy Chief of Research, Harper went well beyond Clapp’s broad vision of long-range planning at the national level expressed in Clapp’s *A National Program of Forest Research* (1926) by bringing planning down to a regional basis, and then to a project and study level. Starting in 1951, Harper aggressively pushed for increased quality of research in the Forest Service by separating the two principal stages of research planning requiring standardized written problem analyses, and study plans based on guidelines from the Washington office (WO). Earlier approaches made no distinction between these sequential steps, and often provided no guidelines or requirements that problem analyses and study plans even be written.⁸ In addition to these planning innovations, throughout the 1950s and early 1960s, Harper sought to fulfill five other research objectives. First, he personally took control of research finances, closely coordinating requests for increases in research funding with key congressional appropriation committees. Second, he established greater confidence in the Forest Service research program with members of Congress, the Budget Bureau, and the Agriculture Department personnel involved in department research policies, coordination, and budget preparations. Third, Harper stimulated forestry schools and agricultural experiment stations to do more research on forestry problems. Fourth, he improved the Forest Service program by putting emphasis on the advanced training of research personnel, increasing the fundamental content of the program, and providing more adequate laboratory and scientific equipment. Along these lines, Harper changed the research job classification system through the “man-on-the-job” classification system.⁹ And fifth, Harper improved the effectiveness of the research program through stronger coordination and inspection methods, an improved publication system, and better

Harper aggressively pushed for increased quality of research in the Forest Service.

⁸ To paraphrase Harper’s words, the purpose of problem analysis was to clarify the technical aspects of a given problem and to identify the main questions that would later become subjects for individual studies. For each designated study, a plan would be drawn that involved a set of principles to be observed, such as a clear statement of the object of the study, a valid design that would permit data analyses leading to results with a calculated degree of confidence, and other items. Eventually, this policy was formally adopted with the publication of *Guide for Forest Service Research Scientists* (1965) (Harper 1978).

⁹ This concept held that a position and the man should grow over the years, depending on the capabilities of the incumbent. A panel of his peers evaluated the research scientist in regard to his research endeavor to establish the appropriate grade level for his position. This system gave technical personnel who wanted to remain in research positions attractive career ladders “as tall” as those for research administrators. Prior to this, research scientist pay, like all other employees of the federal government, fell under Civil Service Commission (CSC) appointment system that was tied to classification standards prepared by the CSC. Harper emphasized the importance of upgrading the number of researchers with advanced training through the initial recruitment process, or by encouraging employees without much training to return to school (Harper 1978, Storey 1975).

station management. For instance, during the 1950s and early 1960s, Harper instituted a multiple-purpose reporting system designed for obtaining information annually from stations by line projects—date of establishment, research progress, number of personnel assigned, publications planned and completed, costs of the project, and the like. He also overhauled and revised the research inspection system in 1960, introducing the General Research Inspection (GRI), a new type of WO inspection of field research. Harper also revamped the Forest Service publishing policies. The Forest Service grouped research publications into three types: General Technical Reports (GTR), Research Papers (RP), and Research Notes (RN). They also encouraged the Society of American Foresters (SAF) to publish a new journal devoted to scientific articles in forestry called *Forest Science*, and supported publishing Forest Service research findings in other scientific journals. Finally, station management evolved by the early 1960s into station support services, headed by an assistant director at the station. Support services soon included information services (library, editor,¹⁰ visual aids, publication production, and information dissemination), biometrics systems (statistical analysis methods, computer programming, data processing, computing, biometric research), facilities engineering (planning and design of research structures and facilities, plant engineering, instrumentation), and operation (administrative services, budget and finance, personnel management) (Harper 1978).

California Station's 25th Anniversary

Meanwhile, 1951 marked the 25th anniversary of CFRES, and the foreword to the station's annual report summarized the status of the station's program as "productive." In timber and range resource management, CFRES had over the past 25 years developed promising management systems. For forest management, there was a system called Unit Area Control (UAC) that recognized the natural units of forest stands and applied management methods that each unit demanded in order to insure full production of timber growth. In range management, research aimed to reconcile the elements of practical livestock management with the growth pattern of forage. The station also conducted research in methods to secure greater productivity from California's brushlands, primarily those in the coastal ranges and in the foothills of the Sierra Nevada. The station's research showed still other ways by which California's natural resources could be managed for the greatest good. The

¹⁰ Clyde Walker was the station's first full-time professional editor. Walker came to the station in 1946 and served in that position until at least the late 1960s. He often recognized findings suitable for publication that investigators themselves had not realized should be put in print (Duffield 1979, USDA FS 1946).

CFRES investigators believed that by applying the laws of genetics to forest crops, strains of trees resistant to disease and insects could be developed, and more vigorous, better formed trees could be grown. In addition to these achievements, the station's Forest Utilization Service (FUS) (see below for history) sought to develop methods of wood manufacturing and uses for species that heretofore had been of little or no value (USDA FS 1951a).

In April of the same year as its anniversary, CFRES held a 4-day conference with Region 5 and the station's many cooperating agencies to discuss the station's objectives, past results, current research, and future plans. Fieldwork at the station's five active experimental forests (Blacks Mountain, Feather River,¹¹ San Dimas, Shasta, and Stanislaus), two operative experimental ranges (San Joaquin, Burgess Springs), and the Institute of Forest Genetics (IFG)¹² was included in the discussion as well. Reminiscent of the District/Region 5 Investigative Committee of the late 1920s and early 1930s, this event eventually became known as the "annual research program meeting," and took place each year thereafter (USDA FS 1951d, 1951f). At the end of the meeting, Director Wyckoff and station staff knew that much research still needed to be done, but on the station's quarter-century anniversary, they confidently believed they could provide the answers demanded by a policy of intensive management of California's wildlands.

Forest Service Research Reorganized

With Dwight D. Eisenhower's election to the presidency in 1952, America began an era of economic prosperity. Businessmen were installed in government at every level as the federal government proposed closer "partnership" with local public and private enterprises. In January 1953, during a general reorganization of the Agriculture Department under Ezra Taft Benson, the new Secretary of Agriculture, important changes came to forestry research and to the CFRES. For instance,

¹¹ However, the Feather River Experimental Forest, which as early as 1911 had a research program emphasizing planting and nursery problems, was deactivated in 1952 and turned over to the Plumas National Forest (Fowells 1983, USDA FS 1958b).

¹² The postwar years brought a large number of visitors to the institute from overseas, in many cases because of funding provided by various United States recovery programs (Austin et al. 1974, Duffield 1979). With an awakening interest in forest genetics and tree improvement in the United States, in 1951, the station encouraged domestic visitors to the Institute of Forest Genetics with a guide that helped them find their way to, and understand, the various collections and field experiments at the facility. The guide gave a general account of the objectives, history, and accomplishments of the IFG. This educational pamphlet was the first to highlight a specific station-related facility independent of the Berkeley headquarters (Austin et al. 1974, Duffield 1979, USDA FS 1951e). One frequent visitor was James G. Eddy, whose habit it was to sign the visitor's register as "Founder" (Duffield 1979).

ongoing insect research programs conducted by the Bureau of Entomology and Plant Quarantine and forest disease research programs directed by the Bureau of Plant Industry, Soils, and Agricultural Engineering were transferred to the Forest Service to modernize and make Forest Service research more efficient and responsive to the needs of clientele. The addition of these divisions to the Forest Service research program confirmed a research relationship that had existed for a very long time. By year's end, technicians from the former Berkeley Forest Insect Laboratory staffed the new CFRES forest insect research division. By 1956, the reorganization was completed, and the station tackled the state's serious insect problems that resulted in the loss of hundreds of millions of board-feet of timber each year. At the same time, technicians from the Division of Pathology in San Francisco staffed the new CFRES forest disease research division. By 1956, this organizational change was completed as well. The eight-person forest disease division continued their work of detecting and appraisal surveying of California's forest diseases, including blister rust control studies. Both new divisions worked in close cooperation with other CFRES divisions in a coordinated program of forest research (Harper 1978; USDA FS 1953, 1954a, 1956). In exchange for transferring the insect and disease research units to the Forest Service, the Agriculture Secretary initially agreed to transfer all Forest Service range research to the Agricultural Research Service (ARS),¹³ but eventually turned over only a very small part of the total program. Two of California station's range technicians were transferred to the ARS in 1953 under this arrangement, but their studies were expected to continue under that agency in close cooperation with CFRES (USDA FS 1953). Following the reorganization, in the latter part of the 1950s, Harper gradually added four additional fields to the Forest Service's general research program: forest engineering, forest products marketing, fish and wildlife habitat, and forest recreation. Studies in each of these fields had been conducted in one form or another in connection with past Forest Service projects. Formally adding them to the Forest Service research program on an organized basis at this time gave them identity, planning emphasis, and budget support from the WO. The addition of these four research fields, along with forest diseases and insects, doubled the Forest Service's research program, which already included the fields of forest management, range management, forest products, forest influences, forest fire, and forest economics (Harper 1978).

¹³ Motivation for this transfer came from western stockmen who were openly critical of the Forest Service range research program, which they believed was slanted in favor of Forest Service policy to reduce range stocking on national forests (Harper 1978).

Challenge of Intensive Management: George M. Jemison Faces New Forestry Needs

In the interim, Station Director Stephen Wyckoff retired in 1954 for health reasons, and George M. Jemison,¹⁴ a non-Californian, replaced him, becoming the station's fourth director (fig. 71). Although George Jemison served only 3 years at CFRES, during his tenure he had a considerable impact on the institution.

First, Jemison tackled one of the station's major problems—cooperative funding. Through his efforts, the station developed ever stronger cooperative relations with various organizations such as the California Board of Forestry (CBF), and was able to sustain and improve its cooperative work with the state of California in several other areas. For instance, in 1954, CBF and the Water Resources Board held their first joint meeting to discuss management of watersheds for improved water yield and better control of floods, which CFRES representatives attended. This meeting came as result of damaging southern California floods, which followed severe 1953 year-end fires. This combination of events, among others, pointed out how California's expanding economy depended on forest land for water. Thereafter, several groups invited the station to discuss ways to improve the water yield of California's watersheds. In conjunction with research needs in this area, in 1955 Director Jemison opened up the long-idle Teakettle Creek Experiment Station located along the north fork of the Kings River. Jemison also arranged for the Central Sierra Snow Laboratory (CSSL), which in that year had been transferred to the Forest Service from the Army Corps of Engineers, to conduct snowpack research in conjunction with this research need. By 1956, Jemison had set up a snowpack research section in CFRES's division of watershed management and seven technical workers were on the job (Jemison 1978; USDA FS 1954a, 1955a, 1956).

¹⁴ George Meredith Jemison earned his B.S. in forestry from the University of Idaho in 1931, an M.S. from Yale in 1936, and a Ph.D. from Duke University in 1942. During those years, he worked for the Forest Service at the Northern Rocky Mountain Forest and Range Experiment Station as a junior forester assigned to fire danger measurement studies under noted fire researcher Harry T. Gisborne. In 1937, he was transferred to the Appalachian Forest Experiment Station (the name was changed to Southeastern Forest Experiment Station in 1947), Asheville, North Carolina, where he engaged in forest fire management research. For 2 years (1938–39), he was assigned to the New England Forest Emergency Project dealing with the aftermath of the 1938 hurricane, which damaged forests in seven New England states. After a short time working as a civilian on military projects, such as the development of napalm, he returned to the Forest Service to work at the Appalachian Station. In 1950, Jemison was made Director of the Northern Rocky Mountain Station, where he had started his forestry career, a post he filled until his assignment to CFRES (Clepper 1971, Harper 1978, Jemison 1978, USDA FS 1955b).



U.S. Forest Service, Pacific Southwest
Research Station

Figure 71—George M. Jemison, fourth director of the California Forest and Range Experiment Station, 1954–1957. He conducted the early environmental research years for the Forest Service and later became deputy chief of research (1965–1969).

Strongly supported by state organizations, the station under Jemison's direction also succeeded in funding major fire research studies. During 1955, for the first time, a research project on prevention of human-caused fires, Operation FIRE-STOP, was begun. With the help of the University of California, a fire research laboratory was established and partially equipped at SDEF to aid in the study of some of the more baffling aspects of forest fire behavior.¹⁵ Additionally, redwood and true fir research as an active program returned to the forefront of the station's research program thanks in part to cooperation with local lumber companies. By 1956, a timber management and utilization research program at the Yurok Redwood Experimental Forest was in full swing, and in the same year, the Swain Mountain Experimental Forest (SMEF) was opened to investigate true fir utilization (USDA FS 1954a, 1955a, 1956). Finally, in September 1956, Jemison set up a new research center at Susanville to knit together the new forest investigations in redwoods and true firs in northeastern California with the existing pine silviculture program at BMEF, and to bring new range investigations conducted at SMEF in line with work

¹⁵ Although forest fire protection research was boosted by these cooperative arrangements, in 1956, the station had a net loss in cooperative funds because a 7-year cooperative project with the Department of Defense related to atomic warfare was closed out.

at the Burgess Springs Experimental Range and at the Harvey Valley Experimental Range.¹⁶ The Susanville Research Center encompassed about 10 million acres in 10 counties in the northeast corner of the state with August L. Hormay as research center leader. As the station's fourth research center, the Susanville facility brought together the technical skills and information from nine research divisions of the station on various problems as needed. At this time, wildlands in this part of the state were used principally for timber, livestock, and wildlife production. However, recreation and water values were growing in importance each day because of the rapidly rising population in the state (Gordon 1982, USDA FS 1959b).

By 1957, one outstanding trend in California forestry was the challenge of intensive management.¹⁷ By this date, generalized forestry knowledge from the Forest Service was becoming less helpful to land managers, who more and more sought specific information from the California station to meet their everyday regional problems. For instance, in northwestern California, the spectacular growth of Douglas-fir logging stimulated great interest in future timber crops of the species, and redwood management continued to receive considerable public attention. East of the Sierra Nevada, range and livestock managers were speedily adopting the Harvey Valley grazing system for bunchgrass ranges (discussed below). On the west side of the Sierra, the genetically improved hybrid pines from the IFG at Placerville drew greater attention as demand for planting stock ran ever higher. And, in southern California, more intensive management of wildlands was on the march in terms of watershed management, and the study of prefire planning had begun with the start of a large cooperative project called Operation FUELBREAK. Furthermore, outside of California, the station began its first efforts to start a viable research program in Hawaii under the name "Institute of Tropical Islands Forestry." Intensive management was the trend everywhere, as land managers and research workers applied it to ever-changing problems facing California forestry (USDA FS 1956, 1957a).

While Director George Jemison confronted these new forestry needs and challenges, one unpleasant aspect of his tenure as director came when Deputy Chief of Research Harper gave him the difficult task of diplomatically, but firmly, separating

Generalized forestry knowledge from the Forest Service was becoming less helpful to land managers, who more and more sought specific information from the California station to meet their everyday regional problems.

¹⁶ In 1951, the Harvey Valley Experimental Range or Allotment, an area of 32,352 acres, was set aside on the Lassen National Forest. Construction and installation of the necessary livestock management facilities (five units) were begun that year, with the last unit fenced and used for the first time in 1954 (USDA FS 1954b).

¹⁷ By 1957, one outstanding trend in California forestry was the challenge of intensive management, or the utilization of all modern methods to realize the greatest gain for a given forest product.

Jemison honestly insisted that he was not a “hired gun” directed to “clear out the hangers-on” at the station.

from the station staff those individuals who were not performing to Harper’s high standards to make room for new research team recruits. Jemison’s effort resulted in several retirements and transfers of personnel. At the same time, Jemison recruited several scientists from other agencies or other units of the Forest Service as replacements to strengthen his staff and shifted the program to meet future needs. Although Jemison honestly insisted that he was not a “hired gun” directed to “clear out the hangers-on” at the station, nonetheless, it was considered a painful time, and was so remembered in the station’s history. When he moved on in 1957 to become the first associate deputy chief of research for the Forest Service,¹⁸ a new position created by Verne Harper, many station personnel were not disappointed to see him leave (Jemison 1978, USDA FS 1956).

Crafts and McKennan General Integrated Inspection Report (1957)

With George Jemison’s departure for Washington, California native son R. Keith Arnold was named as Station Director, a position he held until 1963 (fig. 72). In his words, Arnold’s selection was a matter of him being in the right place at the right time, and being the only Californian on staff with a Ph.D. Arnold recalled in an oral history that he did not feel he was qualified for the position. Apparently, however, he had caught the attention of the Chief of the Forest Service, Richard E. McArdle,¹⁹ who later recommended him for this advancement (Steen 1994). Furthermore, Arnold had considerable experience in California forestry research. Under Station Director Wyckoff, Keith Arnold served as the station’s fire research officer, and headed Operation FIRESTOP. In 1954, Arnold left the Forest Service

¹⁸ When asked what he considered to be the biggest challenge he faced as station director, Jemison replied that it was to sustain the support that the Pacific Southwest Research Station depended on from the California State Board of Forestry and others for their assistance in watershed management studies at the San Dimas Experimental Forest, the Soil-Vegetation Survey, and fire research in southern California. Part of the problem he felt was at least in part the untimeliness in publishing research results—especially at San Dimas and in the fire-weather area. There were also problems in maintaining support for the range management program as well because in 1953, the Forest Service had lost research responsibility for range fertilization and reseeding, two of the more popular and saleable range research programs (PSW 1990k).

¹⁹ Richard Edward McArdle was the first Forest Service chief to hold a Ph.D. (University of Michigan, 1930), and to have been a researcher. He joined the Forest Service in 1924, and eventually became director of the Rocky Mountain Forest and Range Experiment Station (1935–1938), director of the Appalachian Forest Experiment Station (1938–1944), and then Assistant Chief of the Forest Service in charge of state and private cooperative programs from 1944 to 1952, prior to being appointed chief. McArdle was the eighth chief of the Forest Service and served from 1952 until 1962 (Clepper 1971).



US Forest Service, Pacific Southwest
Research Station

Figure 72—R. Keith Arnold, innovative California native who as Director of the Pacific Southwest Forest and Range Experiment Station, 1957–1963, broke away from traditional ways. Later Arnold became deputy chief of research (1969–1973).

to join the forestry faculty of the University of California, but returned to the Forest Service in 1955 as chief of the CFRES division of fire research prior to his appointment as Station Director 2 years later.²⁰ During this early period of his career, Arnold also worked on the Armed Forces Special Weapons Project, which sought to determine the effects of nuclear weapons on forests (Clepper 1971, Steen 1994).

Director Arnold, the station's fifth director, was only in the directorship for a few months when in September–October, a General Integrating Inspection (GII) was made by assistant chief Edward C. Crafts and general inspector Russell B. McKennan. Crafts and McKennan acknowledged that Arnold was new on the job and still in the process of getting himself accepted by his own staff. Nonetheless, they appraised the state of research in California with a critical eye. They commended the station's work for being held in high esteem by other conservation leaders in the state and in particular for Operation FIRESTOP (discussed below) and the

²⁰ Richard Keith Arnold was born in 1913 in Long Beach, California, and received his B.S. in forestry from the University of California in 1937. He went on to Yale to earn his Master of Forestry degree in 1938 and his Ph.D. from the University of Michigan (Clepper 1971). Interestingly, during cooperative work projects with the university, the line between teaching at Berkeley and working at the California Station was often blurred (Steen 1994).

The Forest Service in California faced strong leadership competition in conservation.

prompt application of its findings. They also applauded the station for deciding in the field with the inspectors that the station should move forward cooperatively and progressively in a test of applied watershed management designed to increase water yields by brush conversion and other measures. Additionally, they wanted Director Arnold to realize the necessity of breaking away from the traditional ways of doing things. He needed to understand that the long-range Forest Service objectives in California were undergoing a period of transition as an accompaniment to the economic and social changes underway in the state and in Region 5. The Forest Service in California faced strong leadership competition in conservation, and in Crafts and McKennan's opinion, had either lost or was in danger of losing leadership in certain fields. For example, in recreation area development, California's Division of Beaches and Parks had outstripped the Forest Service. In addition, California's Department of Water Resources was seen as more aggressive and active with respect to overall water problems than the Forest Service. Furthermore, fire suppression leadership in the Los Angeles metropolitan area now seemed to rest with Los Angeles County and the state. Moreover, because the station was dependent on sources other than the federal government for a substantial portion of its funds (close to 15 percent),²¹ inspectors Crafts and McKennan gained the impression that some station personnel looked more to the state for program direction and research funds than to the WO. Meanwhile, relations with other public agencies, such as the University of California, posed a number of problems. Difficulties centered mostly on university space needs and problems over SJER's research program focus (Crafts and McKennan 1957).

On the other hand, the inspectors heard enough dissent between the regional and station personnel involving various lines of research to conclude that purposeful, corrective action was needed.²² Professional differences were normal and healthy, but some of those found by Crafts and McKennan in 1957 had resulted in personal feeling. There was also a problem between the station and Region 5 administration regarding research programming. The inspectors soon realized that the development of research programs and their modification from time to time was

²¹ In 1958, the station had at its disposal about \$969,000 of Forest Service research funds, \$64,000 of funds from the regional office, and \$346,000 from other sources, two-thirds of which was from the state of California, including the University of California. For the station as a whole, forest research funds exceeded cooperative funds by about 2½ to 1, which was not unreasonable (Crafts and McKennan 1957).

²² For example, on the subject of grazing research, some in the regional office felt that the station should develop usable guides in allotment analysis. In timber research, differences of viewpoints appeared in the amount of emphasis that the station devoted to regeneration research, growth studies, and yield tables, and on the direction of genetics research. Conversely, station staff felt that Region 5 personnel were not taking advantage of and using to the fullest practical extent results of disease research.

on a somewhat hit-or-miss basis, done largely by each station division chief in their respective field, and frequently without much formal consultation or discussion, especially with the regional office. Additionally, there was no real program conference between the station and the region, or any formalized program meeting in which the region presented its views as to desirable adjustments to the station's program to meet current or foreseeable needs. The annual CFRES meeting with the region and other cooperators was largely a reporting of accomplishments of the past year, and the telling of research plans for the future, which CFRES staff had already decided upon prior to the meeting. The "Annual Program of Work" required by the WO and prepared by the station appeared to be "only paperwork" as far as use of it by the station was concerned. Given the above circumstances, Crafts and McKennan expected Director Arnold to address these and other administrative, leadership, and research program problems. They wanted Arnold to establish a fully coordinated relationship and research program with the Regional Forester and to extend this relationship and research program between the station and region downward through the ranks. A greater day-by-day exchange was sought between research and regional staff. Furthermore, Region 5 had to fully accept CFRES as an arm of the Forest Service, and the station had to fully accept its responsibility as a member of the Forest Service team (Crafts and McKennan 1957).

Pacific Southwest (PSW) Forest and Range Experiment Station

During Keith Arnold's 6 years as station director, three important administrative changes occurred. The first substantive change Arnold made concerned the station's poor administrative record. When Arnold became director, there were nine division chiefs—one each for forest management, genetics, range, watershed, fire, insects, disease, economics, and products. Two-thirds of them were top scientists, but most were not cut out to be administrators. They were only interested in their own area of expertise, and not concerned with the station as a whole. Frankly put, even a top scientist such as Duncan Dunning admitted he did not like administrative tasks.²³ So Arnold decided to change to four assistant directors, one for application and planning, and the other three to handle the administration of several related areas.²⁴

²³ Sometimes, top scientists at the station, such as Nicholas Mirov, gave the deliberate appearance of being totally inept in administrative matters in order to relieve themselves of the task of getting their paperwork in order (Duffield 1979).

²⁴ Initial assistant directors were Donald W. Lynch (Timber Management, Insects and Disease Research), Earl G. Dunford (Watershed Management, and Range and Wildlife Habitat Research), Harry W. Camp (Forest Products Utilization and Marketing, Economics, and Recreation Research), and Carl C. Wilson (Forest Fire and Engineering Research).

The idea of a Hawaii research program started by [George Jamison] making preliminary contacts in Hawaii.

Although at first many on his staff were unconvinced of the idea's viability, after 2 years of planning and personnel negotiations, the reorganization effort gained support, and in turn several stations and the WO eventually went in the same direction (Steen 1994). Station Director Arnold believed that this reorganization was one of the most significant achievements of his administration (PSW 1990e).

Following this administrative reorganization, Arnold then broadened the station's program by developing a full research program for Hawaii, which Arnold felt was another memorable achievement as station director (PSW 1990e). As noted earlier, George Jamison had gotten the idea of a Hawaii research program started by making preliminary contacts in Hawaii, but in November 1957, Arnold assigned Robert E. Nelson full time to the Territory of Hawaii. Nelson's mission was supported by Charles A. Connaughton, Regional Forester for California, and conceived as a long-term one—lasting for a minimum of 5 years. Before Nelson's assignment, CFRES work in Hawaii had focused either almost exclusively on protecting watershed resources through planting programs, or limited cooperative forest fire protection under the Clarke-McNary Act. But after World War II, when the sugar cane and pineapple industries moved off the islands, the islands of Maui, Hawaii, and Kauai all began to experience severe economic problems. Timber production was seen as a possible solution (Nelson 1989, Steen 1994). Then on April 15, 1959, the station's administrative boundary was formally extended to include Hawaii, which had just become the Nation's 50th state. As a consequence of the Pacific island research program, Keith Arnold decided to change the name of the California Forest and Range Experiment Station to the Pacific Southwest (PSW) Forest and Range Experiment Station (Aitro 1977, Steen 1994), to reflect Hawaiian studies and later research elsewhere in the Pacific.²⁵ Despite the name change, the station's research on problems affecting the management of forest, watershed, and range-lands in California remained unchanged (USDA FS 1959a).

Finally, Arnold handled the administrative problem of moving the PSW Research Station off the campus of the University of California. Shortly after Arnold became director, it was obvious to him that after some 30 years, the growth of University of California was forcing the station to move from its limited Berkeley campus quarters in the Forestry Building (PSW 1990e). By 1959, the PSW Research Station was the single largest nonuniversity user of university space, and as space got tighter on campus, university officials eventually did ask the Forest Service to

²⁵ According to Arnold, program increases for "California" were difficult to get through Congress, so changing the title to "Pacific Southwest" helped in that regard. Doing so also recognized Hawaii as the station's new responsibility (PSW 1990e).

move out of Mulford Hall. Arnold deemed a location near the campus of utmost importance because many PSW Research Station employees were working on advanced degrees, either on a part-time basis or while on leave. Arnold also feared that station staff would lose important direct cooperative contacts with the School of Forestry and other scientists if the station were not near the university. He also realized the need to bring together some of the station's off-campus units into one location as well. In the end, he convinced the General Services Administration (GSA) to rent a new headquarters site for the PSW Research Station at 1960 Addison Street, only a few blocks from its original modest 1926 home on the Berkeley campus in Hilgard Hall, making it easier for young staff members to continue their education (Aitro 1977, Steen 1994). For the first time since the early 1930s, all Berkeley personnel were gathered under one roof. The station occupied the first and third floors of the Stead Building on Addison Street (fig. 73). The first floor of the Stead Building was equipped with 10 laboratories for specialized research in plant biochemistry, plant physiology, forest pathology, forest entomology, and soils. There was also a small electronics laboratory for the development of specialized instruments needed in watershed management and forest fire research. The director and research division administrative offices occupied the building's third floor. Although the station had moved off campus, Arnold continued to maintain and strengthen its cooperative relationship with the university²⁶ (USDA FS 1959a, circa 1960).

By 1959, the PSW Research Station had a corps of more than 100 research scientists who knew California intimately and had acquired their scientific skills in the country's finest universities. In addition to its Berkeley headquarters, station research activities were spread out over its many experimental forests and field laboratories that had been developed over a period of more than 30 years and supported by funds or technical aid from major cooperators, including federal agencies, state agencies, educational institutions, industrial organizations, and endowed foundations. As funds permitted, the station installed instruments, research equipment, and service buildings and started experimental work at these field laboratories. Some of them operated year-round, and others were only open on a seasonal basis. The PSW Research Station's experimental forest and range system provided the

The PSW Research Station had a corps of more than 100 research scientists who knew California intimately and had acquired their scientific skills in the country's finest universities.

²⁶ At this time, the station had a memorandum of agreement with the university covering the use of experimental areas, library, etc., but cooperation in these respects was only slightly closer with the University of California than it was with a number of other institutions. Therefore, the station removed from its publications the credit line used in the past about maintaining the station at Berkeley, California, in cooperation with the University (Harper 1959).



Rosanne Hunt

Figure 73—Stead Building—First Pacific Southwest Research Station home off Berkeley campus with nearby National Guard during “People’s Park” protests, 1969.

framework for many elements needed to insure a continuous research program at the California station. In addition to the station’s six experimental forests (Blacks Mountain, Yurok, Swain Mountain, Challenge, Stanislaus, and San Dimas), there were four experimental ranges (Burgess Springs, Harvey Valley, San Joaquin, and Teakettle Creek), three insect laboratories (Hat Creek, Miami, and Orleans), a fire laboratory (Pilgrim Creek),²⁷ two experimental watershed research areas (Sagehen and Big Creek), and the Institute of Forest Genetics. By the late 1950s, the PSW Research Station had also acquired, in close cooperation with the California Department of Fish and Game, three game-browse areas (Flukey Spring, Doyle, and Buttermilk) to seek ways to seed browse species on deteriorated big-game ranges, and the CSSL. The PSW Research Station also had access to several non-Forest Service institutions for research. They included the Richmond Fire Laboratory on the grounds of the University of California, Richmond; the Forest Tree Physiology Laboratory on the campus of the California Institute of Technology, Pasadena; and the Tuolumne Meadows Forest Insect Laboratory in Yosemite National Park. The location, forest type, area, and research programs for all of the above facilities were clearly described in *A Guide to Field Laboratories of the California Forest and Range Experiment Station* as a supplement to the station’s 1958 annual report (USDA FS 1958a, 1958b, 1959b).

²⁷ Formerly known as the Shasta Experimental Fire Forest (SEFF).

Applied and Fundamental Cooperative Research Efforts

After 1959, cooperation in wildland research with state and local governments, universities, and industries became the key element in the PSW Research Station's program. In 1958, California became the first state to prepare a complete "Wildland Research Plan," which sought new scientific knowledge to help solve the state's current and future forest management problems. At that time, the University of California formed a Wildland Research Center, and the CBF recognized it by appointing an advisory forest research committee. The PSW Research Station played a key role in this cooperative effort, and focused on applied cooperative research results. It directed its efforts and research toward the California Wildland Research Plan's goal of increasing the productivity of California's natural resources while finding solutions to high-priority problems. This cooperation between various agencies made forestry research funds go farther in California and obtained results more quickly.²⁸ Although the California or PSW Station had, since its inception in 1926, worked closely with the state of California, even more cooperative programs emerged at this time between the institutions. Cooperative wildland research programs involved working closely with California's Division of Forestry on fire research, the state's Department of Water Resources regarding watershed research, and California's Department of Fish and Game pertaining to deer ranges. Simultaneously, the station continued its close cooperative relationship with the University of California,²⁹ conducting collaborative work through the university's new Wildland Research Center and the Water Research Center. By necessity, this joint work involved the university's School of Forestry, the Departments of Irrigation, Plant Pathology, and Botany, along with the engineering schools in Berkeley, Davis, and Los Angeles, and computer groups in Berkeley and Los Angeles—not to mention individual scientists. Station cooperation in wildland research also extended beyond the state of California and the university system. Throughout the 1950s, the PSW

Cooperative research was the "name of the game," and this trend was reflected elsewhere in the Nation.

²⁸ Cooperative research was the "name of the game," and this trend was reflected elsewhere in the Nation. For instance, by this time, more than a third of the Southern and Southeastern Experiment Station budgets came from state and private sources (Steen 1998).

²⁹ In 1956, just before Keith Arnold became the station director, cooperative research was given a big boost when Congress passed the Whitten amendment to the Granger-Thye Act, giving the Forest Service authorization to advance funds to cooperators to stimulate and facilitate cooperative work where it was deemed advisable. As a result, many institutions, particularly forestry schools, became interested in cooperative research. Such cooperation was advantageous to both the Forest Service and the institutions. The Forest Service gained the use of laboratories, if needed, for research and the guidance of professors, and universities were able to broaden their graduate programs (Storey 1975).

With the advent of the nuclear age, it had become more than apparent that the relation between science and the federal government was of national importance.

Research Station developed a close mutual relationship with local governments—especially Los Angeles County in the field of forest firefighting research—and a stepped-up association with forest industries to resolve various forest management and industry problems (USDA FS 1958a, 1958c, 1960).

Advances in applied research were gratifying, but basic, or fundamental, research was seen as the key to future progress at the station.³⁰ With the advent of the nuclear age, it had become more than apparent that the relation between science and the federal government was of national importance. In 1960, President Eisenhower underscored this point when he appointed his Committee for Planning National Goals, which emphasized the need to stimulate basic scientific research. On a national level, Lester Harper, and his deputy George Jemison redesigned the Forest Service's research program to look beyond current applied research that had already been incorporated into daily management activities through improved timber harvest techniques, reforestation, range quality, fire suppression, and treatments for insect and disease infestations. Instead, Harper and Jemison saw a future need for fundamental research³¹ at station and university levels to meet the increased demands on the Nation's forests and increased public concern about management quality. Much more knowledge was needed if the forests of the future were to be healthy and able to supply a projected twofold increase in forest resource demand by the year 2000 (USDA FS 1960a). Toward this goal, in the early 1960s, they asked Congress for a "three-fold expansion of Forest Service research in the coming decade to include a hefty building program to house the increased projects and personnel" (Steen 1998).

Meanwhile, Arnold pushed to increase the PSW Research Station's basic research disciplines, particularly in plant physiology, plant biochemistry, biometrics, mechanics of combustion, snow hydrology, forest biology, and forest microclimate studies. The station's 1960 annual report predicted that more than half of the techniques of wildland management that would be in use a decade later would be entirely new and would grow out of current basic research (USDA FS 1960a). As the California station entered into the decade of the 1960s, the covers of its annual reports symbolically reflected basic research principles—depicting a bespectacled scientist with pencil and pad peering into a microscope, alongside applied research

³⁰ In the early 1960s, the distinguishing characteristic of applied research was that it was done for a purpose, while basic research was done without concern as to the usefulness of the results. The difference was in objectives, not methodology (Davis 1963).

³¹ In 1960, the Forest Products Laboratory (FPL) expanded its facilities following its golden anniversary, and began a new era of research that called for a reduction of "applied" military work, which the FPL had conducted since World War II, and an increase in "basic" research that would solve the Nation's and the world's wood products problems. To replace the military work, the FPL increased commercial cooperative funds (Godfrey 1990).

icons such as forestry equipment harvesting trees. Station annual report text continued to defend applied research goals of protecting and using current resources and increasing efficient production, but they also leaned toward expanding forest land capacity in the long run through progress in the basic forestry-related sciences (USDA FS 1961, 1962).

Changes Yet in the Offing

Meanwhile, Harper and Jemison carried on with their plans for Forest Service research reorganization. First, in 1961, the man-on-the-job classification system, which was used as a pilot in the Forest Service after 1957, was formally adopted for grading positions of research scientists (Harper 1978). In addition to this change, Harper and Jemison wasted no time in exploiting the “opportunity this innovation provided by reorganizing the Forest Service research structure from one made up of a number of research centers³² to a system where the basic unit was a research project [research work unit or RWU], headed by a leader, who was himself a research scientist participating personally in the research doing.” Next, in the same year, they established pioneer research units (PRUs). The purpose of these units was to develop new knowledge as a basis for future advances, rather than solving immediate problems through applied research. Each PRU was built around a scientist of outstanding competence in an area of interest to the Forest Service.³³ Finally, during this period, Harper and Jemison, long-time proponents of cooperative research relations, played prominent roles in the passage of the McIntire-Stennis Cooperative Forestry Research Act on October 10, 1962. This act gave Forest Service forestry research a boost, by giving states, through their educational institutions, a stronger role in coordination with the Forest Service research program. The McIntire-Stennis³⁴ Act recognized that the magnitude of the forestry research effort needed in the future would require all available resources, and dramatically change forestry research (Storey 1975).

³² In the decade to come, this renovation would affect the PSW Research Station dramatically because its organization was structured around its research center system.

³³ Although the concept of PRUs appeared sound, implementation was difficult. Problems occurred when the pioneering scientist moved on or retired, leaving the Forest Service with perhaps a laboratory and people built around that scientist (Steen 1994).

³⁴ Senator John Stennis from Mississippi initially gained his interest in Forest Service research after a visit to California and the Institute of Forest Genetics. He had brought back with him a specimen of bristlecone pine that he wished to use in a lesson before a Sunday school class he taught. Senator Stennis, a key member of the Senate appropriations committee, contacted Lester Harper wishing to know more about the piece of wood that had been alive during biblical times. From the experience, Stennis became a staunch supporter of Forest Service research (Steen 1998).

Postwar California Station Applied Research

The following sections consider the applied and basic research aspects of the California Station during the administrations of Stephen B. Wyckoff (1945–1954), George M. Jemison (1954–1957), and R. Keith Arnold (1957–1963). For most of the post-World War II era, the California station research program was divided more or less into the following functional divisions: forest management, genetics, economics, forest products, range, water, fire, insect, disease, wildlife, and recreation.

Forest Management Research

Forest management research in California dealt with a variety of forested lands. For instance, in 1952, there were 16 million acres of commercial forest land, 8.8 million acres of old-growth timber, 4.1 million acres of cutover lands, 1.4 million acres of second-growth timber, and 2.1 million acres of once-forested brushlands. In the postwar era, CFRES research in the forestry problems of these areas was directed first toward converting the old-growth forests into fully productive managed stands, second to improving the quantity and quality of timber growth on cutover land and second-growth areas, and third to replacing brush with timber stands. To accomplish these three goals, California station forest management research was organized into three fields: silviculture, regeneration, and mensuration (USDA FS 1952b).

Silviculture—

Since the California station began in 1926, the goal of silviculture studies had been to develop new forestry procedures designed to keep forest land continuously and adequately stocked with desirable timber species. These procedures could be applied in the management of both old and young forests. However, prior to World War II, analysis of records indicated that previous methods of management were not providing adequate restocking of pine. A new approach was necessary that would take into account the conditions required for optimum growth of these trees and make positive provision for their new growth. Fortunately, just such an approach was developed at the California station, requiring that cutting be fitted to the natural grouping of trees within a forest type, rather than to generalized rules for the type as a whole, as had been the accepted practice in the prewar years. The procedure was named unit area control (UAC),³⁵ and was believed to hold the most promise for sustained-yield management of California's forests. Duncan Dunning, chief

³⁵ The basic concept of unit area control was detailed control of stocking on small forest areas. It provided a basis for classifying stand conditions, which gave the forester a tool for subdividing the forest into natural unit areas small and homogenous enough for uniform silvicultural treatments (USDA FS1951a).

of the forest management division, developed this new approach just prior to his retirement from the station staff in 1951. Dunning's UAC concept was a product of 30 years of research by him in the ponderosa pine and mixed-conifer forests of the Sierra Nevada. By 1951, large-scale trials of UAC were underway at the Stanislaus Experimental Forest and the BMEF. Furthermore, by this date, CFRES staff was holding training sessions with Region 5 foresters on six of California's national forests (Hughes and Dunning 1948; USDA FS 1951a, 1952a, 1952b). After being tested operationally during the 1950s, UAC became widely accepted throughout the forestry research community. During testing, William E. Hallin and Russell K. LeBaron published the station's major findings on the new system in various research notes and miscellaneous papers, and in 1959, Hallin summarized the years of research on UAC at BMEF in *The Application of Unit Area Control in the Management of Ponderosa-Jeffrey Pine at Blacks Mountain Experimental Forest* (USDA Technical Bulletin 1191) (Aitro 1977, USDA FS1959a). With research on UAC complete, early 1960s station research at SEF turned to investigating regeneration and growth after harvest cutting, and direct seeding and planting methods, such as drill seeding and pruning. Studies at BMEF also began to focus on regeneration and growth of pine stands after harvest cutting, and improvement of pine stands by thinning and pruning, while also investigating methods of reducing tree mortality caused by bark beetles and prescribed burning (USDA FS 1958b, 1959a, 1961).

In the meantime, by 1952, the rapid acceleration in the rate of timber harvesting in California concerned Director Wyckoff and many staff members. Cutting of saw timber in California had increased from 2.3 billion board feet in 1945 to 5 billion board feet in 1951. In response, in 1952 the forest management division began a critical review of its program (USDA FS 1952a), and the next year changed directions to concentrate more of its research to studying three timber types besides pines: old-growth stands of redwood and associated species, red and white fir in the higher elevations, and young-growth ponderosa pine on high-quality sites. These silvicultural investigations were somewhat similar to the UAC investigations at BMEF and SEF (USDA FS 1959a).

The CFRES began studying California's redwood-Douglas-fir region in the mid-1950s, largely because of the spectacular growth of logging in this region after World War II, which naturally stimulated research interest. To foresters and redwood timber owners, redwood presented a special challenge. The species had several unusual characteristics, such as great size, special qualities of the wood, and high growth potential. Redwood also presented many difficult logging and utilization problems, such as large amounts of defective material and tremendous quantities of highly flammable, decay-resistant logging slash. Prior to World War II,

The rapid acceleration in the rate of timber harvesting in California concerned Director Wyckoff and many staff members.

redwood forests had never really been the subject of sustained, systematic research at the station, although in the late 1930s Hubert Person had attempted some redwood region silvicultural investigations. Person's studies provided helpful information, but his investigations were limited in scope and were short-term projects. Responding to the need for more research in this area, in 1955 Station Director George Jemison decided to initiate comprehensive research into the forest management problems of the redwood region. A year later, CFRES, in cooperation with the Simpson Redwood Company, a nationally powerful firm, started a 7-year timber management and utilization research program at the Yurok Redwood Experimental Forest (YREF). The new project at YREF centered on High Prairie Creek in Del Norte County, which included about 900 acres in the station's YREF, and an adjoining 1,000 acres owned by the Simpson Company. The first research project there involved managing the conversion of the 20- to 30-year supply of old-growth redwood therein into younger managed stands. The first year was spent making plans, laying out study areas, surveying roads, and appraising 18 million board feet of timber to be logged in the first series of cuttings. Thereafter, they evaluated natural regeneration and subsequent growth, logging costs for different intensities of cutting, methods of logging, and growth of residual stands. The Redwood-Simpson cooperative study also investigated ways to maintain soil productivity, to minimize erosion and undesirable streamflow changes, to get maximum utilization of saw timber and wood residue, and to abate the logging slash fire hazard. Loggers began felling the first clearcut units in September 1958. In 1960, a second series of harvest cutting studies began, and scheduled experimental timber harvesting and regeneration studies continued thereafter (USDA FS 1955a, 1956a, 1957a, 1958a, 1958b, 1960, 1961).

Scientist Douglass F. Roy led the redwood research studies, first summarizing forest management research activities and problems that managers of timberland could expect in the region, then describing where, when, and how to plant redwoods to obtain good results. Roy also provided detailed information on the most important research needs in the redwood region: site classification and yield tables, information on the results of various cutting methods, tree vigor classification for redwood, knowledge regarding regeneration, and ways to improve and fully utilize material harvested from young-growth redwood stands. At the same time, Richard H. May added to Roy's research.³⁶ In 1957, Richard May reviewed the available

³⁶ In the early 1960s, Douglass F. Roy turned to publishing research results on Douglas-fir seed production and regeneration issues (PSW 1985o).

data on coast redwood, such as its area, volume, ownership, rate of growth, and rate of cut, and forecasted the future outlook for redwood (May 1957). Four years earlier, he had detailed the history of the redwood industry in six California counties from 1842 to 1935 (Aitro 1977, May 1953b). While Roy and May toiled away at their research, snarling chainsaws kept cutting the old-growth redwoods (fig. 74) at such a pace that in the early 1960s conservationist groups such as the Sierra Club and the Save-the-Redwoods League became sufficiently alarmed to seek federal and state action to save them (Schrepfer 1983).

Elsewhere in California, vigorous logging had begun on lands containing red and white firs. In response, the station began true-fir research during the mid-1950s, when Director Jemison opened up SMEF (an area primarily timbered with red and white fir) to exploratory cutting studies. In 1956, the station's division of forest management prepared a working plan for experimental harvesting and regeneration operations at SMEF based on even-age management, with the major kind of harvest being clearcutting.³⁷ To prevent the look of a completely systematic pattern in the cut, the station varied selected sites by differences in age of the trees, changes in topography, and location of roads. However, cutting experiments in red fir at SMEF were delayed in 1957 because of a failure of a subsequent timber sale. The experiments were not resumed, however, partly because station staff—unlike their counterparts in the 1930s—felt that actual logging by CFRES personnel seriously detracted from the time available for research by the station's technical staff (USDA FS 1956a, 1957a, 1958b, 1960). While waiting for an adequate timber sale, the station staff passed their time by recording and evaluating seedfall, natural regeneration, and windthrow in true firs (USDA FS 1961).

Meanwhile, as the remaining mature timber in California decreased and the trend toward more intensive forest management increased, a demand for knowledge about young-growth timber materialized. To work on this problem, in 1957, the station assigned personnel to plan forest management studies at the Challenge

As the remaining mature timber in California decreased and the trend toward more intensive forest management increased, a demand for knowledge about young-growth timber materialized.

³⁷ After World War II, Region 5's timber management had gradually turned to clearcutting over selective cutting, and by 1955, clearcutting as a logging practice had taken root in the California region. However, when preservationists, such as the Sierra Club members, happened upon these early clearcut patches in the midst of California's national forests, they were disturbed at the "destruction." They had difficulty distinguishing the new clearcutting method from the razing of the forests in the previous century, which had helped to spawn the organization (Godfrey 2005).



U.S. Forest Service, Pacific Southwest Research Station

Figure 74—Old-growth California redwood stands were investigated by Redwood Sciences Laboratory scientists in the 1970s.

Experimental Forest (CEF)³⁸ (fig. 75), which represented the mixed-conifer young-growth that covered millions of acres along the western slopes of the Sierra Nevada at elevations of 2,000 to 4,000 feet. Their task was to answer several particular questions. What are the most suitable ages for harvesting young growth? How can a forester pick the best trees for future cuts? What is the most economical, positive method to combat undesirable hardwoods and brush? These were but a few of the problems for which answers were needed for future forest management of these timber regions (USDA FS 1957a).

With these problems in mind, in 1958, the station began a program of silvicultural management studies at CEF in cooperation with the Soper-Wheeler Company to get information on the effects of type of harvest cut, slash disposal, seedbed preparation, and hardwood control on the regeneration of young-growth timber. The station's research program also investigated costs and effects of timber stand

³⁸ Although the CEF was formally designated in 1942 to meet research data needs regarding piling demands during World War II, ultimately it was selected for experimentation in silvicultural management of the second-growth forests at lower elevations on the west slope of the Sierra Nevada. However, the California station was not in a position financially to activate the experimental forest until 1957 (USDA FS 1942b, 1957b).



U.S. Forest Service, Pacific Southwest Research Station

Figure 75—Scientist working on Challenge Experimental Forest soil fertility study.

improvement (TSI), optimum rotation age, grade recovery from different-sized trees and logs, volume tables for the area, logging and manufacturing costs, and ways to increase stocking. Research was begun in 1958 with the removal of shelterwood followed by slash disposal, but in 1960 timber harvesting and regeneration studies were suspended at CEF until an advisory board could provide the necessary time for a more thorough inventory of the research problems there. By 1961, this issue was worked out and work continued at CEF (USDA FS 1958a, 1958b, 1960, 1961).

Regeneration—

By the end of World War II, studies of natural seeding, artificial seeding, and planting had isolated the chief obstacles to forest regeneration and had shown ways of getting around a few of these barriers, but not the critical ones. In the early 1950s, California station staff, such as Harry A. Fowells, Douglass F. Roy, and Gilbert H. Schubert, continued to explore new means of regeneration. Occasionally they published research notes summarizing station findings, such as *Recent Direct Seeding Trials in the Pine Region* (Fowells and Schubert 1951) or *Here's How—A Guide to Tree Planting in the California Pine Region* (Corson and Fowells 1952). Subsequently, during 1953, the California State Board of Forestry recognized the

difficulties of forest regeneration in California and appointed a special committee to study tree planting and artificial and natural seeding problems. The station was represented on that committee, and a large amount of the station's forest management research was directed toward the problem of ensuring the establishment of conifer seedlings (Aitro 1977; USDA FS 1951a, 1952b, 1953). For the remainder of the 1950s, Douglass Roy studied and assessed California's pine cone crops, along with means of increasing production through fertilization while Schubert and Edward C. Stone concentrated their attention on ponderosa pine planting and pine seedling root generation (Aitro 1977; USDA FS 1955a, 1961). Despite their work, reliable methods of forest regeneration eluded the California station and other forestry researchers. In fact, in 1957, the California region had the lowest planting success of any region. Only 35 percent of past planting had resulted in acceptable plantations in contrast to a national average of 76 percent (Crafts and McKennan 1957). With increasing frequency, forest regeneration studies reached the point where investigators realized that they needed a better understanding of the basic physiological processes and requirements of trees as living organisms in order to regenerate and grow timber crops more effectively. Therefore, in 1957, under the directorship of Keith Arnold, the station turned to basic research in forest tree physiology. Under a cooperative agreement with California Institute of Technology, fundamental experiments on physiology of conifer seedlings began for the purpose of improving artificial and natural forest regeneration. Experimental results were just beginning to emerge by 1960 through studies of tree growth habits at the Earhart Plant Research Laboratory's controlled environment in cooperation with the biology department. Here, scientists learned more about the life processes of trees and their requirements for nutrients, water, light, and heat (USDA FS 1958a, 1958b, 1959a, 1960). In the meantime, Director Arnold made preparations for a center for studies of the management of planted stands and naturally established young forests at Redding, California³⁹ (USDA FS 1961).

Mensuration—

Providing foresters with the tools for determining growth and yield of timber stands was the object of mensuration work. Prior to World War II, basic aids—volume and yield tables for most of California's important species, as well as sampling methods—had been fairly well worked out. However, as other species, such as Douglas-fir and redwoods, became commercially important, new tables, or modifications of

³⁹ The Redding Silviculture Laboratory was established in 1964 and carried on the heritage of silviculture research that was begun by scientists at the station's Berkeley headquarters dating back to the 1930s. The laboratory is co-located with the Shasta-Trinity National Forest Supervisor's Office in the heart of the northern California forest industry, about 160 miles north of Sacramento and 100 miles south of the Oregon border.

existing ones, were necessary.⁴⁰ Also required were basic studies on growth and mortality in stands of these trees. Despite the need, the station had to defer most scheduled mensuration work after the war because of limited budgets and the need to strengthen silvicultural studies. Mensuration research would not be picked up again seriously until the early 1960s (USDA FS 1946, 1947, 1948a, 1949a, 1951a, 1952b). Significant mensuration research did not occur at the PSW Research Station until 1961, when Lewis R. Grosenbaugh was selected to start the Forest Service's first pioneering research unit in mensuration.⁴¹

Forest Genetics Research

After World War II, Palmer Stockwell continued as chief of the station's division of forest genetics. Stockwell headed genetics until 1950, when he passed away from cancer. Upon his death, Francis "Pete" Righter replaced him, a position Righter held until 1960. During the decade of the 1950s, important scientists in the division included not only "Pete" Righter, but "Nick" Mirov, John W. Duffield, and later Robert Z. Callaham, who many years later became director of the PSW Research Station (1976–1983). Each individual influenced genetic research at the station and approached problems in different ways. For instance, Mirov was a compulsive publisher, who often started a paper at the same time he conceived a study, whereas Righter experienced great difficulty in getting the words on paper, despite the great amount of data that resulted from his work (see for instance, Righter 1954). Despite these and other personality differences, the researchers worked cooperatively (Austin et al. 1974, Duffield 1979, USDA FS 1946).

Major activities and accomplishments at the Institute of Forest Genetics in the prewar era concentrated on mass production of hybrids for large-scale testing. Their work searched for better pines by attempting new crosses among the best timber-producing species in line with new knowledge of phylogeny. But soon, it became

⁴⁰ For instance, in 1950, A.A. Hassel and others devised board-foot and volume tables for second-growth redwoods and for some California hardwoods (Aitro 1977).

⁴¹ Grosenbaugh joined the Forest Service after graduating with a Master of Forestry degree from Yale (1936). Prior to World War II, Grosenbaugh had timber management assignments on the Ouachita and Ozark National Forests, but after the war, he returned to the Southern Region of the Forest Service and in 1946 transferred to the Southern Forest Experiment Station in New Orleans. There he served as silviculturist, mensurationist, and finally from 1951 to 1960 as chief of the forest management research division. Once at the PSW Research Station, Grosenbaugh's research led to innovative developments in forest mensuration, inventory design, and statistical sampling, including the formulation of 3P sampling ("probability proportional to prediction") promulgated in PSW Research Paper 13: *STX-Fortran 4 Program—For Estimates of Tree Populations from 3P Sample—Tree Measurements* (Grosenbaugh 1967). In 1968, the unit moved to Atlanta, where Grosenbaugh retired in 1974.

Experimental crossings caused striking alterations in such properties as diameter and height, growth, root development, stem taper, length of foliage, and resistance to drought, frost, disease, and insects.

increasingly apparent that radically new methods of mass hybridization would be necessary to produce the volume of hybrid seeds wanted at a lower cost. Therefore, in 1947–1948, the genetics division turned to emphasizing experimental crossings rather than mass production crosses, with particular attention to southern pines. By 1951, 70 different hybrid pines had been produced as a result of the station's research in experimental crossings. These crossings caused striking alterations in such properties as diameter and height, growth, root development, stem taper, length of foliage, and resistance to drought, frost, disease, and insects. Progress was greatest in four groups of pines: white pines, western yellow pines, southern pines, and lodgepole-jack pine groups. Field tests for several of these hybrids were conducted in 1951, and a branch arboretum, intended principally to grow pines that did not thrive at the Eddy Arboretum at the IFG, was established in 1956 at an altitude of 7,000 feet near Wrights Lake in the Georgetown District of the Eldorado National Forest. By 1957, the possibility of increasing timber production by planting genetically improved trees had been demonstrated by these new hybrids. Test stock planted on national forests and other land was doing well. Although it would take time to check hybrid performance to maturity, commercial demand for planting stock ran high, and the search for new pine hybrid combinations continued. By 1957, past research efforts reduced viable hybrid combinations to 66. Despite this large number, only three crosses—knobcone-Monterey, Coulter-Jeffrey, and Jeffrey-ponderosa—exhibited real potential and were ready for mass testing. Nonetheless, in that year, the Crafts-McKenna GII recommended that IFG reduce the proportion of its research effort devoted to hybrid breeding and turn to more basic research. At the time of the inspection, IFG's research program was about 50 percent hybrid breeding reconnaissance, 45 percent in "facilitating" studies, which included physiologic, taxonomic, cytological, and biochemical research, and five percent in mass production of hybrid seed. In 1961, IFG turned the majority of its forest genetics research efforts toward these fundamental science subjects (Crafts and McKenna 1957; Duffield 1979; USDA FS 1946, 1947, 1948a, 1949a, 1951a, 1956, 1957a, 1959a, 1961).

Actually, the broadening of the station's genetics research program from applied to fundamental research began much earlier, starting perhaps as early as 1952. As stated in an earlier chapter, during the previous 10 years, the station had devoted most of its efforts to developing and testing a well-defined applied breeding procedure. Primarily, the station had crossed different species of pines, tested the promising hybrids, and then conducted selective breeding tests among the hybrids and their progeny. This work continued throughout the decade of the 1950s and early 1960s, while at the same time experience with this simple pattern of applied

research had demonstrated the need for more comprehensive, fundamental studies to make the pine tree improvement program more effective. Consequently, new studies were undertaken that emphasized specific objectives that would contribute to fundamental knowledge. One such fundamental research project was the study of oleoresin chemistry of the genus *Pinus*, which was undertaken by Nicholas T. Mirov. The results of Mirov's biochemical studies of pines in the late 1950s established that the chemical analysis of oleoresin was a means of distinguishing between pine species. This accomplishment won Mirov impressive recognition in the form of large grants from the Rockefeller Foundation. These grants enabled him to complete the overall study (Mirov 1961). Mirov's report discussed the general considerations of composition of 94 species of the genus, and included suggestions for further work (Aitro 1977; Duffield 1979; USDA FS 1952a, 1953, 1954a, 1955a, 1958a).

Parallel with this study, in 1955, Mirov began another important basic research project, a 5-year study of flowering in pines, with a substantial grant from Resources for the Future, Inc. The practical objective of genetics research was to improve pines. But progress toward this objective was conditioned in part by better understanding of the reproductive characteristics of pines. Therefore, the objective of Mirov's investigation was to develop knowledge on how to readily control flower production, a goal of inestimable value in forest genetics research and tree breeding. Understanding the physiology and anatomy of pine flowering was basic to the development of methods for improving seed production and tree breeding. Key physiology questions involved the biology of flowering and reproduction in pines. Key anatomy questions included: When do flowers (conelets and catkins) begin to form in pines, and what are the patterns of growth as the flowers develop? To do the research, the station reorganized and equipped the laboratory in Berkeley for Mirov so that he could study the anatomy, biochemistry, and physiology of flowering. Unfortunately, the station came too late to this field of study, as other research agencies had already begun substantial work on inducement of flowering in pines. Not wishing to duplicate research being done elsewhere, the station decided, in cooperation with the University of California, to concentrate on studies of pine pollen physiology instead. The station picked this research topic because tree breeders were particularly concerned with regular and abundant flower production. The station's basic studies of pollen physiology gradually built up knowledge needed to increase the storage life of pollen, improve seed set, and overcome forms of incompatibility (USDA FS 1955a, 1956, 1957a, 1958a, 1959a, 1960, 1961).

The practical objective of genetics research was to improve pines.

Despite the need to redirect its research on the biology of flowering and reproduction in pines, by 1962 the achievements made at the Placerville facility had made it a focal point for some 500 scientists and students from 65 countries. In recognition of the IFG's achievements, on November 7, Verne L. Harper, Deputy Chief of Research for the Forest Service, gave the IFG's personnel the USDA Distinguished Service Award. The citation read: "For pioneering the science of forest genetics and the production of pine hybrids leading to international recognition as a center for genetic improvement of the pines of the world." Les Harper also paid tribute to James G. Eddy, the Seattle lumberman who initiated the first tree breeding work in America at Placerville in 1925 (Miller 1963).

Forest Products Utilization Research

Forest Utilization Service or FUS originated in the last days of World War II, when the Forest Products Laboratory (FPL) at Madison, Wisconsin, the WO division of wood products, and Assistant Chief of Research Edward Kotok agreed that a two-man FUS unit should be established at each experiment station. Their duties were to act as service agents of the FPL. Congress liked the idea and immediately funded the concept, which was in accord with Earle Clapp's philosophy from the 1920s that all Forest Service research requiring fundamental studies of a laboratory nature be conducted in Madison, leaving for the regional stations the field experimentation of a local or regional nature. Thereafter, FUS units disseminated FPL research findings to forest industries in their respective regions while identifying regional problems of the timber industries and funneling them to the FPL for needed research (Harper 1978).

In California, the high level of activity in the forest products industries after the war, together with increased interest in more intensive utilization, brought numerous inquiries to the station's FUS. In response, the California station FUS worked hard to stretch the timber supply by searching out the wood-using problems of the region, by referring specific problems to the FPL or other agencies for research, and by bringing the results to local industries, wood users, and timber growers. One objective was to improve sawing by using a new saw filing system developed by the FPL called "duo-kerf." This FPL development used less power than methods previously employed. The California station's FUS also taught interested clientele new nailing techniques that reduced wood splitting, and showed them how to better season lumber through dry kiln demonstrations and field construction. Another objective of the station's FUS was to bring heretofore little-used trees into production, and to find new uses for other species. Forest industries looked for these technological improvements so they could make better use of neglected species,

wood residues for fiber plants, and the smaller timber of second-growth forests. For instance, the station's FUS determined and published the properties of the California red fir so that architects and builders might use it more extensively. Similar studies were made for Douglas-fir from the coastal range forests, where, by 1952, extensive cutting had begun. A third objective of the station's FUS was to find uses for logging and milling "leftovers," which were being wasted. Working with the FPL, the station's FUS explored a wide variety of uses for wood fiber. Fiber containers soon replaced the sawed wood box—the previous standard agricultural packaging container for field crops and for citrus. Alcohol could also be made from sawdust and wood chips for industrial use. Other products included fiberboards, pulp from hardwoods, panels from smaller sizes of lumber, and new plastic materials. These were just some of the new utilization methods investigated by the California station's FUS that would eventually bring new industries to the state and increase employment in its forest industries (USDA FS 1952b, 1953, 1954a).

In the meantime, following World War II, there was concern that the timber supply in the United States was diminishing and that too much was wasted during production. In 1952, the Forest Service undertook what it referred to as a "timber resource review" or TRR. The TRR was devised to bring together the best available information on the timber resources of the country and the current and prospective timber requirements as a basis for reevaluating forestry needs and planning a forestry program for the future. Most of the information on forest area, ownership, timber volumes, growth, and drain on resources was obtained from FRS findings at the several forest experiment stations in the country. A preliminary report was issued in 1955,⁴² and the final report in 1958 entitled *Timber Resources for America's Future* (Steen 1998; USDA FS 1953, 1958d).

These reports set forth the national timber situation and outlook in considerable detail. Viewed against the national picture, California's 360 billion board feet of saw timber represented a sizeable resource. The preliminary TRR indicated that the state had 18 percent of the national supply, and that veneer, poles, piling, and other products were being produced at record levels. Even the state's small pulp, paper, and hardboard industries were greatly increasing. For the remainder of the 1950s, the timber industry in California underwent major changes, trending toward consolidation of ownership and showing more and more interest in complete utilization in the woods and in mills.

Viewed against the national picture, California's 360 billion board feet of saw timber represented a sizeable resource.

⁴² Although this 715-page report toned down the gloom over a timber famine, it did indicate that nationwide there was a significant problem in timber supply and demand. However, the TRR assumption that demand could be met did not take into full account timber losses from many variables, such as fire, insects, disease, and weather, which affected the demand-supply equation (Godfrey 2005).

California FUS research paralleled these developments, demonstrating how to make better use of harvested timber, how to get better growth from existing forests, how to utilize species heretofore neglected, and how to put idle land to work. For instance, in 1960, when a national economic recession began to affect the forest products industry, the PSW Research Station responded by emphasizing that although forest research could not prevent recessions, research results could increase production and marketing efficiency and hence mean the difference between profit and loss when the economic situation was critical. In a highly competitive market, where buyers insisted on better manufactured stock, station research in a variety of areas, such as improving the lumber product by better drying methods, or improving the grading of various species, could make a difference with the consumer. To this end, in 1961, the station would create a new forest utilization, marketing, and economics research division (USDA FS 1955a, 1956, 1960).

Forest Economics Research

As noted earlier, the forest economics division was reorganized just after World War II to include the work of the Forest Resource Survey or FRS. The FRS was a part of the nationwide study by the Forest Service to determine the location and extent of the Nation's forest land, the volume and condition of standing timber, the rate of growth, the rate of cutting, and the effect of losses from fire, insects, and disease. When the FRS was assigned to forest economics, the division was busy conducting cooperative work with the California Division of Forestry on various assignments, most importantly vegetation-soil surveys, which used aerial techniques to map the kind and distribution of soils and associated vegetation on some 25 million acres of privately owned range, brush, and timber lands in the state.⁴³ The merging of the FRS into the economics division brought about greater strength, more effective assignment of staff members,⁴⁴ and prevention of duplication. These two separate but closely related inventories of California resources made up the station's postwar forest economics research program from the late 1940s to the early 1960s.

⁴³ In 1947, Herbert A. Jensen, who trained architects, engineers, and landscape designers for the Office of Civil Defense's industrial camouflage program during World War II, developed and presented a classification system designed to take advantage of aerial photography while incorporating ground mapping techniques to segregate and delineate species composition (Aitro 1977).

⁴⁴ Harold L. Baker and Adon Poli conducted the early work on the FRS from 1951 to 1955. However, it was George F. Burks and R.C. Wilson who, in 1939, demonstrated that photogrammetric methods could be used to make accurate vegetation maps (Aitro 1977).

On July 1, 1946, with the reorganization completed, the long-awaited California FRS began with the inventory phase. The procedure for carrying out the first inventory was to map the different kinds of vegetation on aerial photographs, determine the area of each kind, and then measure enough sample plots on the ground to obtain the needed information within specified limits of accuracy. By the end of 1952, the fieldwork on the first inventory phase of the state's 42.5 million acres of commercial and noncommercial forest land neared completion. A year later, the FRS staff began to compile and analyze the data and publish results. One popular pamphlet from this project, *A Century of Lumber Production in California and Nevada* (May 1953a), provided the public with detailed information on the development of this very important industry. Of particular interest was the rapid expansion of production that occurred just after World War II. Lumber production in California had doubled, reaching a total of nearly 5 billion board feet by 1951 (USDA FS 1946, 1949a, 1951a, 1952a, 1953, 1954). Thereafter, FRS staff began to assemble statewide statistics, and in particular for the national *Timber Resource Review*. The vegetation-soil surveys on forest, watershed, and rangelands of California, conducted in cooperation with the state of California, aided this national forest work (USDA FS 1953). In 1951, fieldwork on the vegetation-soil survey, which the station had been conducting since 1947, was brought to a halt in mid-year by the decision of the state legislature to postpone any further mapping. Two years later, it was reactivated by the state legislature under a cooperative agreement between the station, the California Department of Natural Resources, and the University of California, with the station responsible for the general coordination of the project along with the mapping program. The soil-vegetation data were particularly useful to Region 5 in assisting national forest managers in various projects, including converting brushland to other types of vegetation, road construction projects, and watershed and range management. As the survey continued and new area maps became available, people found more uses for this soil-vegetation information. Furthermore, pressure built up in California for more intensive use and management of western wildlands, and interest in soil-vegetation surveys grew as knowledge of soils and vegetation distribution, characteristics, and relationships helped guide land management for production of timber, forage, and water (USDA FS 1952, 1953, 1954a, 1956, 1957a, 1958a).

Meanwhile, in 1955, the station published and distributed *Forest Statistics for California* (USDA FS 1955c), the first FRS report for California. *Forest Statistics for California* greatly stimulated interest in California's timber resources. Because forest inventories soon become dated as a result of timber cutting, fire, insect and disease losses, land clearing, and timber growth, the station, in collaboration with

Interest in soil-vegetation surveys grew as knowledge of soils and vegetation distribution, characteristics, and relationships helped guide land management for production of timber, forage, and water.

Region 5, planned a timber “reinVENTORY” for the state beginning in 1957, before the ink was dry on *Forest Statistics for California*.⁴⁵ The second California FRS called for the full use of aerial photo techniques to estimate forest land areas by kind of land use, forest type, and size of timber. This was thought to be a more economical survey approach because it reduced the number of field plots that needed to be measured. But in 1960, because of a national economic recession, the second FRS was integrated with Region 5’s timber management inventories as a cost-saving measure. Several additional cost-saving changes soon followed. The next year, the economics division was combined with the station’s FUS into a new division named “forest utilization, marketing, and economics research.” Meanwhile, to increase efficiency in Forest Service tabulating and recordkeeping, the station acquired “modern tabulating equipment,” becoming the only station in the West to fully utilize this new data processing equipment. Before long, the use of computer punch cards reduced time and costs over hand tabulating data on area, volume, growth, and other types of FRS information. With the increasing size and complexity of the Forest Service forestry program nationwide, more and more of the recordkeeping, fiscal control, and tabulating work was handled by these “modern” business machines (USDA FS 1955a, 1956, 1957a, 1959a, 1960, 1961).

Range Management Research

In the postwar years, demands for range forage in California rose along with the pressure for more timber from the state’s wildlands. In fact, by 1955, California had 3.6 million cattle and calves, the most for the past quarter century, and 77 percent more than in 1930. This high inventory put the state in ninth place nationally, but first among the 11 Western States. The effect of these trends on California’s rangeland was to increase the livestock grazing load considerably—an increase of significance considering the gradual reduction of rangeland because of other uses, the encroachment of brush on some areas, and the increasing numbers of game animals within the state (USDA FS 1955a).

Working with Region 5, CFRES realized that range research should focus on developing information on how the state’s 37 million acres of range could be intensively managed for the livestock industry and the general public’s benefit. Therefore, the station’s range research program was subdivided into four main lines of study: mountain range management in northeastern California, foothill range management in the San Joaquin basin, range fertilization, and brushland management. From after the war to the early 1960s, CFRES made rapid advancements in range

⁴⁵ A policy was later established that mandated that this process be repeated every 10 years.

research in each of these areas. After the retirement of veteran range management specialist Murrell Talbot in 1955, station range management research was strengthened by additions of new staff and by organizational changes. For instance, in 1956, the station added a range conservationist position to the SJER. Furthermore, in that year, the establishment of the Susanville Research Center improved opportunities for more effective range research by bringing technical workers closer to field problems (Talbot 1954; USDA FS 1952b, 1956).

At first, mountain-land range management was studied mainly at the BSER on the Lassen National Forest. The BSER was typical of the summer cattle ranges in the region, with perennial-plant vegetation, but after World War II, grazing capacity in the area had dropped to about half of what the land was capable of sustaining. In 1950, A.L. Hormay completed his “rest-rotation grazing” system at BSER, which involved periodic resting of the range from grazing, showing the way to arrest range deterioration and make the land fully productive once again (Talbot 1954, USDA FS 1952b). A year later, Hormay’s rest-rotation grazing system was tested and demonstrated on the Harvey Valley Experimental Range (HVER), a 32,000-acre national forest range allotment set aside on the Lassen National Forest for this purpose. The Harvey Valley system project, begun in 1952, was to be a 15-year study of the growth requirements of bunchgrass plants and the grazing habits of cattle. Its effectiveness was measured in terms of herbage production and weight gains of cattle. The test also included studies of artificial seeding of range grasses and sagebrush control by chemical sprays. Throughout the remainder of the 1950s and early 1960s, the station carried out this research at HVER in cooperation with the Lassen National Forest and the Agricultural Research Service. In part, HVER research answered local opposition to Region 5’s livestock reduction program in northern California⁴⁶ (USDA FS 1954b, 1959b).

Foothill-range management took place at the SJER in Madera County in cooperation with the University of California. It was less controversial than the research to the north. By 1948, CFRES completed research that showed how local cattlemen could use the natural annual-plant range vegetation efficiently while maintaining both good livestock production and satisfactory range conditions. The next logical phase of SJER work aimed to improve forage production through certain cultural practices, such as using commercial fertilizers to build up foothill range production (USDA FS 1952b). J.R. Bentley pioneered much of the investigations in this research area, including the stimulation of indigenous clovers through application

⁴⁶ Following World War II, Region 5 tried to establish an intensive range management program to reduce numbers of livestock in this California region, an approach that caused a range war to flare up on the Modoc National Forest (Godfrey 2005).

Even when several years of drought hit this region in the late 1950s and early 1960s, the advantages of fertilization with sulfur or sulfur-plus-nitrogen were clearly evident at SJER.

of sulfur-bearing fertilizers. Bentley found that the application of sulfur improved the annual plant forage on sandy loam soils of granite origin in the Sierra Nevada foothills. In conjunction with this work, the station, in cooperation with the University of California, the Soil Conservation Service (SCS), and ranchers, made rapid advances in field testing a whole complex of other fertilizers. These tests demonstrated the practicability of commercial fertilizer use and reversed pre-World War II opinion that range fertilization by and large was too costly to be practical (Talbot 1954). By 1957, range fertilization paid off with multiple benefits. Thanks to the tests that ran several years at SJER, livestock ranchers in the Sierra Nevada foothills produced more grass, more grazing, and more meat at less cost through sulfur and other types of rangeland fertilization (USDA FS 1957a). Even when several years of drought hit this region in the late 1950s and early 1960s, the advantages of fertilization with sulfur or sulfur-plus-nitrogen were clearly evident at SJER. Fertilized vegetation started growth earlier on foothill ranges than on other areas, and green-season grazing began more than three weeks earlier. This earlier growth was of prime importance in the management of foothill ranges for two reasons: it enabled the rancher to discontinue use of expensive range supplements, and it gave cattle a good start on weight gain after the costly wintering period (USDA FS 1961).

In addition to addressing the fertilizer question, the CFRES range division tackled California's difficult brushland management problem, which was a veritable contradiction, with too many shrubs in some areas, and too few in others. Brushland-improvement studies started in 1949. Working closely with Region 5, California's Division of Forestry, and University of California, CFRES's range division seriously took on the problem of getting rid of undesirable shrubs and trees. Brush conversion of selected areas to grassland was sought for three reasons: more grazing for livestock, better habitat for game, and more firebreaks for firefighters. It involved brush removal on selected areas, reseeding of cleared brushlands, and control of sprouts. Although this cooperative research effort gathered data that would guide future expenditures, in the postwar years, it failed to answer a number of vexing questions, such as the high cost of controlling reinvasions of brush sprouts as well as several hydrologic and economic aspects of brush conversion and management. The CFRES was more successful in meeting the challenge of too few shrubs, or the restoration of browse by artificial methods on critical winter ranges to feed deer, antelope, cattle, and sheep. A.L. Hormay and other station staff worked on this cooperative project with California's Department of Fish and Game, paying the greatest attention to ranges in northeastern California where bitterbrush and other palatable shrubs had been reduced or eliminated, and where natural regeneration was unlikely for several decades. Most of the work took place at the Flukey

Spring, Doyle, and Buttermilk game-browse areas, which were representative of northeastern California's winter cattle ranges. Besides browse restoration, the station investigated new reseeding and weed control techniques in both the mountain and foothill areas. This work fell to Donald R. Cornelius and Charles A. Graham, whose research established that successful reseeding could increase the forage yield and lengthen the grazing season. In the area of weed and brush control, throughout the 1950s, the station tested selective herbicides, such as 2,4-D and 2,4,5-T,⁴⁷ which were used to improve California forest ranges. Cornelius, Graham, and Gilbert H. Schubert published the station experimental trial data, and Alva G. Neuns, H.R. Offord, and Timothy R. Plumb described the technical application of particular herbicides for killing brush (Aitro 1977; Talbot 1954; USDA FS 1952b, 1955a, 1957a, 1958b, 1959a).

By the early 1960s, the station's range division neared completion of many of SJER and HVER range production projects. At SJER, the station's research program continued to study the effects of range fertilization on herbage production and livestock gains. The station also continued necessary research on range improvement by removal of brush and tree species, and on rotation and nonrotation grazing by seasons on both natural and fertilized annual type ranges. At HVER, Hormay's rest-rotation range management was 10 years into the 15-year full-scale practical testing (USDA FS 1958b, 1959, 1961). But by 1962, the CFRES range division seemed ready to embark upon a new program of research management research designed to improve the use and management of foothill ranges regardless of ownership and location. New research involved three lines of management research—native, fertilized, and converted ranges—plus supporting and cooperative studies. The station expected to produce basic information on the effect of grazing systems on range vegetation and cattle. Such information was needed for the development of grazing management practices that would sustain high-level production without affecting other land uses (USDA FS 1960b).

New research involved three lines of management research—native, fertilized, and converted ranges—plus supporting and cooperative studies.

⁴⁷ The herbicide 4,5-trichlorophenoxyacetic acid, more commonly known as 2,4,5-T, is a widely used herbicide. For example, it is often used as a weed killer for home lawns. It is considered to be less readily biodegradable than the analogous herbicide 2,4-D. The herbicide 2,4-D was developed by a British team during World War II and first saw widespread production and use in the late 1940s. It was easy and inexpensive to manufacture, and killed many broadleaf plants while leaving grasses largely unaffected (although high doses of 2,4-D at crucial growth periods can harm grass crops such as maize or cereals). On the other hand, when these two agents are blended with picloram, they become Agent Orange, a herbicide blend used by the United States military in Vietnam between January 1965 and April 1970 as a defoliant.

Forest and Range Influences and Watershed Management Research

Watershed management research at the end of World War II was called forest and range influences. Headed by Charles J. Kraebel, the division had a staff of five researchers who concentrated their work on continuing analysis of accumulated data from SDEF and the Teakettle Creek and Big Creek installations in the Kings River area. When the Glendora Civilian Public Service camp was closed after the war, the station suspended about 80 percent of SDEF fieldwork. Under the curtailed program, fieldwork was limited to the collection of data from two intermediate SDEF watersheds in the Big Dalton and San Dimas drainages, the large lysimeters, and the master climatic station at Tanbark Flat. Fortunately, in 1948, financial aid from the California Division of Forestry permitted technical staff to devote themselves full time to the analysis of data and the preparation of manuscripts for publication. In the meantime, while trying to maintain the continuity of hydrologic records at SDEF, the station resumed flood-control surveys throughout California, which they had started after the disastrous 1938 floods. At that time, a flood control survey division was created and CFRES researchers were detailed to conduct inter-agency flood control surveys authorized by the 1936 Omnibus Flood Control Act in cooperation with the SCS. At war's end, the flood control survey division had a staff of 10 researchers under David Ilch, who directed the program, and they made immediate progress in completing the backlog of unfinished surveys throughout the state, and conducted new surveys. The station also briefly undertook an unscheduled project involving a general review of the water resources, developments, and plans for the Sacramento River Basin. Part of this project included working with the Central Sierra Snow Laboratory, maintained at that time under a cooperative agreement between the United States Weather Bureau and the United States Army Corps of Engineers (USDA FS 1946, 1947, 1948a).

In 1949, E.A. Colman replaced Kraebel⁴⁸ as head of the forest and range influences division. From the beginning, Colman's task was to broaden the division's research objectives and scope. The new focus of research thereafter became improving water yield, which for a short time also included improving watersheds for

⁴⁸ Charles Kraebel, the station's long-time watershed management expert, stayed on at the station but took a position that allowed him to work more closely with the national administration and foreign governments that required the services of a specialist in watershed management (USDA FS 1949a).

flood control through the services of the flood control survey division.⁴⁹ Several years of drought served as a reminder that California's timber and rangelands must also be managed for yields of water. After 1951, the station's concern became studying how wildland watersheds could be managed to generate clear, usable water with a minimum of flood runoff and soil erosion. Understanding how a watershed functioned was seen as basis for this kind of management. By this date, SDEF lysimeter records indicated basic differences in the amount of water used by several plant species. These data contributed to CFRES efforts to determine the best ground cover for eroding slopes in headwater areas of the Los Angeles River watershed. Methods of restoring plant cover and stabilizing the soil in watersheds damaged by past abuse were also under investigation by the station in other parts of California, such as the mountain meadows in the Sierra Nevada and the north coast range (USDA FS 1949a, 1951a).

Ostensibly, water yield studies were supposed to be conducted statewide, but in reality, CFRES continued to concentrate its watershed management research program on southern California. In the early to mid-1950s, water yield and erosion studies were extended into new stages, and ways were steadily found to improve rainfall measurements. Evaporation studies using SDEF's batteries of lysimeters were extended to study grass, brush, and pines, and the growth of various other plants for cover improvement and soil stabilization. Meanwhile, limited research was conducted on wildfire and the effects it had on streamflow, as well as erosion and watershed damages caused by logging (USDA FS 1952a, 1953, 1954a, 1955a, 1956).

But water supplies for industrial, agricultural, and domestic use continued to be of concern for all of California as plans were being completed in 1953 for the state's most ambitious water transport project, the California Water Plan (CWP) (USDA FS 1953). The CWP envisioned 376 new reservoirs and a vast network of aqueducts throughout the state to bring water from the northern half of the state to where it was most needed—southern California's farms and municipalities. As part of the project, the Sacramento Municipal Utility District (SMUD) was created in 1957 to fund and operate this water and power development (Godfrey 2005). With this and other statewide watershed developments, it became ever more important for the

Water supplies for industrial, agricultural, and domestic use continued to be of concern for all of California.

⁴⁹ In August 1952, flood control survey work by the station was largely discontinued, along with survey work in Oregon that had been conducted in cooperation with the Pacific Northwest Forest and Range Experiment Station. All station flood control survey records were then transferred to the Pacific Northwest Station. One staff member of this division remained at the California station to carry on the necessary work of reviewing reports for California watersheds. This action was part of a larger general reorganization within the Department of Agriculture (USDA FS 1952a).

A 1954 station study of California's major water-yield areas indicated that California's snowpack zone provided 51 percent of the state's streamflow, and the alpine zone, mostly primitive areas withdrawn for recreation, generated 38 percent of the state's water.

Californians could not overlook their ever-present water-supply problems.

Forest Service to study the winter snowpack of the Sierra Nevada, the Cascades, and the Northern Coast Range, which supplied 71 million acre-feet annually, the greatest part of each year's waterflow in California streams. Although the brush-woodland-grass belt and the forest belt below the snowpack line contributed significant acre-feet of water, a 1954 station study of California's major water-yield areas indicated that California's snowpack zone (above 3,500 to 5,000 feet depending on geography) provided 51 percent of the state's streamflow, and the alpine zone, mostly primitive areas withdrawn for recreation, generated 38 percent of the state's water. This Forest Service streamflow study also showed the extent to which California's expanding economy depended on forest land for its water. As important as the flood-control problems were, Californians could not overlook their ever-present water-supply problems. This realization alone probably persuaded CFRES to change the division of forest influences' name to the watershed management division that year (USDA FS 1953, 1954a, 1955a).

In 1955, under Operation WET BLANKET,⁵⁰ the California station acted upon this knowledge in two distinct ways. First, the long-idle Teakettle Creek Experimental Station, currently called the Teakettle Snow Laboratory, was reopened to study water production and control. More importantly, the station earnestly began snowpack research at the recently acquired Central Sierra Snow Laboratory or CSSL,⁵¹ (USDA FS 1955a). Following the transfer, Station Director Jemison started a major cooperative study in snowpack management, matching federal funds with California Department of Water Resources money and relying on field cooperation from other agencies. The CWP, which had been presented to the people in 1956 and discussed widely that year, clearly underlined the need for

⁵⁰ In February 1955, E.A. Colman proposed Operation WET BLANKET. It sought to investigate all methods for controlling snow accumulation and melt and evaporative losses under various topographic and forest conditions, followed by pilot testing of promising methods on calibrated watersheds (Colman 1955).

⁵¹ In 1945, facing an expanding population at the end of World War II, with consequent increasing demand for hydroelectric power and irrigation water, the federal government initiated the Cooperative Snow Investigations research program with the general aim of solving hydrologic problems pertinent to mountain regions of the Western United States. Three outdoor laboratories were established, one being the Central Sierra Snow Laboratory. Following the disbanding of the snow investigations program, the Forest Service assumed sponsorship of CSSL (USDA FS 1986b). The CSSL included a 2,540-acre field headquarters at Castle Creek equipped for basic studies of meteorology, snow physics, and streamflow, and the 3,050-acre Onion Creek drainage nearby including four experimental watersheds equipped with stream-gauging stations and sediment traps. Tests conducted on these drainages were similar to the ones at Teakettle Creek and elsewhere, and were designed to make recommendations for management methods to increase water yield from the Sierra Nevada snowpack. Office-laboratory and staff residences were located at Castle Creek (USDA FS1958b).

this study. To accommodate the CWP need, a new section in the division of watershed management research was created at CFRES. Seven technical workers were assigned to it and the study of snowpack data, which included studying the relations between forest vegetation and water quality, yield, and runoff timing from the snow-covered watersheds. Accordingly, the California station refurbished and expanded CSSL, (fig. 76) and mapped nearby American River watersheds, as well as four major watersheds along the Sacramento and San Joaquin Rivers. While studying forest snow behavior, they also began collecting streamflow measurements. At the Teakettle Snow Laboratory in the Kings River basin, station staff also measured water yield in its watersheds. By the end of 1957, snow zone research was in full swing with 15 studies measuring snow accumulation and snowmelt underway in California. One interesting 1959 study conducted jointly with the Swain Mountain Experimental Forest indicated that the way forests were harvested influenced the amount and the timing of water yield. This study obviously suggested to timber managers seeking more water that they should plan their forest cutting patterns to reach this objective (Anderson 1958; USDA FS 1956, 1957a, 1958a, 1959a). Henry W. Anderson was the prime researcher in snow management research at CFRES in the late 1950s and early 1960s, contributing many articles and publications on the subject. Lucille G. Richards, along with Raymond M. Rice and Allan J. West, made some contributions as well. By 1962, the station's snow zone research entered its 6th year of research, and had clearly made significant progress in answering critical questions on how the snow zone should be managed to improve water yield. This set the stage for accomplishments several years later (Aitro 1977; USDA FS 1959a, 1961, 1986b).

In the meantime, the CFRES watershed management division continued to seek greater water yields for southern California through intensive studies at SDEF. In spite of all the plans for importing water to southern California, 70 percent of the water used there still came from local watersheds. Since the SDEF was established in 1933, it had discovered many of the fundamentals of how these watersheds worked. The SDEF regional research had shown how to measure mountain rainfall accurately, that chaparral plants differed in rates of water use, and that soil depths and different kinds of cover influenced surface runoff and soil moisture. By the late 1950s, the station could precisely estimate rainfall moisture losses, streamflow, and groundwater yields on entire southern California watersheds, thanks in part to the recent development of the nuclear soil moisture probe that sharpened station water-yield evaluations. However, since nearly half of the rainfall in southern California's mountains was lost through evaporation and transpiration, station researchers turned to investigating chaparral defoliation to save water—otherwise known as

The way forests were harvested influenced the amount and the timing of water yield.



U.S. Forest Service, Pacific Southwest Research Station

Figure 76—Central Sierra Snow Laboratory, 1977.

brushland watershed management. In cooperation with California Division of Forestry and the Los Angeles County Fire Department, the station began using brush-killing chemicals to remove “water-wasting riparian vegetation” from parts of the Big Dalton and San Dimas drainages. From this pilot project, the station learned that water yield could be increased by intensive brushland watershed management, and with strong backing from Station Director Arnold, additional research

was encouraged (Crafts and McKernan 1957; Sinclair et al. 1958; USDA FS 1957a, 1958a, 1959a).

Then, at 12:30 p.m. on July 20, 1960, lightning struck the San Dimas Experimental Forest. The Johnstone Fire, as it became known, burned out of control for the next few days. Firefighting crews were able to save all but one of the buildings at Tanbark Flats. By the time the last ember burned out, 15,000 acres of the experimental forest lay in blackened ruin. The Johnstone Fire was a major scientific disaster, but within 48 hours after the fire was extinguished, station staff began to turn this setback to their advantage by converting this disaster into a far-reaching emergency research program. With the slate wiped clean, SDEF shifted its research program to relate prefire records and findings to the new situation. As a result, for the next few years, SDEF staff addressed postfire restoration measures, and moved to establish a strong research program aimed at developing practical methods of rehabilitation, erosion control, conflagration control, and water yield improvement at the facility. With the help of the California Division of Forestry and the Department of Water Resources and the Los Angeles County Fire Department and Flood Control District, SDEF became a pilot model for integrated land management in southern California. Contour basin terraces, concrete stream-channel checks, barley “wattles” on close contours, annual grasses, and perennial grasses were established separately and in combination on 25 small watersheds. Soon, SDEF was ready to begin experiments that compared its prefire data and postfire circumstances to learn about rehabilitation and natural recovery of mountain slopes denuded by fire (Robinson 1980; USDA FS 1960a, 1961).

Forest Fire Research

The Johnstone Fire certainly indicated that fire prevention remained a critical subject to southern Californians. Even so, during World War II, fire research at the station nearly came to a halt. Following the war, budgets were small, and the forest fire research division headed by Charles C. Buck included only four other researchers. Despite limited budgets and personnel, the division was tasked with the enormous responsibility of developing research findings to reduce forest fire damages and fire control costs in all of California. To meet this difficult task, in the late 1940s and early 1950s, the division’s research program was divided into three principal fields. The first was the study of fire behavior—the way fires start and spread. Research work included laboratory experiments in the physics and chemistry of wood combustion, field testing with small fires in different natural fuels and burning conditions, and field observation of large forest fires. Knowledge gained eventually led to the development of a fire-danger rating system for the California

The station tested wetting agents and other chemicals as improvements over water.

region. The second field of research—which was really an extension of the first—was fire control. Fire control research included finding ways to apply fire-behavior knowledge to prevent or control fires. The station studied the organization of large firefighting forces to find more effective methods of using resources when burning conditions were extreme. The station also experimented with chemical treatments to clear firebreaks and to reduce roadside fire hazards. The station tested wetting agents and other chemicals as improvements over water. Finally, the third subject of study pertained to the benefits and damages that result from fire, appraising damages following a fire, such as the possibility of erosion in critical watersheds⁵² (USDA FS 1946, 1952).

In the meantime, in the early 1950s, concern for America's ability to withstand a nuclear war was growing.⁵³ A publicized series of atomic weapons tests at the Nevada proving grounds vividly demonstrated the awesome power and incendiary capabilities of the weapon, and testing of the hydrogen bomb in the Pacific proved to have power many times that of the devices tested in Nevada.⁵⁴ Then in 1953, a series of bad fires in California convinced key individuals at the station, the California Division of Forestry, and the Los Angeles County Fire Department⁵⁵ that the time was ripe for a dramatic gesture to demonstrate that scientific research had the potential to advance fire defense against nuclear attack. They agreed that a program

⁵² In 1949, even with tight budgets, one major accomplishment in the field was the completion of a joint project between fire and watershed research groups that produced fire damage appraisal guides. They displayed the damage expected from fires of various sizes on most of the southern California watersheds, and were relied upon heavily and used often (Wilson and Davis 1988).

⁵³ Interestingly, station staff, such as A. Broido and A.W. McMasters, in the early 1960s investigated and studied the effects of mass fires following nuclear attack on personnel in shelters, concluding that thermal and fire effects of thermonuclear detonations may, under the right circumstances, produce more casualties than any other effect of such detonations (Aitro 1977).

⁵⁴ In response, many national and California fire associations voiced their concern about the incendiary potential of nuclear weapons, with one document stating: "Fire loosed by enemy action on critical cities and wildlands is the greatest threat to defense of the United States in modern war. Mass fire as a weapon was proven in World War II.... Fire services are not organized nor equipped to cope with enemy-set firestorms, although still charged with responsibility" (Chandler 1982: 2).

⁵⁵ These fires included the Rattlesnake Fire on the Mendocino National Forest, which killed 15 firefighters, and the Mount Baldy and Los Angeles County fires near Los Angeles, which burned 24,000 acres in full view of the national television audience watching the Rose Parade and Rose Bowl football game. Keith Arnold, along with Keith Klinger, Chief of the Los Angeles Fire Department, and Jim Mace, Deputy State Forester in charge of fire control for the California Division of Forestry, were the driving force behind Operation FIRESTOP. Arnold had just returned to the University of California after 3 years directing the Forest Service nuclear effects studies (Chandler 1982).

of basic and applied studies, both with high visibility and high potential for immediate payoff, should be initiated (Chandler 1982b). Thus, on July 1, 1954, a cooperative 1-year experiment dubbed Operation FIRESTOP was begun. FIRESTOP was a giant task force involving 11 federal, state, and local fire control agencies, fire researchers, federal civil defense officials, and a number of private companies.⁵⁶ Its central idea was to explore the application of new technology to fire control problems, and to expand the boundaries of fire behavior study. FIRESTOP took place on the Camp Pendleton Marine Corps Base in San Diego County. The project concentrated on fire retardants, fuel studies, seasonal chaparral moisture, aerial firefighting (both fixed-wing aircraft and helicopters), light-weight pipe for extended hose lays, wind machines for fire suppression, and backfiring chemicals. FIRESTOP became the launching pad for “innovative and revolutionary cooperative research in California.” Generally, it demonstrated that a task force effort in fire research paid huge dividends. It specifically showed that liquid fire retardants could be effective in stopping wildland fires, as well as demonstrating the potential of helicopters in firefighting, from transporting personnel to serving as small air tankers. FIRESTOP’s findings became the basis for many important future research efforts including HELITACK,⁵⁷ and the Air Attack program and the use of chemical fire retardants.⁵⁸ In its final phase, a 25-minute documentary motion picture, showing the cooperative contributions of industries and federal, state, and county agencies, as well as the publication of 12 technical reports, stimulated and encouraged interest in expanding fire research budgets in California through both federal appropriations and cooperative funds (Chandler 1982; USDA FS 1954a, 1955a;

**FIRESTOP
demonstrated that a
task force effort in fire
research paid huge
dividends.**

⁵⁶ To make fire research staff Clive M. Countryman and Charles C. Buck available for the project, it was necessary to suspend or severely curtail activity in other fire studies (Chandler 1982, Wilson and Davis 1988). Important researchers in fire management, fire prevention, fire behavior, fire meteorology, and fire chemistry at the station in the postwar period until 1962 included Craig C. Chandler, Wallace L. Fons, James L. Murphy, Arthur R. Pirsko, Mark J. Schroeder, and Carl C. Wilson (Aitro 1977).

⁵⁷ HELITACK was a research and equipment development program aimed at making a fire tool of the helicopter, much like the pumper and bulldozer. Region 5 and California State Division of Forestry cooperated with the station on HELITACK, which was born in 1956. Prior to that date, the helicopter had been used by the Forest Service, but HELITACK goals were to develop and test firefighting accessories for the helicopter, such as the helitanter, a 25-gallon pressurized tank from which water or chemicals could be expelled; a bulk-drop tank, a device to drop water or chemicals directly on a fire; and a hose-lay tray, a means to lay fire hose on the ground from a helicopter in flight (Wilson 1956, 1957).

⁵⁸ The Air Attack program, which involved the use of air tankers (converted PBVs, TBMs, F7Fs, B-25s), and other aircraft, such as spray planes and helicopters, was a joint effort of most fire services in California, with an executive committee that guided all policies and programs of research and firefighting equipment development in California and involved the cooperative efforts of the agricultural aircraft industry, its pilots, its planes, and its research centers (Wilson 1957, 1958).

Wilson and Davis 1988). FIRESTOP was the forest fire research community's first venture into "big science," and it did for fire research what, in a larger and more sustained fashion, Smokey Bear did for fire prevention (Chandler 1982).

In the years following FIRESTOP, the appropriations for fire research rose around 30 percent each year, and thereafter even the National Science Foundation, created in 1950, became involved in fire science. With increased federal and state funds, the station evaluated older projects, such as fire-danger rating systems, and FIRESTOP-related projects such as forest fire retardants and tactical air support on forest fires. In 1957, the station also began a new project, Operation FUELBREAK, on the San Dimas Experimental Forest. As wildfires have no respect for property lines, the project was organized as a cooperative program with the California Division of Forestry and the Los Angeles County Fire Department, much like Operation FIRESTOP had been. Because only a few large fires caused most of the damage to southern California watersheds, Operation FUELBREAK sought ways to ease the firefighter's task by treating vegetation on wide strips or blocks so as to establish plants of low fuel volume and reduce flammability (USDA FS 1957a, 1958a, 1959a). However, the lightning-caused Johnstone Fire that burned the majority of the SDEF forced the station to reorient its FUELBREAK project. The project's staff joined watershed researchers in the effort to turn the disastrous fire to their advantage by developing a research program that pointed more specifically toward watershed management practices aimed at reducing fire and flood losses. The SDEF, as a model for integrated land management, continued its long-range approach to prevention and control of major conflagrations⁵⁹ by developing and testing chemical control of brush after fires or other land-clearing activities, and by searching for fire-resistant plants and for watershed cover that would produce lower fuel volumes at maturity than typical chaparral (USDA FS 1960a, 1961).

The 1960 San Dimas Fire hurt the station's fire research program, already hampered by inadequate fire research laboratory facilities. Besides the limited combustion and fire retardant work conducted at Berkeley, the station had some field studies at the Pilgrim Creek and the Richmond Fire Laboratories. These laboratories were a long way from Berkeley, and maintenance costs of the Pilgrim Creek Laboratory facilities on the Shasta National Forest were using up the station's limited fire research budget. A central laboratory designed specifically for fire research was obviously needed. This need was apparent as early as 1956, when the

⁵⁹ In 1961, the station laid out 74 miles of new fuelbreaks at San Dimas to break brushfields into small units to help keep future fires small (Aitro 1977).

Inaja Fire on the Cleveland National Forest in San Diego County killed 11 firefighters. A groundswell of support for a central fire laboratory materialized after the Inaja Fire, especially after Congressman Clair Engle (D-California) conducted a congressional hearing after the Inaja Fire disaster that resulted in the document entitled *Forest Fire Control in Southern California* (U.S. Congress 1958). It emphasized the complexity of fire control in southern California and provided official justification for increases in fire research funds for the next decade, including the need for a new fire and watershed research center in southern California. Thereafter, the Forest Service and the state of California Wildland Research Planning Committee called for a major fire research facility for that part of the state and an additional annual expenditure of \$500,000 by the federal government. However, 4 years would pass before a bill made its way through Congress authorizing \$900,000 for a “Regional Forest Fire Research Laboratory at Riverside, California.” With money in hand, the Riverside Fire Laboratory (RFL) was built during 1962–1963 to the specifications developed by the station’s fire research staff, and officially dedicated on September 11, 1963. The three-building complex—administrative, technical, and laboratory—finally fulfilled the vision of early California fire control and fire research pioneers and proponents, such as the then-recently deceased S.B. Show. The Riverside facility included an instrument shop, electronics laboratory, staging area, forest meteorology facility, humidity chambers, forest fuels laboratory, communications room, fire behavior training laboratories, fallout shelter, mobile meteorological laboratory, chemistry laboratory, and fire environment chamber. The station was now equipped to meet the needs of southern California clients, but was also encouraged to work closely on national programs as well (Chandler 1982, Godfrey 2005, Wilson and Davis 1988b).

Forest Insect Research

By the time Stephen Wyckoff became director of CFRES in 1945, all periodic cooperative insect control investigations by the station and the Bureau of Entomology and Plant Quarantine had been unofficially dropped, and forest insect research was not pursued vigorously again by the station until at least 1955. Meanwhile, forest insect damage was on the rise in California, a situation that stimulated the formation of the California Forest Pest Control Council (CFPCC) to fight the endemic and epidemic states of insect activity, losses from insects, and determine costs and methods of protection in the state. The CFPCC reviewed pest problems and control programs in the state, and soon thereafter, CFRES began cooperating with this group. Together, they prepared a report on California forest insect conditions, tested

helicopters for bark beetle surveys, and studied the use of residual-type sprays⁶⁰ that offered the most promising solution to killing bark beetles in infested trees and logs. By this time, research on these spray types for bark-beetle control had been in progress for 3 years and was directed toward exploring the toxicity of four insecticides—DDT, toxaphene, lindane,⁶¹ and isodrin—under varying conditions (fig. 77). At the same time, the station continued to explore the California Pine-Risk System begun at BMEF prior to World War II, which tested the ability of pines to resist attack by insects (Aitro 1977; USDA FS 1954a, 1955a).

Meanwhile, in 1956, Station Director Jemison completed arrangements and staffing for a new division of forest insect research,⁶² which changed such research in California tremendously. During the research period following 1956, station scientists laboratory-tested and provided technical guidance for the use of residual-type sprays for Region 5 and the California State Division of Forestry and helped them conduct the first successful large-scale aerial operations⁶³ against a forest insect, in this case the tussock moth.⁶⁴ Field tests of residual sprays helped station entomologists better understand the application and dosage toxicity requirements of these sprays. At this time, the station also studied other insects that damaged particular species, such as the lodgepole needle-miner,⁶⁵ which was responsible for

⁶⁰ Residual-type sprays are insecticides that form a lasting toxic deposit on the surface to which they are applied. Their ability to remain toxic to insects over a period is called residual life. An insect alighting upon or walking over a spray deposit during its residual life will pick up a lethal dose. When an insecticide with a long residual life is sprayed on the bark of an infested tree, it will kill beetles coming out. Sprayed on a healthy tree, it will kill insects attempting to attack through the bark (USDA FS 1955a).

⁶¹ In the United States, the Environmental Protection Agency recently banned all agricultural uses of lindane, but the Food and Drug Administration still allows lindane to be used in pharmaceutical products for the treatment of head lice and scabies. California has banned all uses of lindane, and it is no longer manufactured in the United States. Its use is also restricted or banned in most of Europe and many developing countries.

⁶² The prominent published entomologist at the station at this time was still J.M. Miller, but rising scientists included V.A. Clements, Charles B. Eaton, Ralph C. Hall, F. Paul Keen, Richard H. Smith, Robert E. Stevens, George R. Struble, and Boyd E. Wickman. Notably during this period of the station's history, Keen co-authored with Miller *Biology and Control of the Western Pine Beetle* (Miller and Keen 1960), a classic volume that reviewed the results of 50 years of research involving every phase of the bark beetle problem (Aitro 1977). For an oral history on Ralph C. Hall and F. Paul Keen, see Keen and Hall 1977.

⁶³ The motivation for the tussock moth control campaign was an infestation that had broken out in Tuolumne County, which damaged firs over a considerable area. At this time, crews sprayed DDT in oil solution from a converted B-18 bomber.

⁶⁴ The Douglas-fir tussock moth is an insect that causes damage by devouring the foliage of its hosts, white fir and Douglas-fir. Trees completely stripped of their needles by the caterpillars die; those partly defoliated suffer growth losses and may succumb to later attacks by bark beetles (USDA FS 1957a).

⁶⁵ The lodgepole needle-miner is a native pest of California's high mountain forests. Its caterpillars feed within and destroy lodgepole pine foliage. Some trees die from defoliation alone, others from attacks of the mountain pine beetle, which breeds in the weakened trees.



U.S. Forest Service, Pacific Southwest Research Station

Figure 77—Young scientist in field with specimen bag, 1980.

killing numerous lodgepole pines in Yosemite and Sequoia-Kings Canyon National Parks. To control the needle-miner, station scientists worked closely with National Park Service (NPS) and University of California entomologists. Together, they studied the needle-miner's biology and pathology at the Park Service's Tuolumne Meadows Forest Insect laboratory, and experimented with helicopter spraying of malathion⁶⁶ (USDA FS 1956a, 1957a, 1958a). For other regions of California, the station's Hat Creek, Miami, and Orleans Forest Insect laboratories served as key research facilities. The Hat Creek Laboratory on the Lassen National Forest investigated the biology, behavior, and control of insects that attacked "east-side" forests. Bark beetles were their prime interest, and studies underway in 1958 included investigations on how tree mortality was caused by the western and the Jeffrey pine beetles, on how salvage logging influenced bark beetle populations, and on

⁶⁶ Malathion, 0,0-dimethyl-S-(1,2-dicarbethoxyethyl) dithiophosphate, an organophosphorus pesticide, is today widely used for both domestic and commercial agricultural purposes. It is considered to be one of the safest organophosphate insecticides, and has been used in large pest eradication programs in California, Florida, and Texas.

The sheer number and complexity of the problems that needed to be solved made the station's research effort a defensive action.

how to improve surveys of beetle-caused damage. At the Miami Forest Insect Laboratory just south of Yosemite National Park, station personnel studied forest insect problems on the western slopes of the Sierra Nevada. The Miami Laboratory's research program covered those insects that attacked mixed-conifer forests. In 1958, studies underway also included field and laboratory work on residual-type chemical sprays for bark beetle control. Finally, the Orleans Laboratory, located in the heart of the California Douglas-fir belt in Humboldt County, began field tests in 1956 that emphasized work on the life histories and habits of Douglas-fir cone and seed insects. The Orleans Laboratory also served as a headquarters for forest insect survey activities in northwestern California (USDA FS 1958b).

Meanwhile, in 1959–1960, forest insect damage increased sharply in California. Information collected by station entomologists showed that the increase was general in timber-producing and recreation forests alike, and occurred everywhere in California except the northwest. In fact, 1959 was close to a record year for insect-caused losses in California's forests, most likely owing to drought conditions. In terms of volume of timber killed, insect damage was most severe in commercial forests, particularly the mixed-conifer types, but the destruction wrought by insects caused much concern in many forested areas managed particularly for recreation, such as Yosemite National Park. The western pine beetle, California five-spined engraver, California flatheaded borer, lodgepole needle-miner, and several other insects all caused damage far above tolerable levels. The sheer number and complexity of the problems that needed to be solved made the station's research effort a defensive action. Intensifying its efforts, the station turned decidedly from solutions such as different methods of harvesting timber,⁶⁷ to focus research almost solely on a stepped-up program of finding better, cheaper, and more effective insecticides. Additionally, administrative changes within the Forest Service in 1961 resulted in the transfer of pest surveys from all stations to the regional offices. Following this action, the California station concentrated its full research program entirely on finding effective chemical sprays and employing improved techniques for spraying standing infested trees at a lower cost per unit (fig. 78) (USDA FS 1959a, 1960, 1961).

Forest Disease Research

Much like forest insect research, cooperative disease control investigations between the California Station and the Bureau of Plant Industry, Soils, and Agricultural

⁶⁷ Cultural practice solutions included timber harvesting methods such as "light cutting" or sanitation-salvage logging experiments. Research conducted at BMEF indicated that they clearly affected the pattern of insect-caused mortality.



U.S. Forest Service, Pacific Southwest Research Station

Figure 78—Helicopter spraying forests in early 1970s.

Engineering were suspended during World War II. Some research began again immediately after the war, and continued on a limited basis until 1954. During this period, the station concerned itself with three forest disease research subjects: estimating timber loss from cull and rot throughout the state,⁶⁸ determining the deterioration rates for fire-killed timber, and investigating certain trees diseases, such as white pine blister rust, the chief disease threat to California's sugar pine forests (USDA FS 1953, 1954a). However, true interest in forest disease research was not revived until 1956, when the station created its own forest disease research division. This step centralized responsibility for all forest disease research in Region 5 to the California Station; an action the *Timber Resource Review* pointed out would make the broadest possible use of a small roster of experienced personnel. In the same action, Region 5 transferred all development of blister rust control methods to CFRES⁶⁹ (USDA FS 1955a, 1956a, 1957).

⁶⁸ Station scientist James W. Kimmey conducted much of this research (Aitro 1977).

⁶⁹ The University of California also gave substantial impetus to disease research at this time by appointing a forest pathologist to the faculty of the Department of Plant Pathology.

Accurate evaluation of forest disease importance had been unavailable because of the lack of information on the number, extent, and activity of destructive disease agents.

During the station's first years of operation, station forest pathologists worked together in a coordinated research program. Their first objective was to conduct an extensive forest disease survey, an action that served three essential forest managerial needs. This program provided a statewide cooperative service for detecting and reporting all types of diseases; it provided case histories on the effectiveness of control methods for specific diseases; and it furnished accurate information about disease losses. Until this survey, accurate evaluation of forest disease importance had been unavailable because of the lack of information on the number, extent, and activity of destructive disease agents (USDA FS 1957a). The bad news was that the survey found immediate evidence of heavy losses from dwarf mistletoe in red fir and sugar pine in some areas, and considerable mortality of Jeffrey and ponderosa pine from needle disease in others. On the other hand, there was good news regarding white pine blister rust. Although the disease was building up on sugar pine in northern California, it had not found its way farther south than Dodge Ridge in the central Sierra. The second objective of the disease research program was control. Based on survey information, station pathologists directed the division's research program toward control of dwarf mistletoe⁷⁰ by chemical sprays, and controlling of white blister rust by eradicating *Ribes*, either by cheap manual methods or by herbicides and fungicides. The third objective of the program was fundamental fact-finding studies. For instance, station pathologists investigated over-mature timber with heart-rotting fungi, which the station estimated accounted for the greatest losses in California's forests.⁷¹ Heart rot research addressed the question of how fast wood was being lost to decay fungi, and how site and climate affected the rate of decay. Such information was important to forest managers, who used it to schedule cuttings in present merchantable stands so as to help them reduce future heart rot losses. At the same time, station scientists sought effective control of dwarf mistletoe by basic understanding of the biology of the host and parasite, and learning about the environmental factors that affected incidence and spread of the pest. Work on this project was conducted in close cooperation with the University of California Plant Pathology Department at Berkeley and the Botany Department at Davis. The station also endeavored to develop blister rust-resistant sugar pines through propagation and testing of individual clones and hybrids at IFG. All in all, by 1962,

⁷⁰ In 1958, the station estimated that dwarf mistletoe reduced growth in California forests by an estimated 153 million board feet of sawtimber each year. At this time, all species of California's pines, true firs, and Douglas-fir were attacked and or damaged or killed by dwarf mistletoes, which were widely distributed throughout the region.

⁷¹ According to the station annual report for 1955, 80 to 100 billion board feet of timber had become unusable because of this rot (USDA FS 1955a).

progress was made in two studies of top priority to forest managers—chemical control of white pine blister rust and dwarf mistletoe, and the investigation of growth responses to heart rots (USDA FS 1956a, 1957a, 1958a, 1960, 1961).

Wildlife Habitat Research

Although Earle Clapp's *A National Program of Forest Research* (1926) stated that wildlife research should focus on the place of each species in the forest environment, followed by related research on life habits, it was not until 1953 that the Forest Service formally added wildlife habitat research to the agency's broader research program. In keeping with the national program, the California station began its own wildlife habitat research program in 1956, when CFRES recognized that the ever-increasing pressure of California's burgeoning population for recreational hunting had made efficient management of game refuges a top priority. The station also understood that a key problem to understanding forest range resources was California's growing deer population. To meet these challenges, the station began new research on game-browse habitat in 1957 (USDA FS 1956a, 1957a), and within a year, created a division of range and wildlife habitat research. Wildlife habitat research was added to the range division's mission because a rapidly expanding deer population was exerting heavy pressure on most California deer ranges, particularly wintering areas. The station, much like California Region 5,⁷² recognized that wild animals and fish were products of suitable habitat, and therefore, the station needed to coordinate any major activity like range management with wildlife habitat maintenance. By 1958, the station realized that a majority of the big-game ranges critical for winter survival of deer in California were badly run down. Because they produced below their forage potential, these ranges consequently could not maintain present high populations of deer, let alone the even higher populations needed for the foreseeable future.

The solution was to develop practical methods for improving depleted ranges by seeding browsing plants. With that realization, the California station, in cooperation with the United States Department of Fish and Game, carried out field trials at three game-browse areas, the Flukey Spring Game-Browse Area in Modoc County, the Doyle Game-Browse Area in Lassen County, and the Buttermilk Game-Browse Area in Inyo County. At these three game-browse areas, the station sought ways to

The station understood that a key problem to understanding forest range resources was California's growing deer population.

⁷² In 1958, Region 5 created a Division of Range and Wildlife Management. Its main objective was to systematically improve range forage to benefit domestic livestock and to create habitat for wildlife. By the end of the Eisenhower administration, domestic livestock use of national forest ranges in the state appeared in balance with forage supplies, with about 125,000 head of cattle and 120,000 head of sheep grazing under permit (Godfrey 2005).

seed browse species on deteriorated big-game ranges. Testing trials included depth and timing of planting, effect of competing vegetation on establishment and growth of browse species, and growth habits of bitterbrush strains from different seed sources. Another deer habitat study with a view toward integrated natural resource management was started in 1959 on an experimental area on the north fork of the Yuba River in the Tahoe National Forest. This area represented both winter deer ranges in the west-side conifer timber, and summer ranges at higher elevations. Studies at this location looked into the effects of logging and the conversion of brush to forest on deer habitat, as well as the effects of deer and deer forage plants on forest regeneration, growth, and mortality. In 1961, study plots to investigate the interrelationships of logging and deer were also established at SMEF for summer range, and on the Tahoe National Forest for winter range. Despite these research efforts, however, station personnel realized they were just touching the surface of how to manage wildlife habitat in the face of increasing deer numbers and demands of other uses for the same acres. More research would be required (Godfrey 2005; USDA FS 1958b, 1959a, 1960, 1961).

Forest Recreation Research

As noted in earlier chapters, when the California station was founded, recreation research within the Forest Service structure was barely in its infancy, and only slowly emerged as a research field. Earle Clapp's *A National Program of Forest Research* (1926) had provided a brief statement indicating that research could contribute to forest recreation through maintenance of the forest itself. Then, between 1929 and 1937, E.P. Meinecke of the Bureau of Plant Industry wrote a series of publications regarding camp planning, camp construction, and campground policy for the Forest Service and California State Park managers. In 1939, Lincoln Ellison, from the Intermountain Forest and Range Experiment Station, took up the lead. In his article, "Trends of Forest Recreation in the United States" (Ellison 1942), Ellison recommended research in campground deterioration, roadside vegetation ecology, and recreation economics, but the Forest Service did not act on his recommendations for more than a decade. Fortunately, in the mid-1940s, Verne Harper, then Director of the Northeast Forest Experiment Station, advocated a recreation program. In 1957, after Harper became Deputy Chief of Research, he created a division

of recreation research.⁷³ Harper assigned Harry W. Camp and well-known wildlife biologist Frank C. Craighead to outline research projects and initiate programs in the field for the new division. However, in 1959, Craighead was reassigned, and Harry Camp became the first head of recreation research (Camp, n.d.).

In the spring of 1959, in line with the national forest program and the California Wildland Research Plan, the PSW Research Station developed plans for forest recreation research. The station's recreation program was initially placed under the forest economics division headed by John R. McGuire (later Chief of the Forest Service). Early recreation researchers included Ernest M. Gould, Jr., Richard L. Bury, Arthur W. Magill, and Leslie F. Marcus. Because a reconnaissance of campgrounds and picnic areas suggested that ecological studies might help determine recreation site capacity, and help develop site maintenance and improvement practices, the station's staff focused their initial research in those areas. The first priority was to develop means for measuring recreation use by defining, recording, and evaluating recreation unit use. Other projects investigated factors that affected campground carrying capacity. Additionally, researchers learned that poor seeding survival and reproduction, decreases in shrubby ground cover, soil compaction, and decreased amounts of forest litter affected campsite quality. In addition to studying these problems, particular attention was given to the recreation planning process. One outcome was the development of the notion of a "recreation complex." This concept focused planners' attention on the wide variety of recreation activities that Californians desired, on the need for flexibility to meet changing preferences, and on the importance of the quality of recreation experience. The station presented the "recreation complex"—or use of areas for a multiplicity of recreation activities—as a planning concept that could be applied at the individual site, the subregion, and the regional level. After 1962, the station's recreation research program broadened rapidly as funds and facilities permitted (Aitro 1977; USDA FS 1959a, 1960, 1961).

The first priority was to develop means for measuring recreation use by defining, recording, and evaluating recreation unit use.

⁷³ In 1957, recreational management in Region 5 benefited from several events, including Operation Outdoors, a 5-year expansion and renovation plan for Forest Service recreation facilities. As a consequence, Region 5 hired several recreational professionals and landscape architects to help inventory lands suitable for outdoor recreation use and to prepare plans to meet the recreational demands of the future. At the same time, Region 5 requested research assistance in formulating management plans for the High Sierra Wilderness and in completing a national forest recreation survey. Region 5's goal was to define optimum patterns of use without disturbing wilderness characteristics. In the same year, California also adopted a law calling for a statewide study to document what the state had in outdoor recreation resources, what they needed in the future, and to coordinate recreation development on a statewide basis (Camp, n.d.; Godfrey 2005).

Research in Hawaii

In the mid-1950s, Hawaii was experiencing a rapid growth in population, much like California. Consequently, demand for wood grew in the Hawaiian Islands. With a land area of more than 4 million acres, the islands had at that time about 2 million acres of potentially productive forest lands. For years, the Hawaii Board of Agriculture and Forestry had planted trees throughout the islands to maintain watersheds. Now, they recognized that greater production from their timberland might bolster island economies, but they had little information to guide any commercial development because the condition of timberlands, and the volume, quality, and growth rates of timber stands had never been inventoried. Until 1957, Forest Service contacts with Hawaii forestry officials were rare, but in that year, they asked the Forest Service for assistance, and provided funds to the California station to conduct the first forest survey of Hawaii. Station Director R. Keith Arnold then sent Robert E. Nelson to Hawaii to establish a branch office in Honolulu. Nelson's primary responsibility was to inventory Hawaii's forest resources as an extension of the nationwide FRS. The Hawaiian FRS determined the volume of standing timber, annual growth, natural mortality, and rate of cutting on the islands. Begun in 1957, the Hawaiian FRS was completed in 1961 with the excellent cooperation of Tom K. Tagawa, a staff forester for the Hawaiian Division of Forestry, who helped plan and conduct the detailed work of inventorying Hawaii's forest resource. However, the results were not published until 1963 (Aitro 1977; Camp 2006; Nelson 1989; USDA FS 1957a, 1961).

Beyond the forest inventory, Robert Nelson was also asked to provide technical assistance to the territory on particular forestry matters and to look at Hawaii's research needs, and recommend a plan of action. Program support for Nelson's activities came from the Hawaii Board of Agriculture and Forestry through its Division of Forestry, which provided an office and related facilities and services to the station (Nelson 1989, USDA FS 1957a). Meanwhile, in 1959—the same year Hawaii became a state—the station's administrative boundary was extended to include Hawaii. This action allowed the PSW Research Station to send Walter S. Hopkins, watershed division head, to review Hawaii's watershed characteristics and problems, as well as the state's watershed research needs and opportunities. Hawaii's increasing population meant a rising demand for water, again paralleling the California experience. Because almost all of Hawaii's rainfall fell on its porous upper mountain watersheds and was then pumped from springs at lower elevations, one of the first PSW Research Station projects was to determine which soils, forest cover types, and forest management measures were hospitable to rapid infiltration

and percolation into underground water sources. To this end, research forester Paul Duffy completed an analysis of Hawaii's watershed management problems in 1960. Additionally, two station studies of Hawaii forest soils, started around the same time in cooperation with the Army Corps of Engineers, revealed interesting information on infiltration and percolation rates and the bearing capacity of Hawaii's forest soils (Nelson 1989, USDA FS 1959a, 1960).

Besides watershed management, the PSW Research Station studied timber management issues and the possibilities and problems of developing a Hawaii forest products industry. Under the leadership of Forest Utilization Service head L.N. Ericksen, Gerald D. Pickford and Russell K. LeBaron completed several needed timber production investigations. The first study evaluated tree nursery sites on the islands of Maui and Hawaii, and led to plans to develop a centralized, mechanized, mass production nursery facility. The second study considered the growth and adaptability of certain introduced tree plantations on the Big Island. Results of this later study amazed mainland foresters because planted timber stands were found to contain 130,000 board feet per acre—the most productive forest land in the United States at the time. Subsequently, the California station surveyed wood quality requirements in Hawaii. The PSW Research Station staff found that although strength properties for wood construction and fabrication differed little from other parts of the world, Hawaiian use requirements were quite different. In Hawaii, house construction methods placed a premium on lumber appearance, resistance to decay and insect attack was critical, and shrinking and swelling as construction factors were less critical because of the mild climate. In addition to these studies, the station, in cooperation with the FPL, investigated other forest products utilization subjects, such as sawmill practices and the application of grading to Hawaii-grown woods. One important joint PSW Research Station-FPL study described the quality and yield of lumber from *Robusta eucalyptus*, which harkened back to the days of the “eucalyptus boom” in California in the early part of the century. Finally, in 1960, the PSW Research Station assigned Roger Skolmen, a research forester with special training and experience in wood technology, to Hawaii to accelerate forest products research. Skolmen became a highly valued forestry scientist in Hawaii, and during his tenure there (1961-77), published many important reports describing Hawaii forestry conditions and problems (Aitro 1977; Nelson 1989; USDA FS 1957a, 1959a, 1960, 1961).

In addition to forest resource inventory, watershed management, and forest products research, the PSW Research Station oversaw federal cost-sharing technical assistance programs in Hawaii, including fire control and forest nursery work. Total federal funds granted to Hawaii for these programs was less than \$10,000

Results of this later study amazed mainland foresters because planted timber stands were found to contain 130,000 board feet per acre—the most productive forest land in the United States at the time.

annually, but after 1957, the station reviewed past and present technical assistance in cooperative fire protection, and cooperative forest tree seedling production. New initiatives were rapidly developed for improving upon them, and funding increased. The Forest Service eventually helped the Hawaiian Division of Forestry develop a standard of fire protection—prevention, presuppression, and suppression—that curbed annual area burned to less than 0.1 percent of the area protected. This was a national standard at the time. To study island forest nursery practices, the PSW Research Station detailed Floyd Cossitt to Hawaii in 1960. Based on Cossitt's recommendations (Cossitt 1960), the Division of Forestry established a centralized nursery at Kamuela on the island of Hawaii. By 1962, the Kamuela Nursery began providing Hawaii's Division of Forestry with large quantities of tree seedlings for the state's greatly increasing reforestation programs. The nursery was supported by federal funds earmarked for producing and planting forest trees on state or private lands (Nelson 1989).

In retrospect, the years 1957 to 1962 were formative years for the expansion of California/PSW Station programs in Hawaii. By 1962, the station's official research study boundary had not only been expanded to include Hawaii, but important progress was made in developing new information in several research disciplines. The future promised expanded research studies pertaining to Hawaii's forest economics problems.

Silent Spring

While station scientists from the late 1940s to the early 1960s busied themselves in their research and field laboratories trying to meet California's and then Hawaii's forestry needs, discontent over the declining quality of the environment mounted. Part of the leisure California lifestyle that emerged following World War II included outdoor recreation, and the state's recreation industry blossomed with a whole range of activities including skiing, surfing, boating, hiking, and camping. But as people went outdoors, they increasingly witnessed a worsening degradation of California's air, water, and other natural resources. All of the causes that would drive the environmental movement of the early 1960s and 1970s—the pollution of air and water, the mistreatment of forests, and the attrition of undeveloped areas and parklands by uncontrolled urban development—appeared as early as 1955. As Californians began to experience smog that irritated eyes, noses, and throats; as Californians witnessed factories, cities, towns, and farms pumping toxic effluents, deadly poisons, and raw sewage into the state's rivers, streams, and bays and into the Pacific Ocean; as Californians watched incredulously at the rate that open space, coastline, and farmland disappeared to urban sprawl; and as Californians observed



U.S. Fish and Wildlife Service

Figure 79—Marine biologist, writer, and ecologist Rachel Carson, whose notable book *Silent Spring* (1962) brought environmental concerns to the attention of the American public.

freeways bisect and then trisect neighborhoods into smaller pieces, they became overwhelmed with worry. In 1962, Rachel Carson's (fig. 79) eye-opening and enormously popular book, *Silent Spring* (Carson 1962), warned of the impact of chemicals on the environment, and for the first time alerted Americans of threats to their environment (Godfrey 2005). Carson's *Silent Spring* provided "a convenient starting point for the environmental movement," which went "beyond the conservationist goal of prudent husbanding of natural resources to include quality of life and to place value on things that the marketplace had yet to recognize" (Steen 1998). As will be seen in the next chapter, with the aid of McIntire-Stennis funds, research at the PSW Research Station in the decades ahead would move toward university-based forestry and reflect this growing environmental awareness.

This Page Left Blank Intentionally

Chapter 7: 1963–1979, Environmental Forestry Research

Following the 1962 publication of Rachel Carson's *Silent Spring*,¹ the Nation—and California in particular—embraced a new ethic of environmental protection. The transition from conservation principles to environmentalism was a significant leap for many Forest Service leaders, but by this date, many Californians had already noticed that rampant and unplanned growth and overdevelopment had caused enormous strains on California's finite resources of air, water, forests, and wilderness. In his book, *The Destruction of California* (Dassman 1973), biologist Raymond F. Dassman wrote:

After several decades of post-World War II boom most of California's remaining resources—forests, petroleum, and natural gas, farmland, scenery, open space, water, and even the air itself—approached exhaustion. Like the overused older states to the east, much of the state was congested, littered, polluted, and disfigured. Californians were destroying the unique natural heritage that had contributed so much of their success. Smog, traffic jams, urban sprawl, overcrowded parks, and polluted water were only the most obvious manifestations of profound environmental transformation [Rice et al. 1996: 576].

Dassman went on to lament that greed and ignorance had turned California into the “not so golden state.” His comments were typical of a new environmental movement that “emphasized the interrelationships of nature's parts, the importance of protecting all species to maintain genetic diversity, and the capacity for human-induced environmental changes to spread dangerously in many directions.” Many believed that civilization could not survive unless harmony was reestablished between people and the environment. This reassessment called into “question conventional forms of technological progress, as well as practices in water development, land use, and wildlife management that conservationists once condoned.” Conservation was evolving into modern environmentalism, which emphasized “preservation of the environment as a whole and criticized unrestrained economic and technological growth” (Rice et al. 1996: 600–602). This was at odds with the traditional conservationism of most Forest Service leaders of the time, who believed

¹ When asked about the impact of Rachel Carson's *Silent Spring*, PSW Research Station Director R. Keith Arnold stated: “We got quite an impact on it because the lake one hundred miles north of Berkeley was her observation area. It gave more weight to ecological research certainly, but I can't recall that it caused much immediate change” (Steen 1994).

in the Progressive's "gospel of efficiency" of Gifford Pinchot's day. This belief that resources should be exploited and that the Forest Service unilaterally knew what was best for the public good no longer worked. The Pacific Southwest (PSW) Research Station would soon fall in line with the nascent environmental movement, but first had to undergo some administrative changes (Godfrey 2005).

Harper-Jemison Legacy

In the spring of 1963, Deputy Chief of Research V.L. Harper and Associate Deputy Chief John R. McGuire conducted the first General Research Inspection (GRI) of the PSW Research Station. The major purpose of the GRI was to cover the areas not included in either the General Functional Inspection (GFI) by the Washington office (WO) Research Division directors or in the General Integrated Inspection (GII) by the deputy chief and the chief inspector. The periodic GFI reviewed activities in a single divisional research field (e.g., information and education), while the GII looked into policy matters of servicewide importance, major regional problems, and overall in-service and external relationships. Neither the GFI nor the GII were concerned very deeply with such station matters as program formulation and balance, coordination of research activities, and details of research operation and program administration. The GRI bridged this gap (Harper and McGuire 1963).

The Harper-McGuire GRI pointed out several overall problems at the PSW Research Station. First, the report noted that three areas of research—timber management, watershed management, and forest fire research—received about 60 percent of the total research funding at the station. In their opinion, research programs, such as insects, disease, engineering, recreation, forest products, marketing, and redwood (see "Scientific and Common Names" section) silviculture, were not funded adequately. Harper and McGuire recognized this deficiency and promised special attention to finding more funding for these programs—a promise that the WO fulfilled soon thereafter. Second, Harper and McGuire observed that particular projects seemed to have only broadly stated goals, not clear achievable objectives, so they recommended that all project objectives be sharpened and prioritized. Third, relating to the previous concerns, Harper and McGuire believed that the station needed better control on individual assignments. They therefore suggested that the station discontinue assigning individual research personnel to more than one project. Fourth, the GRI thought that the station's research program was too spread out over many small projects. Finally, Harper and McGuire questioned whether or not the station was too dependent on cooperative funding for much of its research (Harper and McGuire 1963).

On the other hand, many aspects of the station's program favorably impressed the inspectors. The station had handled the reorganization of research that came in 1960–1961 very well. They acknowledged the accomplishments of the Institute of Forest Genetics (IFG), particularly the hybridization work that resulted in producing two key hybrids (knobcone-Monterey and Jeffrey-Coulter) on a large enough scale in California for immediate planting in national forests. The station's range management research program at the San Joaquin Experimental Range (SJER) had been successfully reoriented, and a complex and difficult problem in external relations with the University of California had been overcome there with a new cooperative agreement. Overall, they noted that the PSW Research Station had done an excellent job of training professionals, but especially commended the advanced training done in forest insect research, where five of the seven younger entomologists had, or would receive, their Ph.D.s since joining the station. Finally, they praised the emergency research program following the fire at the San Dimas Experimental Forest (SDEF). In a very short time after the disaster, the station's entire research program at SDEF was redirected, and a new and effective program was installed to take advantage of the postfire situation (Harper and McGuire 1963).

The Harper-McGuire GRI thereafter turned to specific recommendations for each research program, but emphasized research facility expansion. They suggested that the station strengthen its redwood-Douglas-fir work and move it to the campus of Humboldt State College at Arcata in northern California. In May 1963, Humboldt State College had made available a plot of land near the college's forestry building, which was highly suitable for a redwoods laboratory, but a new redwood laboratory would not be built there for more than a decade² (fig. 80). By comparison, the Harper-McGuire GRI advocated consolidating all project scientists involved in ponderosa pine and mixed conifers research at a new headquarters at Redding, in north-central California.³ This priority suggestion was acted upon in 1964, when the Redding Silviculture Laboratory was built on the outskirts of Redding. The laboratory was co-located with the Shasta-Trinity National Forest

Overall, the PSW Research Station had done an excellent job of training professionals.

² Planning for a Forest Service building on the campus of Humboldt College began in 1973, but construction did not begin until 1975. A year later the Redwood Sciences Laboratory would be dedicated. The new laboratory contained about 15,000 square feet of office and laboratory space, including a library, conference room, and data processing area, and the building harmonized with its surroundings. The two-story building houses research hydrologists, geologists, wildlife and fisheries biologists, plant ecologists, biometricians, research technicians, and support personnel who are conducting watershed, wildlife, and fisheries research applicable to the Pacific Northwest from Alaska to California.

³ Although Redding is a principal center for the lumber industry in the non-magnesium coastal part of northern California, it was a considerable distance from any of the experiment stations. Consequently, scientists incurred considerable travel expenses for most fieldwork (Gordon 1982).



Redwood Empire Association

Figure 80—Prairie Creek Redwoods State Park in Humboldt County, California, created in the 1920s as a coastal sanctuary for old-growth coast redwood trees.

supervisor's office, in the heart of northern California's forest industry. From here, the research unit continued the heritage of silviculture research begun by scientists at the station's headquarters dating back to the 1930s, although not without some problems. Finally, the Harper-McGuire GRI recommended that the station give up the office it maintained in Fresno. Research had first begun in Fresno about 1934, but at the time of the GRI, the research program at Fresno was minimal, with most of it being conducted at SJER. Its limited use made their suggestion logical, but as time progressed, this recommendation was nullified by further changes in research priorities⁴ (Gordon 1982, Harper and McGuire 1963).

⁴ In 1970, rangeland research gained momentum when wildlife scientists were added to the range scientists at this location. This move was precipitated by a statewide concern over declining populations of mule deer in California. In 1976, research on threatened and endangered species was added to the responsibilities of the San Joaquin Experimental Range. Soon it was determined that a new laboratory was required and most logically located at Fresno, in cooperation with the university there. Then, in 1979, the Forestry Sciences Laboratory was dedicated on a 10-acre site on the north campus of California State University at Fresno to hold a complex of offices, research laboratories, and computer facilities.

Meanwhile, in 1965, Les Harper retired, just after the dedication of the Redding Silviculture Laboratory. George Jemison, who had been associate deputy chief under Harper, moved to the top research spot, and it fell to Jemison to deal with the early years of the environmental movement sweeping the Nation. One small step forward came in 1967, when the heading “Environmental Forestry Research” appeared in the Forest Service’s annual report. Under this heading, the annual report discussed the need to research air pollution and its effect on tree mortality. In only a few years, cleaner air and other environmental issues, such as water quality, were being investigated on a broader basis (Steen 1998). Of course, clean air and water quality were major California concerns, and the outcry there against smog and water pollution grew ever more strident in the 1960s⁵ (Godfrey 2005).

In the meantime, Jemison significantly changed the Forest Service’s research organization. First, wildlife research, which studied habitat,⁶ was joined administratively with range research. This action stemmed from the manager’s traditional need to balance forage requirements between domestic livestock and big game. Also, fire research—largely a physical science—was conjoined for a few years with insect and disease research to become “protection research.” Of course, through the years, combinations such as these were adjusted in accord with shifts of emphasis and changes in Forest Service leadership. In the budget area, Jemison was able to take advantage of the momentum that he and Harper had built up in Congress. In 1965, the year Jemison took over, the Forest Service research budget was \$31 million. By the time Jemison retired in 1969, it had risen to \$40.7 million. This growth was especially noticeable in the construction of experiment stations and laboratories, which the PSW Research Station took full advantage of, and was reminiscent of the growth in research facilities under Earle Clapp (Steen 1994, 1998).

Jemison significantly changed the Forest Service’s research organization.

⁵ By this time, automobile traffic and other polluters belched more than 12,500 tons of petroleum-based contaminants a day into the air above Los Angeles, making it the smog capital of the state if not the country. Until that time, state agencies had relied on voluntary compliance by local governments, companies, and individuals as a means to keep pollution down. Eventually, some progress was made on muzzling stationary polluters, but the automobile situation was not addressed until 1960 when the California legislature passed the Nation’s first law establishing air-quality standards for vehicles sold in the state after 1966. Soon thereafter, because it was a national and not just a state problem, California pressed Congress to enact air-pollution legislation. Congress took action and passed the Clean Air Acts of 1967 and 1970, both based on California’s smog control experience. Water pollution control efforts in California followed a similar pattern. For decades, local governments, farmers, industries, and individual households casually released a variety of chemicals and pollutants into nearby streams and onto the ground, including sewage, fertilizers, toxic pesticides, and solvents. In the 1960s, California established the Water Resources Control Board, which established minimum water-quality standards, required regions to develop implementation plans and to set up enforcement agencies, and allocated federal and state funds for local water purification (Godfrey 2005).

⁶ The U.S. Fish and Wildlife Service in the Interior Department studied the actual animals themselves.

However, unlike the Earle Clapp years, which pioneered basic forestry research, the Harper-Jemison legacy was one of broad policy decisions that strengthened Forest Service research organizations by giving scientists more opportunity to pursue their interests, while removing administrative responsibilities. Harper and his associate Jemison both believed that the scientist on the project level should be the key person in research. Under their leadership and with their encouragement, Forest Service research went from a research center organization to one dominated by the project concept. This reorganization streamlined administration and put more emphasis on science and the individual project leader, helping the program obtain funding from Congress, and attracting scientists to the Forest Service (Steen 1994).

In California, John R. McGuire,⁷ one of the authors of the Harper-McGuire GRI, headed the PSW Research Station, becoming its sixth director (fig. 81). He assumed the directorship during the last years of the Harper administration (1963–1965), and was at the PSW Research Station for most of the Jemison era (1965–1969). During his tenure at the station, McGuire followed Harper and Jemison’s prescription of giving advice and encouragement to individual scientists on the project level (Steen 1994). In fact, for the first time, PSW Research Station annual reports not only listed and summarized current investigations,⁸ but also attached the names of responsible scientists and their most recent publications alongside the progress report for each Station research project (USDA FS 1963, 1964a).

Administrative changes, large and small, occurred as well. For instance, by 1965, the station had been fully reorganized under four assistant directors, which took the day-to-day administrative responsibilities away from individual scientists to give them more time for research. Additionally, the research team working on remote sensing of the forest environment moved from Beltsville, Maryland, to Berkeley (USDA FS 1965b). Station Director McGuire also closed the Susanville Research Center in early 1965. Most of its researchers had moved to the newly

One unusual subject in the early 1960s was the possibility of nuclear attack at the height of the Cuban missile crisis.

⁷ John R. McGuire earned his M.F. degree from Yale University in 1941 and worked at the Northeastern Forest Experiment Station at New Haven. After serving in World War II in the Pacific, McGuire returned to the New Haven Station, but in 1950 moved to a research station at Upper Darby, Pennsylvania, while completing his M.A. in economics at the University of Pennsylvania. In 1963, he became the Director of the PSW Research Station, and in 1967 moved to the Washington, D.C., research office. In 1971, he was chosen as Chief during a time of increasing environmental awareness by the public.

⁸ One unusual subject that McGuire and his staff dealt with in the early 1960s was the possibility of nuclear attack at the height of the Cuban missile crisis. To this end, McGuire, along with Region 5 Forester Charles Connaughton, developed a “War Disaster Plan.” It was premised on the possible occurrence of widespread and severe destruction to the Bay Area with little or no advance warning, and assumed that continued occupancy would be impossible (USDA FS 1964b).



U.S. Forest Service, Pacific Southwest
Research Station

Figure 81—John R. McGuire, sixth Director of the Pacific Southwest Research Station, 1963–1967, and Chief of the Forest Service (1972–1979) during implementation of the Forest and Rangeland Renewable Resources Act (1978) and the National Forest Management Act (1976).

established Redding Silviculture Laboratory, which was in line with a new “official” philosophy to get researchers “out of the boondocks and into university centers where they have good access to computers and can commiserate with their colleagues” (Gordon 1982).

Station Director McGuire also took a number of actions to improve communications between research scientists and the people who used the station’s research results. These included Region 5 forest managers, members of the scientific community, practicing “on-the-ground” professionals in all kinds of disciplines, and the general public (Vitas 1966). One action was the August 1966 inauguration of the station publication *What’s New in Research*, a monthly news bulletin that provided the scientific community and the general public with articles and photographs of topical interest related to PSW Research Station research, such as DDT use,⁹ or adapting army night flight helicopter technology to fighting fires. Early issues also provided station personnel with news and abstracts of recent publications, as well as briefings on research conducted at other experimental stations nationwide (PSW 1966a, 1966b). Some of the changes made by McGuire to improve station communications were suggested by an Informational and Education GFI conducted by George Vitas in 1966 (Vitas 1966). In the end, during McGuire’s tenure, it became possible through increased funding to employ more people trained in fields other

⁹ By 1965, the use of DDT became a controversial topic at annual insect field meetings in California (Hall et al., n.d.).

It was a time when the station started to decentralize administratively.

than the traditional forestry research disciplines. Consequently according to McGuire, “the benefits of rubbing up against ‘alien’ ideas were becoming apparent.” It was also a time when the station started to decentralize administratively, as some of the assistant directors moved out of Berkeley to other station facilities (PSW 1990j).

Research and the Environment

In March 1967, McGuire moved on to Washington to work in the research office as Deputy Chief of the Forest Service in charge of programs and legislation,¹⁰ and the next month, Robert D. McCulley (1967–1971)¹¹ was appointed to replace him at the Berkeley facility,¹² becoming the station’s seventh director (fig. 82). Station Director McCulley, “one of those crusty guys that would challenge the hell out of you,” guided the PSW Research Station during the early years of the environmental decade (Steen 1994: 222; USDA FS 1967). Many critical issues confronted McCulley upon taking office, including legislation that mandated environmental planning and management, such as the National Environmental Policy Act (NEPA) of 1969, and the California Environmental Quality Act (CEQA) of 1970. In this new era, conservation needed to work with environmentalism, for following the passage of NEPA, the Nixon administration declared that the 1970s would be an environmental decade, called for the Nation to begin to repair the damage done to the Nation’s air, land and water, and pledged a “New American Experience” that included more government responsiveness to citizen’s needs (Godfrey 2005).

¹⁰ Many years later, McGuire remembered that his tour as station director was like “a bed of roses” compared to some of his later positions with the Forest Service. He recalled that much attention was paid to strengthening PSW ties with the rest of the Forest Service, the state, the University of California, and some state colleges. He also recalled that it was a time of rapid change in providing library and other information services and in the use of computers—even taking a week-long course himself in computer programming (PSW 1990j).

¹¹ Robert McCulley began his Forest Service career in 1937 on the Sierra National Forest in California after receiving a B.S. in forestry from the University of California, Berkeley. After a variety of short-term assignments, McCulley spent 6 years at Lake City, Florida, conducting silvicultural research on longleaf and slash pine; six years at Franklin, Virginia, assigned to silvicultural research in loblolly pine and hardwood forests; and 10 years at the North Central Station in St. Paul, Minnesota, where he was chief of the division of timber management research. Before coming to the PSW Research Station, he was assistant to the deputy chief for research in the Washington Office, and succeeded John R. McGuire (McCulley, n.d.).

¹² At this time, the experimental station’s headquarters, laboratories, data processing center, and offices were still in the Stead Building at 1960 Addison Street. The station also rented space in the Mercantile Building two blocks away (Harper and McGuire 1963), but by 1967, these arrangements were deemed unsuitable, so the station expanded again and took offices in the Koerber Building located at 2054 University Avenue (USDA FS 1967).



U.S. Forest Service, Pacific Southwest Research Station

Figure 82—Robert D. McCulley, seventh Director of the Pacific Southwest Research Station, 1967–1971. He oversaw the station's implementation of the National Environmental Policy Act of 1969 and the California Environmental Quality Act of 1970 in California.

During these years, former California Station Director R. Keith Arnold¹³ replaced George Jemison as deputy chief of research. Arnold, who served in that post from 1969 to 1973, bristled with imaginative ideas, and was widely considered an innovator (Steen 1994). In response to the president's new direction, Chief Forester Edward P. Cliff issued *Framework for the Future: Forest Service Objectives and Policy Guides* (USDA FS 1970), which recognized that many Forest Service programs were not addressing the public's environmental concerns (Godfrey 2005) and promised that the Forest Service would develop and make available a firm scientific base for the advancement of forestry. With input from Arnold,¹⁴ *Framework for the Future* stated six specific research policy goals: to conduct research needed to insure the rapid and efficient advancement of programs aimed at obtaining optimum benefits from forest resource management, protection, and utilization; to promote forestry through cooperative programs with educational institutions and

¹³ R. Keith Arnold was recruited for the deputy chief of research position from the University of Michigan, where he had been dean of the School of Natural Resources. There he had been criticized for dismantling the hard, discipline-oriented program and substituting "some fuzzy environmental stuff" (Steen 1994).

¹⁴ A year earlier, Arnold ambitiously issued *Forest Service Research Program for the Seventies*, a 250-page document. Based on major research accomplishments of the 1960s, the preface written by Arnold foresaw many important developments in forestry research for the coming decade (USDA FS 1969a).

Forestry research would increasingly be directed toward creating a better habitat for people concerned with environmental quality.

other public and private organizations; to make research results rapidly and equally available to all through information, education, demonstration, and technical assistance; to foster relationships between research scientists and forest managers that facilitate joint implementation of research results; to support professional and vocational education in forestry and related disciplines; and to support professional societies in forestry and those related to forestry (USDA FS 1970a). Naturally, given Keith Arnold's personality, his goal was "to move forestry research to the cutting edge of environmental policy," and stressed to his station directors the necessity of increasing "their concern about the environment and how it impacted forests" (Steen 1994, 1998).

Meanwhile, in his first year as PSW Research station director, Robert McCulley expected that forestry research would increasingly be directed toward creating a better habitat for people concerned with environmental quality, and acknowledged the pressures and problems being created in California and Hawaii by population growth. The station's 1967 annual report touched upon the urban influences that were damaging forests, and suggested the station bring urban forestry to California's cities.¹⁵ One example of the need was that in the Los Angeles Basin, smog blown up and out of the valley into the mountains was killing ponderosa pines around scenic Lake Arrowhead. Also, people were moving their homes farther out into the steep, brush-covered hillsides, creating fire control problems worse than any ever known in the past while reducing watershed values through erosion or pollution. But McCulley optimistically felt that through research and good land management, adverse land impacts such as these could be reduced. Station scientists were directed to explore ways to develop less persistent insecticides, to find smog-resistant trees, to create more attractive ways to landscape, to plan better development of the countryside, to lessen sediment in streams, to improve fire protection, and in general, to improve the productivity of forest lands while maintaining environmental quality (USDA FS 1968c).

In the meantime, a GII of Region 5 and the station confronted Station Director McCulley, who had been in his position for less than a year. Deputy Chief E.M. Bacon and general inspector H.E. Howard conducted the 1968 GII whose itinerary included the Berkeley facility, as well as the new Redding Silviculture Laboratory, the Riverside Fire Laboratory, the SDEF watershed laboratory at Glendora, and the IFG at Placerville. The 1968 GII discussed programs in Hawaii, but that state was not included in the itinerary (USDA FS 1968e). The Bacon-Howard GII both

¹⁵ By the late 1960s, an urban forestry movement had begun in the United States as people realized that their cities were becoming more and more vulnerable to pollution and to destruction of natural beauty. Urban forestry research aims were to establish, maintain, and grow trees that would improve living in urban situations (Doolittle 1969).

applauded the station's achievements and made particular recommendations for improving the station's programs. It praised the station for its success in expanding scientific investigations through cooperative funding, its good relations with University of California officials at Berkeley and Riverside, its equal employment opportunity program for minorities,¹⁶ and its fuelbreak program on the southern California national forests, which promised to reduce the number of large fires and their associated high costs (fig. 83).

Although the GII highlighted many areas worthy of commendation at the PSW Research Station, it also acknowledged that there were persistent problems in three areas: improving social orientation, intensification of ecological technology, and adjustment of organizational capabilities. In the tense sociopolitical climate of 1968, the Bacon-Howard GII reported that the station, in a joint effort with Region 5, should find ways to “tune into” public input in the decisionmaking process, and to restructure their advisory committee to be more nearly reflective of a greater range of public interests. Regarding ecological technology, the GII was very specific. Besides finding a more satisfactory system for gathering and dispensing research information, a perennial problem, Bacon and Howard also recommended that the station develop a system for identifying and measuring environmental contaminants affecting vegetative growth in California forests, assign higher priority to revegetation of exposed soils, accelerate the production of genetically improved tree stock and reduce the cost of reforestation in coordination with other resource activities and protection requirements, continue to refine the techniques for type conversion and incorporate aesthetic and ecological considerations into the program, and develop reliable guidelines for increasing production of commercial timber from California's second-growth tree species. The GII further recommended that the station “revisit” cultural practices such as the use of DDT and other pesticides, clearcutting practices, and reforestation of barren areas, taking into account aesthetic and natural values of environmental groups such as the Wilderness Society and the Sierra Club. Finally, regarding the adjustment of organizational capabilities, the GII suggested greater attention to the growing gap between research staff and forest managers, which widened as more and more research moved from the

The station should find ways to “tune into” public input in the decisionmaking process, and to restructure their advisory committee to be more nearly reflective of a greater range of public interests.

¹⁶ In 1968, minorities made up 11.5 percent of the station's permanent workforce, and the search for more people with qualifications for professional positions continued (USDA FS 1968e). At this early date, the station began observing Black History Month, and in 1990, Station Director Ronald Stewart instituted a Hispanic Heritage Month and American Indian Heritage Month, the first year that these occasions were celebrated on a national basis (PSW 1990a, 1990n).



U.S. Forest Service, Pacific Southwest Research Station

Figure 83—The destructive aftermath of fire.

field to the laboratory and the computer. In other words, station research scientists were increasingly being seen as “ivory tower” types whose inherent differences in orientation, organization, and interests worked against the free flow of information to Region 5 forest managers (USDA FS 1968e).

Station Director McCulley certainly had his hands full following the Bacon-Howard GII, and the introduction to the PSW Station 1969 annual report entitled “A Livable Home for Man” described the weaknesses and strengths of 20th-century technology¹⁷ (USDA FS 1969b). He acknowledged again the station’s growing concerns about the degrading quality of California’s environment, with its growing population problems, air and water pollution, noise, scarred natural beauty, disappearing open space, and increased dumping of waste. Thereafter, the station’s

¹⁷ The first moon landing was in 1969, and from outer space, evidence of air pollution over southern California was quite evident.

research program shifted to put more emphasis on the interactions among ecological factors, stressing interdisciplinary research to answer these environmental problems and manage the land in harmony with nature. Director McCulley pointed with pride to one particular project that he felt met these goals. In 1969, the station had prepared a landscape analysis of the small town of Nicasio, in Marin County, California. The PSW Research Station study, financed in part by an America the Beautiful Fund grant and conducted in cooperation with the University of California, resulted in a 50-page report entitled *Nicasio: Hidden Valley in Transition* (Twiss et al., n.d.). The Nicasio study considered the major environmental factors that might affect future development: geology, climate, vegetation, water, soil, wildlife, scenery, and historical and archeological sites. This applied research report was the first of its type in the western United States—setting a precedent for future NEPA studies nationwide (Aitro 1977, PSW 1968e, USDA FS 1969b)—and was indicative of the shifting national emphasis toward applied research that began with the election of Richard Nixon as president in 1968.

The shift in attention after World War II from basic or fundamental research back to applied research began shortly after Keith Arnold became research chief. The change was also furthered by a General Accounting Office (GAO) report, which was highly critical of forestry research, stating that it had failed to convert research findings to significant field practice. Eventually, the GAO critique found expression in the offices of key congressmen, who thereafter advocated applied research and technology transfer to private industry. This application emphasis led to the placement of an assistant director of planning and application at each experiment station. Robert A. Ralston initially filled that post at the PSW Research Station. Additionally, opposition had also built up against the research center/project organization created under Harper and Jemison, which some believed caused Forest Service research budgets to grow out of control. By the early 1970s, an in-house Forest Service study proposed that the “superheated” Forest Service research organization, with its burgeoning personnel and facilities, be scrapped altogether and replaced with a much simpler system (Steen 1998, USDA FS 1969b).

In the meantime, in late 1971, Robert McCulley stepped down as station director. Harry W. Camp¹⁸ served as acting director until April 1972, (fig. 84) and then was appointed director. Camp served in this post until his retirement in December 1973. By the time Camp assumed the directorship, Forest Service research had developed into an organization built around multidiscipline research work units

The Nicasio study considered the major environmental factors that might affect future development: geology, climate, vegetation, water, soil, wildlife, scenery, and historical and archeological sites.

¹⁸ Harry W. Camp had 40 years experience with the Forest Service, and from 1965 until 1971, he was assistant director of forest products utilization and marketing, economics, and recreation research at the Berkeley Station.



U.S. Forest Service, Pacific Southwest Research Station

Figure 84—Harry W. Camp, eighth Director of the Pacific Southwest Research Station, 1971–1973. Camp addressed equal employment opportunity issues and the establishment of an employee union—the first for the Forest Service.

Individual RWU project leaders decided what aspects of the research program to prioritize.

(RWUs), which differed from the old functional divisions.¹⁹ For instance, a hydrologist, an engineer, and a silviculturalist might all work in one place, but each might be assigned to a separate RWU. Also, assistant directors had completely replaced division chiefs and were responsible for supervising several RWUs. Vern Harper initiated this policy in 1960–1961, and George Jemison and Keith Arnold continued it. During this transition, an individual scientist's research program shifted from studies that were based upon an organized long-term research program and mainly assigned from the WO, to a system whereby individual RWU project leaders decided what aspects of the research program to prioritize, and then channeled their studies to those ends. However, this situation sometimes had the unfortunate effect of resulting in projects of a personal nature and scientific self-aggrandizement (Klade and Lassen 2005).

¹⁹ The older functional divisions were forest management, genetics, economics, forest products, range, water, fire, insects, disease, wildlife, and recreation.

Harry Camp's time as the station's eighth director had relatively little impact on forestry research in California, but several important events occurred on his watch. First, in 1971, the California station stopped the publication of its annual report. In its place, the PSW Research Station launched in 1972 a weekly employee news-sheet entitled *For Your Information* (FYI). *For Your Information* kept employees up to date on station news (hirings, transfers, etc.), and research taking place at the Berkeley Station and other PSW Research Station facilities. Second, in the fall of 1973, the California station began the publication and printing of *Forestry Research: What's New in the West*, which was based on its earlier in-house publication *What's New in Research* (1966–1973). *Forestry Research: What's New in the West* featured broader popularized accounts of research programs and covered results not just at the PSW Research Station (California, Hawaii, Guam, and American Samoa), but at three other western stations—Pacific Northwest (Alaska, Oregon, and Washington), Intermountain (Montana, Idaho, Utah, Nevada, and part of Wyoming), and the Rocky Mountain (North Dakota, South Dakota, Nebraska, Kansas, Colorado, Arizona, New Mexico, and part of Wyoming, Oklahoma, and Texas). Copies of *Forestry Research* were distributed by each experiment station, and the primary audience for the publication ranged from Forest Service managers to employees at the forest ranger district level. Typical *Forestry Research* issues contained a focal article highlighting a particular research area for each station, plus a dozen or more brief announcements of publications of direct interest to its readers. With few exceptions, public affairs specialists wrote the articles, bridging the gaps between typical scientific writing and more easily understandable accounts that presented research results. However, scientists always reviewed the pieces to ensure accuracy (Klade and Lassen 2005). By 1979, the publication changed its name to *Forestry Research West*, and eventually just to *Forestry West*. At the PSW Research Station, notable public affairs specialists and editors in the late 1970s and 1980s included Marcia Wood, John K. McDonald, and Richard B. Pearce.

Another challenge faced by Harry Camp as station director involved the development of an employee union, which, according to Camp, was a “first” for the Forest Service.²⁰ Just holding the station together during these early organizational activities took much of his time (PSW 1990h).

²⁰ Actually, in California, agitation for better working conditions and salaries in the Forest Service went as far back as 1919, when California District 5 faced turbulent employment problems as enlisted men returned to the Forest Service seeking their former jobs, and Bolshevism threatened to spread among rangers and supervisors. At the time, many of these “agitators” were forced out of the agency (Godfrey 2005).

This EEO problem was exacerbated by the fact that for a long time, women and minorities—particularly women—were discouraged from going into forestry.

Finally, equal employment opportunity (EEO) issues were yet another very important administrative change that took place during Harry Camp's time as station director. In the early 1970s, many women and minorities in the Forest Service began to complain about discrimination in job evaluations, claiming that the Forest Service was a "white man's" organization and that women and minorities were not being given equal opportunity for job advancement. This EEO problem was exacerbated by the fact that for a long time, women and minorities—particularly women—were discouraged from going into forestry. Women tried to apply to forestry schools across the Nation, but they were often flatly turned down, or they were accepted into some schools but not allowed into the field once they were hired. These complaints came to a head in June 1972, when Gene Bernardi, a Forest Service employee at the PSW Research Station, filed a class action suit against the Forest Service alleging sex discrimination in both the hiring and the promotional practices of the Forest Service. Bernardi alleged that she was denied promotion because of her sex and that discrimination on the basis of sex was a common practice in the Forest Service. The lawsuit *Gene Bernardi et al. v. Earl Butz* was filed in federal court under the Civil Rights Act of 1964. However, the case did not go to trial. Instead, in June 1981, the parties negotiated and approved a settlement: the Bernardi Consent Decree (No. C- 73-11110 SC) (fig. 85). While denying that any of its practices were discriminatory, the Forest Service pledged under the Bernardi Consent Decree to strive to eliminate underrepresentation of women within each job series and each grade level (Godfrey 2005).

Meanwhile, in 1973, Deputy Chief of Research Keith Arnold abruptly left the Forest Service to accept a position at the University of Texas, and Chief Forester McGuire asked M.B. "Dick" Dickerman,²¹ who had been his associate deputy, to take his place. During Dickerman's short administration (1973–1975), one important research program that emerged was the 3-Bug Program of 1974, which attacked the rising insect epidemics that had begun across the country in the late 1960s and

²¹ Murlyn Bennet Dickerman earned his master's degree in forestry from the University of California in 1936, joined the Forest Service, and was assigned to the Northeastern Forest Experiment Station, where he stayed until 1941. He transferred to the Lake States Forest Experiment Station just prior to World War II; and served during the war in Washington, D.C., on loan to the War Production Board and Office of Price Administration. In 1947, he rejoined the Forest Service and was assigned to the Northern Rocky Mountain Forest and Range Experiment Station in Missoula. Dickerman became the station director for the Lake States Forest Experiment Station in 1951, but moved to Washington in 1965, where he became associate chief for research under George Jemison and Keith Arnold in 1968 (Steen 1994).



U.S. Forest Service, Pacific Southwest Research Station

Figure 85—Signing of consent decree. Front row: Station Director Harry Camp; to his left, Gene Bernardi, June 1981.

early 1970s. With a special appropriation of \$6 million, Forest Service experiment stations fought the tussock moth in the Northwest, the gypsy moth in the Northeast, and the southern pine beetle in the South, using various pesticides not specifically banned,²² as well other means, such as biological control of forest insects (Steen 1994, 1998).

In 1975, Dick Dickerman retired and Robert E. Buckman²³ (fig. 86) replaced him as Deputy Chief of Research, a position Buckman held until 1985, as long a time as the combined tenure of his three immediate predecessors (Jemison, Arnold, and Dickerman). During Buckman's decade-long tenure, he was responsible for 800 scientists at 75 laboratories organized into eight experiment stations, as well as the

²² Before 1972, DDT had been effectively used to control tussock moth outbreaks. However, in that year, the Environmental Protection Agency banned DDT use because of public outcry against the insecticide and would not grant authority for the Forest Service to use it unless the agency met certain stringent conditions, including an accelerated research program that included alternatives (Steen 1994).

²³ Robert "Bob" E. Buckman was awarded a master's degree in Forestry in 1953 by the University of Minnesota following military service in World War II and Korea. He joined the Forest Service in 1955, and earned a Ph.D. in 1959 from the University of Michigan. He worked at the Lake States Forest Experiment Station for more than a decade, but in 1965, he transferred to Washington, D.C., and eventually succeeded M.B. Dickerman as deputy chief for research (Steen 1994).



Courtesy of the Forest History Society, Durham, NC

Figure 86—Robert E. Buckman, career researcher and Deputy Chief for Research (1976–1986) whose leadership propelled passage of the Forest and Rangeland Renewable Resources Research Act of 1978, which authorized the Forest Service to conduct basic research.

Forest Products Laboratory (FPL) in Madison. Naturally, during his years in the post, he also witnessed and was involved in many important events that directly affected Forest Service research. Important statutes passed during his time included the Forest and Rangeland Resources Planning Act (RPA) of 1974,²⁴ which required the Forest Service to make an assessment of natural resource needs every 10 years and required research to provide specific information for long-term forest projects;

²⁴ The Forest and Rangeland Resources Planning Act (RPA) of 1974 required the Forest Service to periodically assess the condition and productive capability of all private and public forest and rangelands in the United States. Under the RPA, the agency was required to prepare a program that defined the share of national needs for goods, services, and amenities the Forest Service should provide through its management of national forests, state and private cooperative programs, and research. The RPA program also defined specific levels of outputs and investments for each of the nine regions of the Forest Service. To be sure outputs and investments reflected current needs and capabilities, every 5 years the RPA program was reviewed, and every 10 years an RPA assessment was conducted. The initial RPA assessment and program were completed in 1975, and the RPA program updated in 1980. In developing the national RPA program, the Forest Service sought nationwide public involvement to identify major public issues, concerns, and opportunities to be addressed and established targeted outputs (Godfrey 2005).

the National Forest Management Act (NFMA) of 1976,²⁵ which called for a comprehensive management plan for each national forest and mandated scientific studies on topics such as biological diversity; and most importantly, the Forest and Rangeland Renewable Resources Research Act (F&RRRA) of 1978,²⁶ which updated the McSweeney-McNary Forest Research Act of 1928 and complemented RPA. The F&RRRA became the Department of Agriculture's primary authority to conduct research activities. The 1978 act granted expansive authority to conduct research and technology development on all U.S. lands related to the protection, conservation, and sustainable use of natural resources. The F&RRRA also authorized competitive grants to conduct research and authorized cooperative agreements with university, industry, and other partners as needed to complement national program needs. Besides giving authority to conduct investigations into five major areas of renewable resource research—management, environment, protection, utilization, and assessment—the 1978 act expanded research activities to encompass international forestry and natural resource issues on a global scale (Steen 1994, 1998). For the remainder of the environmentally conscious 1970s, Robert W. Harris²⁷

²⁵ The NFMA, which amended the RPA, required that individual plans be prepared for the management of the land and resources of each national forest, including determination of timber harvest levels. In response to NFMA, the Forest Service issued planning regulations on September 17, 1979, that mostly were prepared by a committee of scientists. The regulations required that each national forest undergo a long-range planning process with mandated public involvement (Godfrey 2005).

²⁶ By 1978, questions regarding the interpretation of the McSweeney-McNary Forest Research Act, such as authorization of international forestry, had arisen. The F&RRRA was designed to alleviate these problems (Steen 1994).

²⁷ Robert W. Harris began his Forest Service career in 1939, while working for his B.S. in forestry degree at the University of Idaho. In 1942, after doing graduate work in forest ecology at the State College of Forestry at Syracuse, New York, he entered the military. He returned to the Forest Service in 1946 and in 1947 worked in various capacities at the Pacific Northwest Forest and Range Experiment Station in La Grande, Oregon, and then in Portland. From 1957 to 1960, he was assistant director of the Division of Range Management in Washington, D.C., in charge of a nationwide program of range allotment and analysis and management planning. From 1960 to 1971, he served as a research administrator for range, wildlife, watershed, and recreation programs in Oregon, Washington, and Alaska. In 1971, he became director of the Intermountain Station, where he was a recognized authority on methods of evaluating trends of quality on rangelands (Harris, n.d.). After he left the station, Harris became associate deputy chief of research in Washington, D.C., where his major activity was coordinating the regional/national planning effort for forestry research. His PSW Research Station experience provided significant background for this assignment (PSW 1990i).

Station Director Harris observed unequal treatment of people and abuse of administrative practices, and during his tenure he took steps to correct a class society perception within the station.

and Robert Z. Callaham²⁸ served as PSW Research Station Directors, seeing the California station through the turbulent controversies that embroiled the Forest Service at that time, such as the criticism leveled at the agency for the quantity and quality of timber harvesting in national forests. Harris (fig. 87), who served as director for only 2 years (1974–1976), came from the Intermountain Forest and Range Experiment Station in Ogden, Utah. As director of the PSW Research Station, Harris was in charge of 30 forestry and range research programs in California and Hawaii. Besides dealing with the early years of RPA—to which the station contributed through its skill in collecting and interpreting data—Harris oversaw several significant scientific developments. One in particular was the 1974 development by the Riverside Fire Laboratory of FIRESCOPE (Firefighting Resources of Southern California Organized for Potential Emergencies), a methods and vocabulary system for interagency cooperation in fire suppression. FIRESCOPE established incident command systems (ICS) that are still in worldwide use today to manage situations where groups of people need to work together in complex emergency situations, such as fire, floods, and earthquakes (Steen 1998).

One particular challenge that Station Director Harris faced came on the day he reported to the station. On that day, three station members presented him with an ultimatum and request for management reform based upon observed unequal treatment of people and abuse of administrative practices. Specifics of that challenge were sufficient to command Harris' attention, and during his tenure he took steps to correct a class society perception within the station. He and upper administrative staff members thereafter took steps to encourage administrative staff and scientific support staff to become a more visible part of PSW. In the same vein, Station Director Harris began to actively recruit minorities and women for jobs, and many minorities and women received their start or advancement in the Forest Service during this period (PSW 1990i).

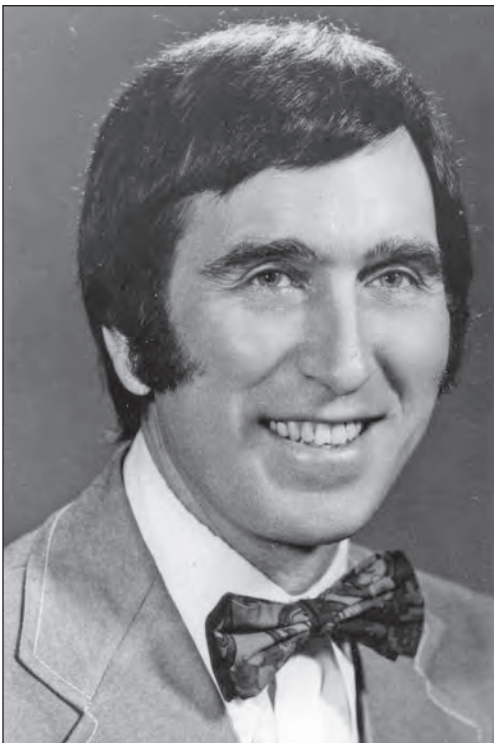
Robert Callaham (fig. 88) finished out the 1970s as PSW Research Station director during President Jimmy Carter's administration. When Callaham took over the station directorship after serving 12 years in the WO, he believed that among the eight stations nationwide, the PSW Research Station did not rank as high as he had hoped and announced that his main goal was to restore the Berkeley Station to national leadership (PSW 1990g). Nonetheless, the energetic Callaham, who spent

²⁸ Station Director Callaham began his career in the Forest Service in 1949 after receiving his undergraduate degree in forestry from the University of California (UC). In 1955, he earned his doctorate in botany, also at UC, and, except for 2 years spent at the Intermountain Research Station in Spokane (1958–1960), he was at the Berkeley Station. In 1964, he was transferred to Washington, D.C. Initially he was assigned as chief of the branch of Forest Genetics Research, but eventually served in a number of other assignments before becoming an assistant to Deputy Chief of Research Robert Buckman (PSW 1976).



U.S. Forest Service, Pacific Southwest Research Station

Figure 87—Robert W. Harris, ninth Director of the Pacific Southwest Research Station, 1974–1976. He actively recruited minorities and women for station jobs.



U.S. Forest Service, Pacific Southwest Research Station

Figure 88—Robert Z. Callaham, 10th Director of the Pacific Southwest Research Station, 1976–1983. He served while the station was at the peak of its development in terms of personnel numbers and facilities.

The PSW Research Station was at the peak of its development in terms of personnel numbers and facilities.

the early part of his career at the PSW Research Station, was pleased and proud to return as director. During the Carter administration, RPA, NFMA, and F&RRRA increased funding to the National Forest System (NFS) and gave momentum to the Forest Service research program. According to Robert Buckman, the Forest Service could not “pull off RPA without very significant research.” The years from 1976 to 1980 saw budget increases and the first overall growth of Forest Service research since the Harper/Jemison days. Fortunately for the Forest Service, Rupert Cutler served as assistant secretary of agriculture during this period. Cutler had a keen interest in the Forest Service and had a strong environmental orientation (Steen 1994).

During his first years, despite high inflation and the energy crisis during the Carter years, Callaham enjoyed a period very favorable to research. The PSW Research Station was at the peak of its development in terms of personnel numbers and facilities. In contrast to its initial modest quarters in Hilgard Hall in 1926, 50 years later the station maintained modern research centers in strategic locations in California and Hawaii. Facilities in northern California included the headquarters at Berkeley, which housed not only its administrative offices but laboratories for a number of research units; the Institute of Forest Genetics at Placerville (the first and oldest such institute in the United States); a unit at the University of California, Davis, for field evaluation of chemical insecticides; the Central Sierra Snow Laboratory (CSSL) at Soda Springs; the Redding Silviculture Laboratory, a major field unit concerned with silviculture of Sierra Nevada conifers; and the Redwood Sciences Laboratory, recently built at Arcata. In southern California, there was a field unit at the Fresno Forestry Sciences Laboratory on the campus of California State University, conducting environmental research on range-wildlife relationships and threatened and endangered species; a unit at Glendora, which studied management of chaparral and related ecosystems; and the Riverside Forest Fire Laboratory. Research in Hawaii and the Pacific Basin was centered at the Institute of the Pacific Islands Forestry in Honolulu.²⁹ In addition to these facilities, much of the station’s research was conducted in a number of outdoor laboratories. These included the San Joaquin Experimental Range, a 4,560-acre experimental forest 25 miles north of Fresno where grazing systems suited to management of annual-plant ranges in the Sierra Nevada foothills were developed, and nine experimental forests, located up and down the state. In northern California, there was the Redwood Experimental Forest 4 miles north of Klamath in the Six Rivers National Forest, with 935 acres

²⁹ The Waiakea Arboretum on Hawaii State Forest reserves near Hilo, Hawaii, was used for silvicultural studies in cooperation with the Hawaii Division of Forestry and the Hawaii Department of Social Services (USDA FS 1967).

of coast redwood and Douglas-firs, where silvicultural research in those types of trees was conducted. At the other end of California, the 12,670-acre North Mountain Experimental Area (NMEA), covered in chaparral, was located 35 miles east of Riverside in the San Jacinto Mountains, and was used for forest fire experiments and demonstrations.³⁰ Research was also conducted and carried out through cooperative agreement on other federally administered lands, on state lands, and on privately owned lands (Aitro 1977, USDA FS 1967).

Of course, as time passed, and the station's responsibilities grew, there was a commensurate expansion of the station's staff as well. By 1977, research staff included more than 100 scientists, representing more than 20 or more disciplines. The diversity of the staff—which included foresters, geneticists, botanists, biologists, plant physiologists, plant pathologists, entomologists, geologists, hydrologists, meteorologists, ornithologists, wildlife biologists, range management specialists, soil scientists, landscape architects, sociologists, economists, mathematicians, operations research analysts, and last but not least, computer specialists—graphically demonstrated the scope of the station's program. They worked in RWUs, or on special research and development programs. About 25 research teams specialized in areas such as forest genetics, timber culture and forest management, forest fire and related sciences, forest economics, forest insect and disease control, recreation and land-use planning, range management, watershed management, wildlife habitat,

³⁰ The North Mountain Experimental Area (NMEA) was established on January 8, 1964, when Public Land Order 3221 withdrew land previously administered by the Bureau of Land Management, Department of the Interior, from all appropriation under the Public Land laws, including mining and mineral leasing laws. Nearly the entire area is covered with chaparral, and is representative of low-elevation southern California interior wildlands. No unique or special features are found within the NMEA. Since 1932, nearly all of the vegetation on the experimental area has burned. A major fire that year burned over 80 percent of the area, and the Bailiff Fire in 1967 consumed 60 percent of the NMEA. Other fires have swept the area since 1983, with the result that almost the entire acreage has been burned at one time or another. Early studies at the NMEA centered on fuelbreaks and fuel properties. Plant control research was conducted in two main categories: (1) the eradication of either selective brush plants or all vegetation, and (2) the reduction of plant growth with growth-inhibiting substances. The research centered on the use of herbicides, which were believed to give the most effective and economical control of brush regrowth in established fuelbreaks. Another project, a study of shrub seed production, dispersal, and deposition on chaparral vegetation, was concerned with developing better techniques for reducing the volume of hazardous brush fuels. Other studies involved development of a low-volume shrub that would slow down or repel fires and the use of sheep to reduce fuel volume on fuelbreaks. Studies to determine fuel properties affecting fire behavior of chamise and other species were also included. The NMEA was also the site of wind pattern investigations, which compared collected wind data with predictions from theoretical models of valley convection currents. The remaining seven experimental forests included Blacks Mountain (10,332 acres), Challenge (2,250 acres), Onion Creek (2,935 acres), San Dimas (17,163 acres), Stanislaus-Tuolumne (1,485 acres), Swain Mountain (6,157 acres), and Teakettle Creek (3,200 acres) (USDA FS 1967).

The California station turned its research to the biology, ecology, and control of insects, while conducting a comprehensive investigation of chemicals already used to control pests.

anadromous fisheries, and threatened and endangered species. Their research was evolutionary rather than revolutionary, and paralleled the Nation's changing concerns for environmental resources (Aitro 1977).

Station Investigations in the Environmental Era

During the period from the publication of Carson's *Silent Spring* in 1962 to the passage of the RPA in 1978, the California Station had five station directors.³¹

Additionally, its research program transitioned from one divided into distinct "traditional" functional divisions (e.g., forest management, genetics, economics, forest products, range, water, fire, insect, disease, wildlife, and recreation) to a program based upon interdisciplinary RWUs that addressed critical problems such as smog or erosion.

Following the publication of *Silent Spring*, the evaluation of chemicals for the control of forest insects was an important research topic. Chemical insecticides had been used for many years to protect forests against destructive insect pests, but station scientists had long recognized that these uses could affect organisms other than the target insect, thus disrupting biological systems in ways that were only partially understood. The California station, like other Forest Service experiment stations in the post-*Silent Spring* years, therefore turned its research to the biology, ecology, and control of insects, while conducting a comprehensive investigation of chemicals already used to control pests. By 1965, nine lines of investigation were underway, targeting defoliators such as the Douglas-fir tussock moth, and the spruce budworm (the most widely distributed and destructive defoliator in North America). The station's interdisciplinary, multifaceted insect research program included entomology, chemistry, toxicology studies, spray physics and formulation, plant and insect biochemistry, field operations, equipment development, biostatistics, and ecological studies. The California station's ultimate goal was to develop a control strategy that minimized damage to the forest—one designed to provide land managers with a wider choice of approaches to the problem (USDA FS 1965a).

A successful insect control strategy however did not mean total reliance on chemicals. It also included biological and silvicultural control methods—such as sanitation-salvage logging, which was widely used against the western pine beetle—to provide ways to check losses. Other approaches to insect control

³¹ They were John R. McGuire (1963–1967), Robert D. McCulley (1967–1971), Harry W. Camp (1971–1973), Robert W. Harris (1974–1976), and Robert Z. Callahan (1976–1983).

included virus and bacterial treatments³² and sex attractants, as investigations sought to find substitutes for DDT and other insecticides for use against forest defoliators. For instance, in 1964, the PSW Research Station began an enhanced research program in insecticide evaluation. Under the direction of Arthur D. Moore, its goal was to develop safer chemical and other treatments for forest insect control. Staff assigned to the team included entomologists, chemists, a plant physiologist, an insect biochemist, an ecologist, plus laboratory technicians and other specialists. In 1966, noted organic chemist Julius Hyman³³ joined the Berkeley group as an advisor and leased his laboratories for much of the work on the development of Dow Chemical's Zectran, a nonpersistent carbamate insecticide found to be highly toxic and selective against the spruce budworm (PSW 1966b; USDA FS 1966a, 1968c, 1968d). In the 1960s, Station scientists also conducted research on stabilization of the insecticide pyrethrins,³⁴ derived from pyrethrum, a daisy-like flower that was grown in China as early as 2,000 years ago (PSW 1972b). Meanwhile, George R. Struble, an entomologist with the station since 1931, evaluated biological studies and techniques for measuring insect populations, and reviewed chemical control methods he had studied at Yosemite National Park, where a needle-miner epidemic in 1947 had ravaged 20,000 acres. In this case, malathion proved the most effective "stop-gap" measure, but Struble concluded that the best chance for protection in the long run was the use of natural enemies of the needle-miner, such as certain parasite species (PSW 1967d). At the same time, plant physiologist Carl E. Crisp, with the Berkeley insecticide evaluation research team, worked on designing a "systemic" insecticide—a highly specialized molecule that could penetrate plant foliage, travel inside the plant to where insects were feeding, and then collect in sufficient quantities to kill them (PSW 1968c). Alongside this stealthy "poison pill" approach,

³² In the mid-1970s, there was hope that micro-organisms would prove to be a safe and sound tool for pest management of insects such as the tussock moth. One major concern was whether or not they would be harmful to wildlife or humankind when sprayed in the forest (PSW 1974c).

³³ Julius Hyman graduated from the University of Chicago in 1922, formed his own company by 1931, and after World War II created the insecticide chlordane, which was four times as effective against houseflies as DDT. In 1952, he sold his company to Shell Oil and established Hyman Laboratories in Florida, but moved to Berkeley in 1958 (PSW 1966b). By 1967, the station listed the Hyman Laboratory located at 2840 8th Street in Berkeley as one of its project locations (USDA FS 1968c).

³⁴ Prior to World War II, pyrethrum flowers were a known insecticide with Japan as the leading exporter. But when the war cut off supplies, people turned to using DDT and other chlorinated hydrocarbon insecticides instead. By the early 1970s, PSW Research Station scientists "rediscovered" pyrethrins in their search for new and safer substitutes for DDT. In 1969, the station tested the ability of pyrethrins to control insect outbreaks, and results were quite satisfactory. It was found to be highly toxic to many insects, but harmless to mammals, aquatic insects, and fish (PSW 1972b).

The station hoped that insect control by sex attractants, and other natural chemicals, could be cheaper, easier, and used on a broad scale.

entomologist William D. Bedard³⁵ used “love” to control the western pine beetle. In 1967, scientists had discovered compounds that attracted common bark beetle pests (fig. 89). With this discovery, the PSW Research Station tested these artificial sex attractants in the woods by placing the compounds in “sticky” traps. The beetles picked up on the odor and were caught in the mesh as they tried to fly away. Initial tests were so successful that the Miami Forest Insect Laboratory began a full-scale field test in 1968. The station hoped that insect control by sex attractants, and other natural chemicals,³⁶ could be cheaper, easier, and used on a broad scale, much like the popular use of lindane at the time (PSW 1968a; USDA FS 1968a, 1969b).

While this work was underway, the California station participated in the nationwide 3-Bug Program and in 1974 began cooperative research on the Douglas-fir tussock moth, which had become a serious problem in northern California starting in the summer of 1964 (Hall et al., n.d.). Although the tussock moth was the target organism, woven throughout the station’s program was a continuing thread of concern for other forest life—insect-eating birds, fish, and other aquatic life, pollinating insects, and insect predators that might prey on the tussock moth or other forest pests. (fig. 90) The safety of these organisms had to be established before the Environmental Protection Agency (EPA)³⁷ approved and registered an insecticide for use in controlling any insect pest. Pacific Northwest Research Station researchers assigned to conduct field tests of chemical insecticides for the nationwide tussock moth program, an assignment unique within the Forest Service research organization, felt they had a high potential for controlling destructive forest insects. Three years of field experiments and monitoring test plots pre- and postspraying that started in 1976—along with hundreds of hours of laboratory analyses by PSW Research Station scientists led by Patrick J. Shea, and cooperators such as the United States Fish and Wildlife Service and several universities—resulted in

³⁵ William D. Bedard was in charge of the Miami Forest Insect Laboratory from 1964 to 1971. He, Paul E. Tilden, and David L. Wood of the University of California at Berkeley studied pheromones of the *Ips* beetle and western pine beetle from 1967 to 1982. There were field tests to identify and confirm pheromone components that might help protect trees from bark beetle attacks. In 1971, Tilden was placed in charge of the facility, a position he held until he was transferred to Berkeley in 1982 (Tilden 1983).

³⁶ By the early 1970s, the station turned toward natural over chemical insect control. For instance, in 1973, Richard H. Smith, an entomologist at the Berkeley laboratory investigated limonene, a colorless, lime-scented chemical found in the xylem of ponderosa pine, which appeared to make trees with a high percentage of this chemical resistant to western pine beetle attacks (PSW 1973; USDA FS 1969b).

³⁷ In July of 1970, the EPA was created in response to the growing public demand for cleaner water, air, and land. The EPA was given the power to establish and enforce environmental protection standards, to conduct environmental research, to provide assistance in combating environmental pollution, and to recommend to the President new policies for environmental protection.



U.S. Forest Service, Pacific Southwest Research Station

Figure 89—Testing artificial sex attractant as an insect control strategy, 1967.



U.S. Forest Service, Pacific Southwest Research Station

Figure 90—Collecting foliage samples, 1977–1978.

In the environmental research era, air pollution became a significant new research area.

the EPA registering Sevin-4-oil for use in controlling Douglas-fir tussock moth, and Orthene for use against western spruce budworm. Nonetheless, in the end, they also learned that the myriad variables involved in the life sciences made the search for answers to seemingly simple questions, such as the impact of a chemical on insects, birds, and animals, far more complex than was apparent in the beginning (McDonald 1979, USDA FS 1978).

In the environmental research era, insecticides were not the only field of research in California. For a time in the late 1960s, air pollution became a significant new research area. Robert V. Bega, a station plant physiologist, began looking into the problem as early as 1958, but it was not conclusively diagnosed as smog³⁸ until 1962. Even then, it was not until 1968 that the station began to monitor smog levels in cooperation with the United States Public Health Service. Using aerial and satellite photographs, the remote-sensing team noted that thousands of ponderosa pines in the Lake Arrowhead area, in the San Bernardino Mountains 60 miles southeast of Los Angeles, and perhaps the famous Torrey pines at Torrey Pines State Park, were dying from human-made pollution. Of course no research program could possibly cure the trees without getting rid of the smog, but Forest Service scientists like Paul R. Miller, who headed the station's smog research program at the University of California at Riverside, hoped to determine where damage was occurring, find individual trees not susceptible, and find others that were highly susceptible to be used as "indicator" trees. By 1969, an aerial survey revealed that 1.3 million trees were being killed or injured by smog in the San Bernardino National Forest alone. Thereafter, the station worked on developing a system for nationwide detection and evaluation of smog damage in forest and agricultural areas (PSW 1968f, 1968g; USDA FS 1966a, 1967, 1968a, 1969b).

Besides air pollution, water management in the snow zone (above 5,000 feet in the southern Sierra Nevada and above 3,500 feet in the northern Sierra Nevada and Cascade Mountains) also became an important aspect of the station's environmental research program. At the CSSL, and field study areas at the Swain Mountain, Onion Creek,³⁹ and Teakettle Experimental Forests and other facilities, snow zone research

³⁸ Smog destroys the chlorophyll in the leaf tissue and speeds up the aging process. The first symptom is a yellow needle mottle, which gradually spreads to whole clumps of needles, beginning with the oldest needles. Gradually, younger and younger needles are affected. As needles drop, the tree becomes thin and spindly, dying of the blight, or in its weakened state, can be finished off by beetles or other pests.

³⁹ The Onion Creek Experimental Forest was established in 1958 in the north drainage of the American River on the Tahoe National Forest west of Truckee, California, to develop techniques for increasing water yields from forested lands in the Sierra Nevada snow zone. Research at Onion Creek covered the relationship of Sierra Nevada snow dynamics to the red fir-white fir ecozone, and also involved the use of meteorological and streamflow data to develop and calibrate rain-on-snow models (Adams et al. 2004).

reached its peak. These investigations included studying the effect of vegetation manipulation on snow accumulation and melt, on streamflow, and on sediment production and reduction. The purpose of this research was to increase the water-yielding potential of the Sierra Nevada (PSW 1972c; USDA FS 1963, 1968a, 1969b, 1972a).

To learn how to control snowmelt, CSSL and other scientists first studied the way snow accumulated and melted. Since 1909, snowpack scientists had relied on a device called the Mount Rose snow sampler, invented by James E. Church, who also performed the first snow studies in California. However, Church's device was limited because it measured only snow density or water content, and destroyed the site for further tests. Scientists, such as those at CSSL, needed to know many other factors, such as how rain affects snow, how water moves through the snow, and how different layers in the snowpack absorb water. So in 1964, CSSL researchers developed a new device that gave them a complete snowpack profile. The "Nuclear Profiling Snow Gage," designed by James L. Smith and Donald W. Willen, gave them the fourth dimension to snow surveys they were seeking. The device used a radioactive source—cesium 137—to determine this information and was patented in 1973 by the United States Atomic Energy Commission, which financed much of the research. By 1972, many snow and water hydrologists used the radioactive probe for research, flood forecasting, streamflow, and avalanche hazard prediction (PSW 1972c; USDA FS 1963, 1968a, 1969b, 1972a). Other studies on snow hydrology conducted by the CSSL under the leadership of Henry Anderson, who had succeeded James Smith as project leader in 1964, included the study of suppression of evaporation from the snow surface using hexadecanol, the investigation of soil water movement rates, research on the management of shadow sources for controlling solar light and heat, a methodology for calculating the extent of boundary shading for any combination of date, slope, and aspect in the contiguous United States, and calculation methodologies for estimating snowpack density in wilderness areas by measuring albedo, or reflectivity (PSW 1979b; USDA FS 1967, 1986b).

Meanwhile, California water resource planners recognized that long-range state water needs required the exploration of all feasible alternatives for providing adequate supplies. This included enhancing California's water supply through cloud seeding using dry ice pellets. In 1975, an interagency agreement between the Bureau of Reclamation, the PSW Research Station, and the state of California for the "Sierra Ecology Project" was signed. This study assessed the effects of additional snowfall and meltwater on components of central Sierra Nevada's forest ecosystem. James Smith headed the Sierra Ecology Project until 1981, when Neil H. Berg succeeded him as coordinator. The project continued until at least the

mid-1980s (USDA FS 1986b). By the time the Sierra Ecology Project was underway, the Snow Zone Hydrologic RWU operated the CSSL year round. Monthly snow measurements (January to May) were used by forest managers, hydrologists, weather forecasters, flood control agencies, as well as reservoir managers and all major water suppliers and hydroelectric power companies in California to estimate the water content of snowpack, and to predict how much runoff streams and rivers would receive when the snow melted. For the remainder of the 1970s, CSSL continued its research program of gathering snowmelt statistics and soil moisture content data. The CSSL crew gathered the latter information at its Teakettle and Onion Creek locations, which were critical to many forest management activities such as logging and planting. Five types of forest soils were monitored, with the goal being to use measurements of air temperature, streamflow, precipitation, and other environmental factors to predict how wet a soil would be at any given time. Although the results of these studies were primarily applicable to the Sierra Nevada, many of the experiments carried out at CSSL were of interest to researchers worldwide (Gordon 1982).

In the 1970s, SDEF staff continued to study hydrophobic soils and their formation in mountain watersheds, but with little progress.

Besides studying snow zone water management, the PSW Research Station continued to conduct research on the management of southern California brushland watersheds at the San Dimas Experimental Forest. By 1963, the SDEF was finally beginning to recover from the 1960 Johnstone Fire. In the intervening 3 years, SDEF staff had successfully shifted their attention to the problems of postfire erosion. In that time, they learned that many normal soils had become highly water repellent after being burned by forest fires. This caused increased runoff and erosion in the watershed (PSW 1967c, USDA FS 1965b). Researchers at Glendora, such as Raymond M. Rice, believed that water-repellent soils were responsible for much of the excessive runoff and erosion that occurred after wildfires, as well as the swiftness with which even small amounts of rain could cause erosion on burned hillsides. Scientists at SDEF experimented with ways to break up the water-repellent layer, trying various treatments such as wetting agents; but from their research on these “hydrophobic” soils, they learned that there were no simple answers to this problem. They would not find one during the 1960s (PSW 1969d; USDA FS 1963, 1968c, 1969b).

In the 1970s, SDEF staff continued to study hydrophobic soils and their formation in mountain watersheds, but with little progress (fig. 91). They therefore turned their attention to other watershed problems, such as soil slippage on converted grasslands. In this endeavor they were more successful. Post-Johnstone Fire research determined that conversion of native chaparral to grass greatly increased the chance of soil slippage on steep slopes (FS 1966a). The 1970s also saw a change



U.S. Forest Service, Pacific Southwest
Research Station

Figure 91—Scientist studying “non-wettable” soils in laboratory.

in SDEF research owing in part to increased participation by the staff and faculty of nearby California Polytechnic State University in San Luis Obispo and Pomona College in Claremont. New cooperative ventures focused on the effect of fire on animals, on soil micro-organisms and their responses to fires, and the effect of fires on chaparral growth. These new fire research efforts supplemented the Forest Service’s long-term research into vegetation management, erosion control, water quality, fire prevention, and streamflow studies that had been monitored since the early days of SDEF. In 1972, the 1,370-acre Fern Canyon Research Natural Area (RNA) was set aside so that scientists could compare it to the managed and manipulated areas in other parts of SDEF. Throughout the late 1970s, numerous scientific papers, based in part on SDEF research on mountain watersheds and water yield, fire effects and ecology, soil and slope stability, and vegetation management, were presented at symposia. In fact, in 1976, SDEF became part of the United Nations-sponsored “Man and the Biosphere” program, and scientists from the United States and other nations carried out research studies using its facilities. By 1980, the Ecological Institute of America had also designated SDEF as an “Experimental Ecological Reserve.” Over the course of nearly 50 years, SDEF had certainly met its primary objective of providing an experimental area where problems in hydrology, erosion, and associated processes could be studied on a scale ranging from the laboratory, through use of plots, to entire watersheds of various sizes (Dunn et al. 1988, Robinson 1980, Storey 1982).

Five percent of the fires caused most of the damage in California.

The subject of fire research was just as complex as watershed research, and no less important. With the dedication of the Forest Fire Research Laboratory at Riverside in 1963, the third fire laboratory in the Nation,⁴⁰ much of the station's fire research was moved there. James L. Murphy, Clive M. Countryman, Mark J. Schroeder, Lisle R. Green, and James B. Davis worked on fire control systems planning, forest fire behavior, fire meteorology, modification of chaparral fuels through the use of fuel breaks, and fire control tactics under the leadership of assistant director for forest fire and engineering research Carl C. Wilson (USDA FS 1963, 1964a, 1965b). In 1966, the Riverside Laboratory also directed its efforts mainly at problems associated with large fires through Project FLAMBEAU, which fell under the direction of program manager Edward M. Gaines. At this time, according to a station publication entitled *Stopping the Big Ones...Through Fire Research* (USDA FS 1966c), 5 percent of the fires caused most of the damage in California. Project FLAMBEAU's goal was to gain an understanding of the factors associated with "mass fire" behavior by describing and scientifically measuring such phenomena (USDA FS 1966a, 1966c). The Office of Civil Defense and the United States Defense Department contracts, which materially aided Project FLAMBEAU, were signed with these agencies because they shared mutual interests in the behavior and control of mass fires.⁴¹ In 1965, Station Director John McGuire, through a staff realignment, permitted the station to not only meet the needs of California clients, but to work with other regions on specific fire research problems, such as fire meteorology with Region 4 (Intermountain) and minimizing the impact of slash burning on atmospheric pollution with Region 6 (Pacific Northwest). Furthermore, considerable work was conducted at this time on the use of helicopters in fighting fires, including the use of helitankers to drop fire retardants and the perfection of helicopter night flying through advanced technologies developed during the Vietnam War.⁴² Other assignments for the scientists at Riverside included the first effort to bring the computer to the fireline in Project INFORMAP, a computerized display of information such as topography, fuels, and location of roads and firebreaks on maps—data that was vital to the dispatching of men and equipment to forest fires.

⁴⁰ The other two forest fire laboratories were in Missoula, Montana, and Macon, Georgia.

⁴¹ Much of this work on fire effects of nuclear attack is listed in Hostetter 1966.

⁴² Research on night helicopter flight was a cooperative effort between several agencies, including the United States Army Night Vision Laboratory, Los Angeles County Fire Department, California Department of Forestry, the Bureau of Land Management, and private industry, such as the Aerospace Corporation. Its main goal was to use military technology in developing a helicopter system for detecting and fighting forest fires at night, including the use of night vision goggles and FLIR—a forward-looking infrared system that allowed pilots to look at video screens in the cockpit to see a daylight picture of whatever was in the infrared scanner's field of view (PSW 1974b, 1975a).

A year later, in 1968, the California Division of Forestry in San Bernardino tested this computer-fire dispatch system, the first of its kind in the world. Although it proved highly useful in helping fire bosses make decisions about the best use of limited manpower or equipment, researchers planned improvements that would make it faster, cheaper, and more foolproof (PSW 1966a, 1968d; USDA FS 1963, 1966b, 1967, 1968c, 1969b, 1971; Wilson and Davis 1988).

Despite these achievements in fire research, the 1970 fire season incinerated any smugness that had been built up by station fire scientists. Known as the “Big One,” virtually the entire southern California region was afire at one time or another. Tinder-dry fuels and Santa Ana winds blowing up to 70 miles per hour combined to produce the greatest number of large-scale fires burning out of control at one time in California’s history.⁴³ The 1970 fire season resulted in 16 lives lost, 772 structures destroyed, and over 500,000 acres charred. These devastating fires proved to be a major turning point in stimulating fire research at the station. In the aftermath of the fires, a groundswell of interest in forest fire research developed in southern California, and major political and moral support emanated from Sacramento and Washington, D.C. For instance, in California, Governor Ronald Reagan appointed a Task Force on California’s wildland fire problem, and in Washington, D.C., Deputy Chief of Research Keith Arnold, who had overseen Operation FIRESTOP in the early 1960s, soon provided excellent support for fire research in California (Wilson 1984).

From the 1970 fire season, the Forest Service learned that things just did not work well when it had as many fires as occurred that year. One particular problem was communicating with other agencies because each one used different radio frequencies and terminology. To alleviate this problem and others, the PSW Research Station led by program managers Stan Hirsch and Bob Irwin undertook Project FIRESCOPE (Firefighting Resources of Southern California Organized for Potential Emergencies) along with Region 5, the California Division of Forestry and southern California fire agencies from Los Angeles, Santa Barbara, and Ventura Counties. This was one of the most ambitious cooperative studies embarked upon

From the 1970 fire season, the Forest Service learned that things just did not work well when it had as many fires as occurred that year.

⁴³ “During one week in late September to early October, more than 524,000 acres of valuable watershed, timber and recreation lands were destroyed by separate blazes in Central and Southern California. Of this acreage, 207,000 were national forest land that burned on five national forests (Los Padres, San Bernardino, Angeles, Cleveland and Sequoia). During the height of the Laguna Fire on the Cleveland National Forest, which burned 185,000 acres, more than 2,000 men battled the blaze, including Forest Service and Native American crews from Regions 1, 3, 6 and 8. Thirteen persons lost their lives in fire-related incidents. Five of the thirteen were killed in a helicopter crash on the Fork Fire on the Angeles National Forest” (Godfrey 2005: 471–472).

FIRESCOPE required that the terminology for all agencies be consistent and, when fires occurred, that resources closest to the fires be used, regardless of the agency's protective responsibility.

by the Riverside Forest Fire Laboratory. One objective of the FIRESCOPE program was to provide fire managers at all levels with the information needed to make prompt decisions. Another objective was to coordinate the efforts of southern California fire protection agencies and facilitate their working together on major wildland fires, rather than protecting their own areas. Essentially, the FIRESCOPE program developed the methods and the vocabulary for interagency cooperation, resulting in an ICS that managed a wide range of activities when multiple groups of firefighters needed to work together in complex fire situations. This required that the terminology for all agencies be consistent and, when fires occurred, that resources closest to the fires be used, regardless of the agency's protective responsibility. FIRESCOPE also led to computerized dispatch centers shared by the Forest Service and the California Department of Forestry and Fire Protection (Godfrey 2005).

By 1974, research was underway by the Forest Service and its cooperating agencies to complete FIRESCOPE'S three-part action plan for fire management for the wildlands of southern California. Part I, system policy and operations, sought to establish a coordinated concept that could be fitted to the legal, procedural, and political requirements and constraints of all agencies, and to specify system performance requirements for resource status, situation assessment, logistics, communications, decision criteria, and other operational needs. Part I also developed uniform procedures, terminology, and training standards. System development, the purpose of Part II, translated system performance requirements into hardware and software design, and evaluated existing fuel, meteorological, fire spread, and other applicable models. It also improved or initiated new development work as needed, determined total system communication requirements, and developed a coordinated system for information transfer and display at field incident, coordinating center, and agency headquarters levels. Part III, system fabrication and installation, begun in 1976, procured and installed the hardware; Forest Service managers to employees at the ranger district level acquired and stored the required database information on fuels, topography, fire suppression resources, and transportation networks; prepared detailed computer programs for data collection, storage and retrieval, and model processing operations; and finally, developed training programs to prepare agency personnel for system implementation. No program in the Forest Service ever started smaller and got bigger over time

than FIREScope.⁴⁴ The ICS, which was the primary FIREScope product,⁴⁵ has today been adopted throughout the country and worldwide where multiple agencies or multiple jurisdictions are involved in earthquakes or other emergency situations (Godfrey 2005, USDA FS 1974).

There were other byproducts of the 1970 fire season. Certainly, there was an increased effort to better understand Santa Ana winds⁴⁶ and their effects on fire weather and on fire behavior. After the 1970 fire season, Carl C. Wilson, Assistant Director for Fire Research at the PSW Research Station, plainly stated, “Under really bad weather conditions, a fire is just going to burn until it runs out of fuel.” In his opinion, the real problem was forest fuels. “Unless we break up the large expanses of flammable fuels for protection of individual homes and communities, we can expect to have these fire disasters during critical fire weather” (PSW 1971). Of course, no one could stop a Santa Ana wind from blowing, but fire control specialists could do something about forest fuels, the other major factor that affects fire ignition and spread. So station fire research scientists intensified their investigation of forest fuels modification, such as stands of chaparral, which can have 10 to 40 tons of fuel per acre or more, in order to reduce the number of really big “disaster” fires in California. Station staff J.S. Horton and Charles Kraebel began the study of fuels management in 1927, and in 1955 published *Development of Vegetation After Fire in Chamise Chaparral in Southern California* (Horton and Kraebel 1955), which was still considered one of the best references available on the subject as late as 1970. They advocated managing and protecting chaparral in southern California

⁴⁴ The FIREScope program, developed by the station in cooperation with California state, county, and city fire agencies was eventually turned over to the Forest Service State and Private Forestry branch for implementation and then taken over by the state, which became responsible through its Office of Emergency Service for its maintenance as an interagency fire coordinating system. The Forest Service Pacific Southwest Region continued to be one of the system’s funding agencies. In 1987, the FIREScope program received a plaque from the United States Federal Emergency Management Agency for its exemplary practice in emergency management (PSW 1987b).

⁴⁵ As a precedent to FIREScope, the station had also developed a computer-simulation model to evaluate alternative fire management organizations. It was designed to model all possible fire agency configurations. The Sequoia National Forest was one of the first to test FOCUS in the field, and helped that forest configure the best organization of resources such as air tankers, helicopters, crews, and engines for fire management. This saved the Forest Service much time and money in fire suppression efforts (Godfrey 2005). “Although the model was used on several national forests, its large data requirements and complexity made it intractable for many users” (Wilson and Davis 1988).

⁴⁶ Santa Ana winds are very warm, dry winds, or “foehns,” that blow across mountain ranges and down the lee slopes. Foehns (pronounced firns) occur in nearly all mountain ranges throughout the world. Mark Schroeder, who headed the Riverside Fire Laboratory’s meteorology studies in 1970, described them as perhaps the “most critical fire weather problem anywhere in the world” (PSW 1970b: 7).

from wildfire for fire/flood control reasons, which inadvertently contributed to a dangerous and unnaturally heavy buildup of dead fuels. After the 1970 fire season, the PSW Research Station realized the errors in this approach and formed the Chaparral Management RWU at Riverside and Glendora, California. The RWU's mission was to develop a fuel science management program that first searched for alternative, fire-resistant groundcovers to replace California's chaparral, and second, found ways to reduce current fuel buildup in southern California through prescribed fires,⁴⁷ the use of herbicides, or other means, including experimenting with the grazing of goats along fuelbreaks in critical areas (fig. 92). Toward these ends, from 1971 to the early 1980s, station fire research scientists concentrated their attention on a chaparral inventory system, evaluation of postfire erosion rates, and information on photosynthetic rate and water needs of several important chaparral species, all of which set the stage for future site-specific forest fuels modification research projects (PSW 1971, 1983d; USDA FS 1971; Wilson and Davis 1988; Wood 1978a).

Fire research made good use of computer calculating power in its endeavors, such as the ICS, and the PSW Research Station led Forest Service research in advancing the use of computer technology in many other ways. For instance, in 1963, David A. Sharpnack developed a computer model to test L.R. Grosenbaugh's suggestions for better sample-tree-measurements outlined in *STX-Fortran 4 Program—For Estimates of Tree Populations from 3P Sample—Tree Measurements* (Grosenbaugh 1964). Another example was a computer simulation model for projecting participation in major forest recreation activities developed by staff social science analyst Stanley Naparst. In recreation, computers were also used to estimate the effect on recreation use of changes in urban population and to predict winter sports use, either existing or proposed. Practically every discipline began to use computer technology. For instance, in 1968, Elliott L. Amidon and Gary Elsner developed a computer mapping system that retrieved and gathered map data and associated quantitative information from other sources to create map overlays. Eight years later, their earlier work was refined into VIEWIT, a computer program that allowed planners to predict how a new road, timber sale, or other proposed use

⁴⁷ Starting in the late 1950s, the PSW Research Station found that various staff members were speaking out against prescribed burning. Despite the early history of Forest Service opposition to "light burning" in the 1910s and early 1920s, the station became interested in using prescribed burning as a method of fuel hazard reduction in eastern pine stands, and conducted several experiments at that time. But after the experiments, station staff concluded that broadcast burning was not feasible in these stands either for fuel hazard reduction or for thinning young-growth stands because they felt that they could not control the fires (Gordon 1982).



U.S. Forest Service, Pacific Southwest Research Station

Figure 92—Goats grazing fuelbreaks, 1979.

would affect the way a forest landscape would look under as many as 14 options. Computers also helped IFG geneticists to analyze 30 years' worth of collected data for a ponderosa pine growth performance study at three Sierra Nevada elevations (PSW 1975b; USDA FS 1963, 1967, 1968a, 1969b).

Finally, the Management Sciences Staff (MaSS) used computer programs, such as the Planning-Programming-Budgeting System, to develop a range of alternative budget choices for California's national forests, while a second research group concentrated their attention on the development of the Resource Allocation Model to prepare long-range multiple-use plans for wildlands and to determine the forest cutting schedules that best fit a land manager's goals. The MaSS had been administratively established and assigned to the Berkeley headquarters in November 1962 in an agreement between PSW Director R. Keith Arnold and the WO. The MaSS was an internal think tank for the Chief's office and was charged with conducting rigorous, long-term, often sensitive studies that were of high importance to the agency, and differed from the work of the Washington Office Policy Analysis staff, whose assignments were usually on a shorter timeline. The staff served as management sciences consultants to all branches of the Forest Service, and was the only unit of its kind in the agency. The MaSS grew over the years to become the home—temporarily, for the most part—of some 100 employees: scientists and other professionals, business managers, support workers, and students. During its existence, MaSS conducted more than 110 major studies and provided more than 125 major

Management Sciences Staff (MaSS) used computer programs to develop a range of alternative budget choices for California's national forests.

consultations. Its members published some 140 papers, articles, and reports. About half of these were in-house documents covering a wide variety of topics in the management sciences, including physical, social/economic, behavioral, and mathematical sciences. In a multidisciplinary organization, which proudly counted 26 disciplines at one time, its lasting contribution was the demonstration that management sciences could be used to refine and sharpen the effectiveness of Forest Service decisionmaking. The PSW Research Station provided MaSS with an enriching and supportive environment for 26 years⁴⁸ (PSW 1988j).

By the mid-1970s, station computer use became even more sophisticated. In 1973–74, station and Region 5 information services staff members put together a library service especially designed for California foresters called CALFORNET (California Forest Research Information Network). They felt that too many useful research findings were simply gathering dust on library bookshelves because researchers were unaware of their existence. Based upon interlibrary loan cooperation, CALFORNET included collections not just at the Berkeley Station, but those at the University of California, School of Forestry and Conservation and the university's Forest Products Laboratory. Credit for creating the program goes to Bruce Yerke, in the station's science literature service, and Al Groncki, general assistance officer for Region 5's division of State and Private Forestry. Eventually the list of cooperating libraries included in CALFORNET grew to include University of California campus branch libraries, corporation libraries, and the National Agricultural Library in Beltsville, Maryland. Access to the system was granted to Forest Service employees, University of California graduate students and faculty, California Division of Forestry employees, and to industrial consultants, extension

⁴⁸ Funding and guidance on choice of studies came from the Chief's office. Staff scientists were responsible for applying the latest theories and methods in the management sciences to solve Forest Service problems and to improve decisionmaking within the agency. The MaSS studies dealt with fast-moving emerging and complex issues for which the agency wanted an examination of the basis of the issue, a rigorous analysis of the factors influencing the issue, and implementable recommendations. Some of the major multiyear studies included designing models for evaluating aircraft used in fighting wildfires; land management planning and budgeting models, and designing and evaluating effectiveness of public involvement models. The MaSS also did strategic analysis of information flow within the Forest Service, especially focusing on how the management of policy and direction would be changed by the implementation of the Data General distributed information system, the largest distributed information system in the world at the time, that connected every Forest Service unit and every employee across the agency. Members of the permanent professional staff and their specialties included Ernst Valfer, staff director and engineering and psychology; Daina Dravnieks, natural resource economics, geography; William A. Hager, civil engineering, forestry; Ernest Hirsch, operations research; Robert Hubres, forestry, land-use planning; Malcolm W. Kirby, operations research, industrial engineering, business administration; Stephen Laner, psychology, operations research; Gideon Schwarzbart, mathematical statistics, operations research; Dwain C. Wegner, operations research, mathematics; and Peter Wong, transportation engineering and mathematics (Dravnieks 2007).

foresters, faculty members at schools of forestry, and instructors of college-level courses on land-use management (PSW 1974a). Around the same time, PACFORNET (Pacific Coast Forest Research Information Network) was developed. It allowed librarians and technical information specialists to conduct literature searches or to track down materials that might help solve a particular problem in wildland management or other research subjects. If little was written on the subject, PACFORNET put California, Hawaii, and the Pacific Northwest researchers in touch with other scientists or specialists who might be doing similar research⁴⁹ (Wood 1979c).

Pacific Southwest Research Station staff members welcomed the ability to easily conduct computer literature searches, especially because of new environmental considerations regarding topics like outdoor recreation, which concerned many Californians. In 1960, John R. McGuire, then head of the station's forest economics division, implemented a recreation research program at the Berkeley Station, the second program of its kind in the Forest Service—the first being established at the Northeast Experiment Station only months earlier. But it was Robert H. Twiss who headed the program throughout most of the 1960s, and who made recreation studies an important research field in California (Aitro 1977, Camp, n.d.).

Under the direction of Twiss, California recreation research was greatly affected by two factors: explosive population growth and competition for public lands. The highest priority was assessing recreational use in the national forests and determining its place in the multiple-use picture. Early researchers on the subject initially attempted to define a recreation unit of use and how best to record and evaluate it. But under Twiss, recreation research involved a number of subjects related to ecological trends in recreation areas. Studies ranged from better understanding of visitor activities and needs in national forests, to studying the environmental impact of visitor use on campground soil and vegetation conditions, picnic areas, and trails, as well as other forest resource uses, such as logging and grazing. The station investigated trends in the use of outdoor recreation sites that helped managers operate city camps in forest areas, and other studies sought ways to foster plant growth in heavily used recreation areas where conventional reforestation methods were ineffective. On the problem of maintaining and enhancing recreation sites, or researching techniques of rehabilitating recreation sites that were over-used and hence had scarce vegetation, station researchers worked closely with Region 5 forest managers. Together, they tested plant materials and cultural treatments in these difficult-to-manage sites. Recreation research also included the study

⁴⁹ In 1979, WESTFORNET replaced PACFORNET and expanded the service to include all of the Western Forest Service regions and stations (Wood 1979c).

of visual or scenic aspects of forestry and related practices, and implemented new concepts of environmental design for resource management in scenic areas. For some forest environmental design projects, the station also worked closely with Berkeley's Department of Landscape Architecture, and the Department of Landscape Horticulture, University of California at Davis. For instance, in 1968, station staff worked closely with Berkeley professor R. Burton Litton, Jr., to develop a set of terms and definitions that allowed foresters, engineers, landscape architects, and others to speak the same language when it came to discussing forest landscapes (Magill and Leiser 1967; USDA FS 1963, 1964a, 1965b, 1966a, 1968c).

Floyd L. Newby led the station's recreation research program in 1969, followed by Ronald A. Oliveira in 1971. During the tenure of these two leaders, the recreation program underwent considerable change, which started when recreation research came under a new RWU designation, "Forest Recreation and Landscape Management." During this time, the PSW Research Station continued to develop methods to rehabilitate and revegetate overused recreation areas; to estimate carrying capacities as an aid in planning recreation areas; to establish criteria for assessing future recreation use, including user expectations, distances willingly traveled to a recreation source, and crowding tolerance; and to advance interpretive services. But the recreation research program languished for 2 years after Oliveira left in 1974. Then in 1976, Station Director Robert Callaham redirected the program and renamed the RWU Land Use and Landscape Planning Methodology Research. A year later, Callaham added urban forestry research to the RWU and placed the program under the direction of J. Alan Wagar. In 1979, urban forestry research became a separate RWU, but in 1981, these two projects were recombined into Landscape Management and Urban Forestry Research, again under Wagar's direction. However, the redesignated RWU emphasized urban forestry over landscape management, and this emphasis continued into the 1980s. By then, urban forestry had four major assignments: to develop better systems for planning, designing, and maintaining urban forests and related resources; to create and improve methods for selecting trees and shrubs for a variety of city conditions; to find ways to interest city residents in urban forestry; and to use technical information systems to distribute up-to-date information about urban forestry. Results of the RWU's research were intended for use by arborists, horticulturalists, landscape architects, city and regional planners, city and county park managers, tree care specialists, homeowners, and others (Camp, n.d.; USDA FS 1969b, 1977f).

Recreation research and urban forestry were new research assignments for the PSW Research Station in the environmental era, but two other very important traditional research aspects in the station's program were range and wildlife habitat

Recreation research and urban forestry were new research assignments for the PSW Research Station in the environmental era.

management. In range research, long-term experiments begun in the 1950s were beginning to show significant results a decade later. By 1963, 10 grazing seasons had passed since rest-rotation grazing management had been implemented on the Harvey Valley Allotment on the Lassen National Forest. Vegetation plots established in past years, and cattle responses within the allotment, continued to be studied and reexamined yearly by Philip Lord and William Sanderson. Over time, they compared their collected data to that on nearby allotments, which were under season-long management. By 1967, Lord and Sanderson determined that the Harvey Valley cattle had gained just as much weight from rest-rotation grazing as from season-long management, but with the added benefit of leaving the range in better condition. Senior range expert August L. Hormay continued to collect additional information for his long-term study of growth and reproduction of bitterbrush in northeastern California, while at the same time H. Reed Sanderson and Charles H. Graham studied high-elevation meadows that made up an important part of the Sierra Nevada's summer livestock range (fig. 93). Some wildlife habitat research was conducted in cooperation with the National Park Service and the University of California, which sought data to answer problems such as the effect of horse and pack stock travel, the encroachment of lodgepole pine, and the periodic buildup of meadow voles in Sequoia National Park. Further west, on the SJER, grazing scientist Don A. Duncan totaled the results in unfertilized and fertilized grazing



U.S. Forest Service, Pacific Southwest
Research Station

Figure 93—Typical
mountain meadow in
California.

They ascertained that heavy cattle grazing—properly timed—could reduce the large bunchgrass that crowded out browse seedlings without killing all grass or seriously damaging established browse.

units, which put the effectiveness of fertilizer applications in a positive light. For the remainder of the 1960s and into the 1970s, the Management of Annual-Plant and Related Ranges RWU and the Management of Perennial Grass Ranges RWU steadily continued along these and other range research lines (McDonald 1985; USDA FS 1963, 1964a, 1965b, 1966a, 1967a, 1968c).

As noted earlier, in 1965, wildlife research was joined administratively with range research, and wildlife scientists began to take greater interest in range management, simply because cattle grazing often reduced grass growth on deer ranges. Heavy livestock use in the past was thought to be largely responsible for changing the climax bunchgrass association to a sagebrush-bitterbrush on some of the Great Basin winter ranges, such as the Devil's Garden winter deer range in Modoc County. This change benefited deer, but with reduced livestock use on ranges thanks to Forest Service grazing policy in California following World War II, bunchgrass appeared to be increasing to the detriment of the browse. Before livestock grazing could be prescribed as an effective means to manipulate vegetation so as to favor browse, the station needed to know if and how they could reduce bunchgrass without killing browse (Godfrey 2005; USDA FS 1963, 1965c, 1969a). So, in 1965, station wildlife habitat researchers, in cooperation with the California Department of Fish and Game, closely studied cattle grazing habits, which they believed provided clues to better winter deer range. After 2 years of study, ecologists Don Neal and Tom Newman learned that cattle graze on the larger bunchgrass plants first, leaving smaller ones until feed is scarce. They also learned that cattle eat very little bitterbrush—a staple of the deer diet—until new twig growth starts. But in late July and early August, they learned that cattle begin to feed on bitterbrush as grass wanes. Thus, they ascertained that heavy cattle grazing—properly timed—could reduce the large bunchgrass that crowded out browse seedlings without killing all grass or seriously damaging established browse. Their studies of the competitive interaction between cattle and deer continued into the early 1980s (McDonald 1985; PSW 1968c; USDA FS 1967, 1969a).

Although the study of cattle-deer interactions preoccupied much of their time, station wildlife habitat researchers also conducted other noteworthy cooperative investigations. For example, they studied the relationship between soils, vegetation, and deer distribution along California's north coast, and changes in fish habitat and stream ecology caused by logging and road building on experimental watersheds in the Caspar Creek drainage near Fort Bragg. Under project leader Richard L. Hubbard, the station worked on these and other projects related to wildlife habitat improvement and management in the 1960s and 1970s. Additional studies included investigations of High Sierra wildlife habitat, aerial photointerpretation to evaluate

stream habitat, voice printing endangered forest birds such as the southern bald eagle, the peregrine falcon, and the spotted owl, and closely watching the California condor,⁵⁰ which station wildlife biologist Jerry Verner felt was threatened with extinction (Hubbard and Hiehle 1965; PSW 1979a; USDA FS 1964a, 1965b, 1966a, 1967, 1968c; Wood 1978b, 1979b).

Last, but certainly not least, PSW Research Station scientists continued major studies regarding forest genetics, forest resource surveys, and forest management issues related to ponderosa pines, redwoods, and red and white firs at its Redding and Arcata laboratories, as well as on related experimental forests.

In the post-1963 period, the Institute of Forest Genetics carried out its research program to develop better forest trees by applying the known science of genetics and the techniques of tree breeding, but the principal means of tree improvement continued to be selection and hybridization. The IFG pressed on with selecting trees that showed superior qualities in the forest so that their progeny might be used in planting new forests. Such trees, and cuttings from them, were also used in hybridization work, in which new kinds of trees were created by controlled pollination, combining the qualities of two parents to produce hybrid progeny with desirable characteristics. One of the first crosses, the knobcone-Monterey pine, had been spectacularly successful⁵¹ and gave early impetus to the hybridization program. However, although some hybrids were successful, by the mid-1960s, hybridization was generally proved to be a rather slow and costly means toward tree improvement. Even so, by 1965, staff members and visitors from all parts of the world had written over 255 articles about research work conducted at IFG. And, by the late 1960s, IFG had become a historic Forest Service tourist attraction. Visitors were guided along a “nature” trail that included touring the famed Eddy Arboretum, IFG’s nursery, greenhouses, and the hybrid plantations, along the way observing scientists as they went about the business of studying the improvement of pines, true firs, and other important commercial Western U.S. trees. Visitors were also taken through two “freak gardens” where unusual phenotypes were transplanted for further scientific observation (USDA FS 1965c, 1966a, 1968b).

Hybridization was generally proved to be a rather slow and costly means toward tree improvement.

⁵⁰ “In 1964, Region 5, in cooperation with the Audubon Society, Bureau of Sport Fisheries and Wildlife, and the California Department of Fish and Game, began a program to keep an official count of California condors at the Sespe Condor Sanctuary on the Los Padres National Forest. In 1966, that number stood at fifty-one. Subsequent counts indicated that the great birds were barely holding their own. By 1969, bird watchers tallied only fifty-three. These relatively few condors were all that remained of a population that numbered in the hundreds in the previous century, and the Forest Service and State wildlife agencies began to consider the condor in danger of becoming extinct” (Godfrey 2005: 443).

⁵¹ For instance, in 1969, 10-year-old hybrids of knobcone-Monterey pine were outgrowing ponderosa pine three to one in experimental plots at the Challenge Experimental Forest in Yuba County, California (USDA FS 1969b).

In the 1970s under project leaders Stanley L. Krugman and later F. Thomas Ledig, IFG's research program turned away from hybridization and began to investigate tree physiology, reproduction, and other factors that limited tree growth and development because new laboratory techniques, such as starch gel electrophoresis⁵² (fig. 94), provided answers to many critical questions faster than was possible through hybridization and other long-term studies. Institute research geneticist M. Thompson Conkle pioneered this technique to separate enzymes (proteins) electrically, thereby giving him a fairly direct look at the genetics of the tree. With starch gel electrophoresis, scientists were thereafter able to determine the genetic potential of forest trees, predict the results of a given cross, and learn how enzymes related to various stages of growth in the tree without waiting 10 to 20 years or more to see hybridization experimental results. In 1979, the station even sponsored the first international symposium on the use of this technique in forest genetics, as well as in forest insect research. Besides this genetic research, the IFG placed increased emphasis on studying the mechanisms by which trees resisted attack by various insects and disease. The IFG geneticists worked closely with practicing Forest Service personnel to furnish answers to insect and disease problems such as bark beetles, white pine blister rust, and western gall rust in hard pines. In 1967, blister rust was found in the central Sierra Nevada on the Mi-Wok District of the Stanislaus National Forest—farther south than it had ever been reported. Following this discovery, IFG started to make substantial progress in producing sugar pines that were immune to blister rust (PSW 1968b, 1972a; USDA FS 1969b, 1972b, 1980a).

Great progress was made in conducting forest resource surveys in California as well, thanks also to technological advances—in this case, remote-sensing techniques. From 1963 to 1964, Ezra M. Hornibrook led Forest Resource Survey (FRS) work at Berkeley. During this period, he began the first statewide inventory of Hawaii's timber resources, while the station continued research on the soil-vegetation survey of California in cooperation with the state. In 1965, this research unit was enhanced when Robert N. Colwell and his remote-sensing team moved to the Berkeley Station from Beltsville, Maryland. A new RWU entitled "Remote Sensing of the Forest Environment" was formed. The RWU's mission was to develop sensing techniques for forestry applications using Earth-orbital vehicle photography and imaging, to research and develop aerial survey methods to detect and evaluate infestations of forest pests, and to apply photointerpretation to forest

⁵² A Canadian scientist developed the starch gel electrophoresis technique in 1955 and used it for research on blood serum proteins. The technique later became widely used in studying fruit flies, and by the early 1970s was used in medical research to help diagnose human diseases such as enzyme deficiencies (PSW 1972a).



U.S. Forest Service, Pacific Southwest Research Station

Figure 94—Forest Service technician preparing starch gel for electrophoresis, 1980.

resource inventories (USDA FS 1963, 1964a, 1965b, 1966a). By 1967, Colwell, an expert photogrammetrist, guided the PSW Station's remote-sensing research program, using Gemini mission photos to map vegetation boundaries, soil types, and a host of other ground features. By studying low-altitude color photography and using special film-filter combinations, Colwell's remote-sensing RWU could detect insect attacks before they could be spotted visually on the ground. For instance, in 1967, large-scale color aerial photographs (1: 8,000) and a stratified two-stage probability sampling design was used to survey 1.6 million acres of timber for damage from the Douglas-fir bark beetle in northern California national forests. Colwell's remote-sensing team conducted the survey in cooperation with station mensurationists and entomologists from California Region 5. Together, they determined that a high stand density of two to three times normal allowed the beetles to build up and cause damage (American Forests 1968; PSW 1967a, 1967b; USDA FS 1967). In 1968, Robert Heller replaced Colwell as project leader. Heller continued to apply Earth-orbital vehicle imagery to forestry problems, in cooperation with the National Aeronautics and Space Administration (NASA), and eventually these techniques were used to detect and evaluate air pollution damage to southern California national forests. Heller later continued this line of research with Apollo mission images (USDA FS 1968c, 1969b).

In 1970, the nationwide FRS, which had been a function of the Forest Service for over 40 years, was due for an update. Local and national planners, as well as

The remote-sensing research unit anxiously waited to see the imagery to see if it would provide faster and more accurate inventories that were vital to wildland managers who needed to make up-to-date resource decisions.

Congress, needed the FRS and its statistical analysis to better understand timber volume, growth, and harvest needs. Over time, a variety of methods had been used to increase the efficiency and reliability of sampling for the FRS, but during this time, basic techniques had changed little. On-the-ground tree measurements, coupled with the use of one level of aerial photographs, were the basic techniques used. However, since it took years to collect this data, the reports were often outdated by the time they were compiled by the Forest Service. Furthermore, in the 1970s, it was very difficult to get a good picture of the entire forest resource at one time because of rapidly changing patterns of land use coupled with a tremendous rate of wood utilization. Thanks to space-age imaging, research foresters at the PSW Research Station were technically equipped to meet the monumental task at hand. In 1970, Heller's remote-sensing unit and Philip G. Langley's forest measurement unit inventoried millions of acres of forest in Arkansas, Georgia, Louisiana, and Mississippi using space photographs along with multistage probability sampling for the first time. This experiment of sampling from space photos was believed to be the forerunner of a complete future information system that would allow the Forest Service to conduct inventories in this manner. Many optimistically looked forward to the launching of the Earth Resources Technology Satellite (ERTS), a space platform designed to collect data on Earth resources of all types, which would make it possible to gather forest data from space on a continuing basis (PSW 1970a). The ERTS-1 mission (570 miles above the Earth) took place in 1972 and was followed by Skylab (260 miles above the Earth) in 1973, both of which provided photo-like imagery of the Earth's surface. The remote-sensing research unit anxiously waited to see the imagery to see if it would provide faster and more accurate inventories that were vital to wildland managers who needed to make up-to-date resource decisions. In this they were not disappointed, for they found that although there were some data problems, and some usage limits, much of the information gathered was what they needed on the location, size, and composition of forests and rangelands (Wood 1975a).

Although space technology was fascinating, the vital research focus of the California Station since 1926 had been silvicultural research. Following the 1963 Harper-McGuire GRI, PSW Research Station Director John McGuire strengthened silvicultural research by setting up two new headquarters for such work in California. At the Redding Silvicultural Laboratory in the 1960 and 1970s, Douglass F. Roy headed up research in three of California's major timber types: pine, mixed conifer, and true firs. With a staff of eight to assist him, and a new

headquarters building and three experimental forests (Blacks Mountain,⁵³ Swain Mountain, and Challenge), Roy and later project leaders developed a wide range of timber management studies. At the Challenge Experimental Forest and elsewhere, they studied the intensive management of ponderosa pine stands, levels of ponderosa pine growing stock, as well as logging costs in young-growth pine.⁵⁴ In 1979, they issued two important publications on the ponderosa pine growth in California and related matters pertaining to moisture (PSW 1978, USDA FS 1964a).

But the most important field of research in California forestry at this time was studying red and white firs. By the late 1970s, California true firs provided one-fourth of the state's volume of merchantable timber, and managing true firs became the major research task for the Redding Silviculture Laboratory. One of the most pressing problems was how to get good natural or artificial regeneration after old-growth stands had been logged. Donald T. Gordon, who had worked at the station on the subject since 1960, experimented with shelterwood cuttings and small clearcuttings at the Swain Mountain Experimental Forest (SMEF). At SMEF, he learned that small openings were best for the regeneration of red and white fir and that successful true fir establishment was dependent on quantity of seed more than any other factor (USDA FS1966a, Wood 1975b). Other silviculture research led to California researchers developing true fir management guidelines, ranging from how to raise nursery seedlings successfully to how to prevent the spread of the parasite dwarf mistletoe in young stands of true fir. Specialists from a variety of disciplines—forestry, plant physiology, plant pathology, forest entomology, and others—worked together on the true fir studies. With foresters from Region 5, they worked in a group known as the True Fir Task Force (TFTF). Its mission was to improve the field survival rate of nursery-grown true fir, and they made several contributions toward this end. Plant physiologist James L. Jenkinson recommended

The most important field of research in California forestry at this time was studying red and white firs.

⁵³ By 1960, logging experiments at the Blacks Mountain Experimental Forest (BMEF) were completed, and logging equipment, tools, and supplies were either transferred or sold. As there was little use for the Blacks Mountain branch station after this, most buildings were transferred to the Lassen National Forest. The Berkeley office took whatever cooperative logging funds remained and used them to meet severe cost overruns occurring on road construction at the Swain Mountain Experimental Forest. In 1968, the Forest Service centered all east-side pine research at Bend, Oregon, under the aegis of the Pacific Northwest Forest and Experiment Station. Though BMEF was not disestablished at that time, it sat idle for the next 12 years. In 1972, a decision was made during Harry Camp's administration to convert BMEF to a young-growth forest. Unfortunately, in the process, the Lassen National Forest staff could not recognize and record Duncan Dunning's tree class work begun in the 1930s, so these important data were lost forever (Gordon 1982).

⁵⁴ At the Challenge Experimental Forest, besides tested methods of planting ponderosa pine, the station investigated native hardwoods of north-central California. A little-used resource, they were studied to determine their suitability for furniture and other special uses. New studies were also made to improve the regeneration of three California hardwoods—madrone, black oak, and tanoak (USDA FS 1966a, 1969).

lifting seedlings out of the nursery setting in either December or January and putting them in cold storage prior to planting. This operation allowed a survival rate of better than 80 percent, a level Region 5 hoped to achieve in its planting programs.⁵⁵ Research plant pathologist Robert B. Vega also worked with TFTF. Vega recommended certain seed fumigation procedures that reduced root infections from as high as 80 percent to almost zero, while colleague Robert F. Scharpf showed in a large-scale demonstration how thinning could control dwarf mistletoe in true fir stands. Finally, entomologist George Ferrell developed a risk-rating system based on easily assessed characteristics of mature California red fir, Shasta red fir, and white fir, very similar to the Ponderosa Pine Risk Rating System, developed by the station in the 1930s. It determined the mathematical probability of a particular tree succumbing to attack by insects, disease, or other natural causes within a 5-year period (Wood 1975b, 1979a, 1980c).

In the meantime, at the Arcata quarters of the Redwood Sciences Laboratory on California's north coast, which was maintained in cooperation with Humboldt State College, silviculturalist Kenneth N. Boe headed redwood and Douglas-fir studies (fig. 95). Boe's mission was to concentrate his attention on young-growth redwood stand management, while his colleague, Robert L. Neal, Jr., continued his work on the subject of harvesting and regenerating old-growth stands at the Redwood Experimental Forest (REF) (USDA FS 1963). Boe and Neal felt strongly about the need for good forestry practices in the redwood region. By 1969, Boe and Neal's redwood silviculture research concentrated on furnishing information on harvesting and production costs, and the merits of different silvicultural systems. Timber companies were increasingly concerned with growing redwoods and not just cutting them, and therefore wished to better understand the benefits and problems of clear-cutting versus selection cutting. To answer these harvesting questions, the Arcata

⁵⁵ In 1989, the California State Board of Forestry bestowed upon Jenkinson the Francis H. Raymond Award, which was given to a person or organization who contributed the most to the protection and wise use of forest resources in California, becoming the first researcher to receive this distinguished honor. The Raymond Award was named after the former state forester who served for 25 years, and led efforts that resulted in the Professional Foresters Licensing Act. For years, survival and establishment of planted seedlings in California forests were at best erratic. Plantations failed, but the causes remained obscure. As it turned out, the key to resolving the problem was the physiological capacity of seedlings to grow new roots quickly after they were planted. Jenkinson's research demonstrated that the precise stage at which a seedling is lifted from the nursery and its subsequent duration in cold storage were critical factors that affect root growth capacity and, therefore, survival. The savings in replanting costs, as a result of his research, were estimated at \$3 million a year for California's national forests alone—and the potential savings were even greater when the techniques were applied to private forest lands (PSW 1989d). In the same year, Jenkinson added another award to his mantle—the USDA Superior Service Award for his significant contribution to improved reforestation success and reduced land management costs in the Western United States (PSW 1989e).



U.S. Forest Service, Pacific Southwest Research Station

Figure 95—Architect's rendering of new Arcata laboratory, 1975.

group tested various methods on the REE, where they found that each logging method had distinct advantages and disadvantages. Clearcutting, whose end product was an even-aged new forest, was found to be more efficient in converting old growth to younger, more managed stands. However, one problem in clearcutting was “blow down” at the windward edge of standing timber. In contrast to clearcutting, selection cutting was designed to create a new forest with trees of several age classes. This harvesting practice was found useful where it is important to maintain the look of the forest. In terms of long-range productivity, however, the merits of each system were still an open book. In the meantime, Arcata researchers turned their attention more specifically toward managing younger timber and better utilization. Around 1967, demands on the commercial forests of the region had increased considerably, and some estimated that within 10 to 25 years, most of the old growth on private lands was likely to be gone. As companies began to shift their operations to second growth, they needed accurate information on how to improve young stand growth, which then included thousands of acres in the redwood region. Therefore, Arcata scientists turned their studies toward this kind of research. New projects⁵⁶ included precommercial thinnings to determine optimum

Selection cutting was found useful where it is important to maintain the look of the forest.

⁵⁶ In addition to these redwood studies, in the 1960s, the Arcata laboratory studied management systems for Douglas-fir stands, as well as regeneration of Douglas-fir by seeding, planting, and natural means (USDA FS 1964a, 1965b).

The Redwood Sciences Laboratory investigated mass erosion, such as landslides and soil creep, the major source of sediment contaminating California's north coastal watersheds and often the costly consequence of poorly planned logging and road building.

levels of growing stock, weeding of stands, and thinning of redwood sprouts (PSW 1969c, USDA FS 1967).

In the 1970s, Redwood Sciences Laboratory scientists continued to investigate natural and artificial regeneration of redwood and Douglas-fir on a variety of sites. Research forester James L. Lindquist showed how growth of redwood sprouts was influenced by different levels of overstory stocking, or by the diameter of the parent stump. At other sites, research forester Rudolph O. Strothman tested the response to repeated thinnings of previously unthinned stands of commercial-sized young growth redwood and Douglas-fir (Wood 1978b). Research also continued on harvest management systems in the 1970s. Plant physiologist Robert J. Laacke developed a way for managers to predict whether a proposed harvesting treatment would be successful on their sites, and planned to provide information on both the economic and biologic costs of various stand treatments. At the same time, research forester William W. Oliver experimented with thinning regimes for sapling and young saw-timber stands of Douglas-fir because there was very little information regarding the proper levels for thinning (PSW 1986t; Wood 1975b, 1979a).

Finally, starting around 1966, the Redwood Sciences Laboratory also investigated mass erosion, such as landslides and soil creep, the major source of sediment contaminating California's north coastal watersheds and often the costly consequence of poorly planned logging and road building. At this time, researchers studied 15 sites between Fort Bragg and the Sacramento Valley to learn the mechanics of landslides and natural soil creep. Field observations were compared with laboratory analysis of soil properties. Redwood Sciences Laboratory studies by its engineering geologists of the mechanisms of soil creep enabled forest managers to forecast and reduce erosion rates caused by certain land use practices (USDA FS 1966a, 1967, 1968c). In the 1970s, much of the research on road construction and logging on water quality and flood peaks was done in the Caspar Creek drainage on the Jackson State Forest, a site that was representative of northwestern California's second-growth redwood and Douglas-fir. According to principal hydrologist Raymond M. Rice, preliminary results showed that road building did not affect flood peaks, but it did increase sedimentation. In the Douglas-fir forest that lay east of the redwood belt, researchers such as geologist Philip B. Durgin studied problems associated with logging on steep, granitic batholiths. According to Durgin, landslides there were most frequent when granitic rock was at an intermediate stage of weathering. At the same time, hydrologist Robert R. Ziemer led studies to determine how logging affects the role that roots play in maintaining slope stability (Wood 1978b, PSW 1999f).

Hawaiian Environmental Research Program

Forestry research in Hawaii exemplified the breadth of pertinent subjects that the station confronted overall during the environmental era. During the period 1963 to 1969, the station's cooperative Hawaii forestry research program, which was headed by Robert E. Nelson, generally expanded along the same research lines established during the preceding 6 years—forest economics, forest products, watershed management, timber management, and forest insect and disease research.⁵⁷ Also during this period, close to 90 publications and reports were issued by station personnel on Hawaiian forestry problems. These publications dealt with research results in watershed management (evapotranspiration, erodibility of watershed soils, rainfall-runoff relations on small watersheds), timber management (chemicals for control of vegetation, species adaptability of introduced trees,⁵⁸ silvicultural methods for native and introduced trees),⁵⁹ forest products technology (physical and mechanical properties of Hawaiian-grown woods, durability of local and imported woods, and wood seasoning methods), and marketing⁶⁰ (Nelson 1989, USDA FS 1964a). However, protecting Hawaiian watersheds was still seen as key to the state's concerns, which meant maintaining an adequate cover of trees in the mountains.⁶¹ Meanwhile, in 1967, the station's Hawaiian Laboratory was named the Institute

⁵⁷ Tree ferns were a predominant problem in Hawaii forests. Although tourists loved them, they were a thorn in the side of foresters who tried to establish new seedlings for reforestation projects on the Hawaiian Islands. Most defoliant and herbicides did not seem to work on them (PSW 1967d).

⁵⁸ Since 1958, more than 800 foreign tree species had been planted in Hawaii for testing as potential timber trees. The station, under research forester Craig D. Whitesell, studied their performance, and 60 to 85 species were eventually selected for further work (USDA FS 1965b). Between 1964 and 1968, desirable species were planted in 15 locations in an effort to find better trees for timber and for improvement of recreation, aesthetics, wildlife habitat, and watershed values in Hawaiian forests (USDA FS 1968c).

⁵⁹ Research forester Roger Skolmen conducted many of these studies on the quality, physical characteristics, and durability of both native and introduced species. Skolmen worked closely with industry, recommending processing and milling techniques for Hawaiian-grown woods, and furnishing technical assistance to lumbermen and mill owners (PSW 1969b).

⁶⁰ In 1963, the station sought to determine what markets existed for species being produced in Hawaii, and what species would be needed for future markets. Wood products in the Hawaiian Islands were very much in demand. For instance, until 1965, Hawaii imported almost all of its wood products, with 18 million board feet of timber being used annually for wood containers and housing in Hawaii, and 80 million board feet being used in military support activities in the Pacific area (PSW 1969b, USDA FS 1965b). Markets included not just local usage but also the mainland, such as the California and Michigan furniture industry (USDA FS 1963, 1967).

⁶¹ Early explorers also brought sheep, goats, cows, and horses to the islands. Because they were gifts, the kings put a kapu (taboo) on them and they ran wild. Overgrazing destroyed vegetation, trampled the soil, and contributed to floods and erosion. Then in the 1800s, native forests were abused even more as loggers cut them heavily without regard to reforestation (PSW 1969b).

Additional factors were adversely affecting the native forests at an accelerating rate, including fires, insects, diseases, feral animals, aggressive noxious plants, and even rats.

of Pacific Islands Forestry (IPIF) in recognition of the growing influence of the program in the region. The location of IPIF at the crossroads of the Pacific in Honolulu as a station field office established it as an effective source of information about tropical and subtropical forestry for the Pacific Islands (USDA FS 1967). Subsequently, IPIF scientists began providing limited technical assistance to American Samoa,⁶² Guam,⁶³ and the Trust Territory of the Pacific Islands (Micronesia)⁶⁴ on a limited basis. Although IPIF helped government officials of these three territorial areas in the Pacific during the 1960s, no formal cooperative programs were started (Nelson 1989).

In 1970, IPIF and the Hawaii Division of Forestry reviewed forestry research needs in the state 50th state. In a joint PSW Research Station/Hawaii Department of Land and Natural Resources document entitled *Forest Conservation Research Plan for the Seventies* (Ahuja and El-Swaify 1975), IPIF reemphasized the need to continue research started earlier, but identified new problems and opportunities that required investigation. It had become apparent to IPIF and the Hawaiian Forestry Division that many additional factors were adversely affecting the native forests at an accelerating rate, including fires, insects, diseases, feral animals, aggressive noxious plants, and even rats. This increasing forest damage and destruction occurred at a time when groups and individuals in Hawaii were joining together in an environmental movement to demand the preservation of Hawaii's endemic flora and fauna. The IPIF scientists responded positively to the public's changing attitudes, and were eager to tackle the newly emerging problems of preserving, protecting, and developing Hawaii's complex forest resources and those of other Pacific areas. *Forest Conservation Research Plan for the Seventies* encouraged continued silvicultural research emphasizing tree species adaptability testing on

⁶² American Samoa is a group of seven tropical islands in the South Pacific Ocean, which in 1963 had a total land area of 76 square miles and a population of over 20,000. The Department of the Interior administered them as a U.S. Territory with an appointed governor. Initial work included surveying the forest resources, but, in 1966, the WO abruptly terminated this work (Nelson 1989).

⁶³ Guam is another territory that was administered by the Interior Department and included a land area of approximately 130,000 acres, of which 50,000 acres were military holdings (U.S. Air Force and Navy). Brush and tree-covered areas total about 70,000 acres with grass and barren areas making up about 50,000 acres. Guam officials were highly concerned about vegetation destruction and watershed damage caused by extensive and frequent wildfires in the grasslands and forested areas, as well as erosion on large areas of bare lands (Nelson 1989).

⁶⁴ The Trust Territory of the Pacific Islands included the Marshall, Northern Mariana, and Caroline Islands. Encompassing some 2,000 tropical islands spread out over a vast area of the western Pacific Ocean, the Trust Territory had a total land area of only 717 square miles and a population of about 126,000. The station initially provided technical assistance in resource survey methodology, procurement of aerial photography, and other topics (Nelson 1989).

various sites, enrichment and mixed-species experiments, tree spacing and thinning experiments, expanded koa forest regeneration research, and listed topics of wood products research that had not been undertaken by the institute or the FPL in Madison, Wisconsin, but IPIF did not start additional projects in the latter area and instead gave priority to environmental issues (Nelson 1989).

One critical environmental problem was the epidemic decline of ohia lehua (*Metrosideros collina*) trees, resulting in the decimation of thousands of acres of forest. This was a particular concern on the island of Hawaii, but it was also later discovered on Kauai. Ohia lehua was an important forest resource because it provided a variety of values, such as watershed cover, wildlife habitat, timber, forage, and recreational importance. Therefore, between 1970 and 1976, IPIF concentrated much of its attention on the problem and issued many reports and publications pertaining to ohia forest decline—its extent, severity, and the insects, diseases, and other factors possibly related to the death of these trees. Despite IPIF efforts, the etiology of the epidemic remained a mystery. During this same time, IPIF also focused some research efforts on another environmental problem, the Mauna Kea mamane forests on the Island of Hawaii, which also had been declining for decades.⁶⁵ Fortunately in this case, the culprit was discovered—feral goats and sheep. The subsequent removal of these animals resulted in the regeneration of the native mamane forest at Mauna Kea. This action helped restore critical habitat for palilas, large Hawaiian finches that fed almost entirely on immature mamane seed pods, and which were listed in 1967 as endangered by the U.S. Fish and Wildlife Service. Then there was the problem of noxious weeds. The extensive spread of these highly flammable introduced grass species caused increased fire hazard and fire occurrence throughout the islands. The need to determine an effective weed control measure was obvious, but by 1976, only preliminary research and experimental control work was underway. Meanwhile, IPIF made some progress in fire research and developed a forest fire danger rating system for the Hawaii Division of Forestry and other fire control officials, who were thereafter trained in the system's use (Nelson 1989).

In 1977, the Forest Service celebrated 20 years of forestry research and technical assistance in Hawaii. Robert E. Nelson still served as IPIF's project leader and the institute was assigned four individual RWUs. They were Pacific Islands (Territories), Maintenance of Native Hawaii Forest Ecosystems, Hawaii Forest Insect and

In 1977, the Forest Service celebrated 20 years of forestry research and technical assistance in Hawaii.

⁶⁵ Mauna Kea is the tallest volcano on the Island of Hawaii. From sea floor to summit it towers more than 5.6 miles (9 km). It is also the second largest volcano on the island. It began erupting on the sea floor about 800,000 years ago. Most of the volcano is made of shield-building lavas.

Disease, and Timber and Watershed Management. These four RWUs formalized an organization of research activities and responsibilities that had been in effect for several years (USDA FS 1977d, 1980b).

Until 1977, IPIF had informally provided limited technical assistance to Guam, the Trust Territory of the Pacific, and American Samoa on forestry problems. Then in 1977, this program was formalized, which increased the California Station's role in western Pacific forestry. Thereafter, IPIF initiated research in a number of priority problem areas, one of which was the development of data needed to determine tree species that would be successful in reforestation programs. The IPIF scientists also sought to develop a central source of general and technical information about the forest resources of the Pacific area. By 1980, IPIF was working closely with foresters and officials of these island nations to inventory and survey forest resources, and to develop techniques for establishing and managing healthy, productive stands of native and introduced tree species (USDA FS 1977d, 1980b). On the other hand, IPIF's Maintenance of Native Hawaii Forest Ecosystems RWU continued to develop guidelines for rehabilitating, maintaining, and managing mamane, koa, and ohia forest ecosystems. (Nelson 1989; USDA FS 1977a, 1977c, 1977e)

Although preserving native forests in Hawaii in near-pristine condition was deemed an unattainable goal, by 1979 preservation of many endangered endemic species through habitat management and protection appeared plausible, but overwhelming. For instance, although the epidemic decline and death of trees in the ohia rain forest on the island of Hawaii was of no major significance in terms of commercial timber losses, it was causing large reductions in populations of native birds. Furthermore, rats, diseases, insects, pigs, and aggressive introduced plant species were all damaging Hawaii's forest resources. The Hawaii Forest Insect and Disease RWU, under project leader Charles S. Hodges, accepted the responsibility of identifying the major insect and disease problems in Hawaiian forests (Nelson 1989; USDA FS 1977a, 1977c, 1977e).

Meanwhile, project leader Roger G. Skolmen's task for the IPIF's Timber and Watershed Management RWU was to develop and share the scientific knowledge needed to manage forests of native and introduced species in the Hawaiian Islands for timber production or watershed protection. At the onset, much Forest Service research emphasized developing information to support growth of the local timber industry. By 1979, the development of a timber resource base adequate to support a viable, large timber industry was not on the horizon, but the potential was there.



U.S. Forest Service, Pacific Southwest
Research Station

Figure 96—Sampling soils for hydrologic characteristics, 1977.

Nonetheless, the Timber and Watershed Management RWU had developed much information regarding watersheds and their management. Water yields, erosion, and situation control were becoming very important because water consumption had increased considerably with population growth (fig. 96). As Hawaii headed for near-explosive growth in tourism, as the long-reigning sugar and pineapple industries waned in economic importance, and as strong and visible interest in natural resources of the islands were shown by environmental groups, better watershed management also required better fire protection and more extensive revegetation programs (Nelson 1989; USDA FS 1977a, 1977c, 1977e). In the closing decades of the 20th century, IPIF would have to meet ever-challenging problems for Hawaii and Micronesia.

Research Budget Peaks

By 1979, the PSW Forest and Range Experiment Station had reached the apex of its growth as an institution, and the station's investigations during the environmental era from 1963 to 1979 reflected that philosophical preference. However, when Ronald Reagan took over the White House in 1981, he appointed the business-friendly and arch-conservative John B. Crowell, Jr., as Assistant Secretary of Natural Resources and Environment. Soon thereafter, Station Director Robert Callaham would be challenged by the “draconian” budget cuts that came to the

The PSW Forest and Range Experiment Station had reached the apex of its growth as an institution.

Forest Service's research program under Crowell's tenure. The shift was dramatic and painful; according to Deputy Chief of Research Buckman, "We were in a desperate situation. Imagine a \$140 million budget; overlay inflation, each day it cost more to do business, and Crowell wanting to push that budget down to \$100 million." Subsequently, budget justification determined whether research was conducted or not. Furthermore, the Budget Impoundment and Reform Act of 1974⁶⁶ prevented station directors from lobbying for local needs, such as a research laboratory or program increase (Steen 1994). While coping with these issues, Director Callahan moved the station's research program from environmental management to ecosystem management.

⁶⁶ Increased spending for programs initiated or expanded during the "Great Society" era of President Johnson, combined with escalating expenditures to support military efforts in Vietnam, heightened concern in Congress about budget deficits and spending controls. In response to both the frustration generated by the fragmented nature of the congressional budget process and the perceived encroachment of the executive onto the budgetary turf of Congress, Congress passed the Congressional Budget and Impoundment Control Act of 1974. The major purposes of this act were to reassert the congressional role in budgeting, to add some centralizing influence to the federal budget process, and to constrain the use of impoundments.

Chapter 8: 1980–1994, Ecosystem Research

Faced with inflation, high interest rates and other economic problems, as well as social disruptions, Americans elected Ronald Reagan to the presidency in 1980. Congressional staffer Dennis C. Le Master wrote:

The election of Ronald Reagan and a Republican majority in the Senate in 1980 brought sweeping changes to Washington. The new administration's attention was focused upon the domestic economy, upon fulfilling the president's campaign promise of reduced taxes, increased defense spending, and a balanced budget. To this end, the Reagan administration worked for and achieved unprecedented tax and budget cuts in its first year in office. The cuts signaled that policy making during the Reagan years would be conducted through presidential budget requests, budget resolutions, and the funding programs in appropriation acts [Le Master, 1984: 177].

When President Reagan was governor of California, he was apathetic at best toward environmental protection, and during his presidency, the staffs of federal environmental agencies were discouraged from vigorous enforcement of regulations. In California, environmental groups had sought to preserve the environment as a whole and criticized unrestrained economic and technological growth at the expense of the environment, but their apocalyptic predictions for the future if environmental harmony was not restored, and their refusal to compromise, diminished their credibility in the eyes of those who were pro-business and others who questioned this radical style of environmentalism. Many saw environmental battles as increasingly anti-business. Pro-development, conservative political leaders, who came to power on Reagan's coattails, were convinced that environmentalism was a threat to the state's economy (Godfrey 2005). Was the environmental era clearly over in California? And what new philosophy would replace it?

Although California prospered economically in the 1980s—mostly because President Reagan's huge increases in federal spending for military projects dramatically stimulated the economy—it brought a mixed blessing for California's environment. The public once again became dismayed over pollution caused by the supposedly "clean" computer and related high-technology manufacturing industries. By the end of the 1980s, a resurgent environmental movement had arisen in California. This new ethos exhibited a concern for a common natural world, and spanned class, regions, gender, ethnicity, and political lines in the state. This same movement developed among the Forest Service scientific community as well, resulting in ecosystem management.

By the end of the 1980s, a resurgent environmental movement had arisen in California.

Californians had been trying to heal what they had destroyed in the past, while using resources to their sustainable limits. At the same time, they wanted to avoid leaving a wasted environment for future generations.

Ecosystem management was more a merging of traditions than a radical departure from the past. Some historians say that the origins of ecosystem management lay in Aldo Leopold's *A Sand County Almanac* (1949) and its "land ethic" (fig. 97) *A Sand County Almanac*, reissued in 1966 in paperback form, catalyzed the environmental movement, much like Rachel Carson's *Silent Spring* (1962). But even before Leopold's book became well-known to the general public, the Forest Service had begun research on managing lands on an ecosystem-wide basis in the Pacific Northwest at the H.J. Andrews Experimental Forest near Blue River, Oregon. By the 1960s, research in Oregon, and similar research at the Hubbard Brook Experimental Forest in New Hampshire contributed to a new management approach, initially called "New Forestry," that emerged in the 1980s as ecosystem management (Lewis 2005). In looking back over its history, the Forest Service in California had been working toward this holistic goal from the very beginning, but had never quite understood it. In many ways, Californians had been trying to heal what they had destroyed in the past, while using resources to their sustainable limits. At the same time, they wanted to avoid leaving a wasted environment for future generations (Godfrey 2005).

Essentially, ecosystem management was the harmonization of two ways of looking at resource management. The Forest Service's utilitarian conservation ethic meant taking care of the land and using resources wisely. The environmentalists



U.S. Forest Service

Figure 97—Aldo Leopold, early ecologist responsible for laying the groundwork for the Gila Wilderness—the first administrative wilderness in the National Forest System.

wanted to accomplish these same ends but were also concerned with addressing the cultural and social needs of people, including aesthetic beliefs and lifestyles of all cultural and social groups (Godfrey 2005). As early as 1971, Charles A. Connaughton, a former chief of the Pacific Southwest (PSW) Region 5 (1955–1967), summed up the ecosystem approach in a speech entitled “What’s Ahead in Forestry—A Challenge to Research,” which he delivered at the 50th anniversary of the Southern Forest Experiment Station:

In recent months there have been references to a trend or desire to organize research on the basis of ecosystems. This seems in contrast somewhat pointedly with recent Forest Service experience aimed at organizing research on a problem basis. When the two are contrasted, the ecosystem approach seems generally favorable if we define the ecosystem as “an ecological community functioning as a whole in nature.” This approach means that research will be directed toward an understanding of the system as a whole and of all of its interrelationships. This contrasts with the selection of various parts to be studied in isolation. It means understanding the reasons *why* and *how* the whole picture fits together as well as what happens if any single phase of it is adjusted or modified in relation to other components.

The desirable research organization is one that considers the ecosystem the base and includes a system of studies, which deals with the community as a whole. As a supplement to this, however, and equally important, there must be a body of research which deals with specific detailed problems. The results of these detailed studies can and must be fitted into the ecosystem research in order to understand the impact of one detailed study on another [Connaughton 1971: 556–557].

Connaughton went on to say that detailed studies were like making bricks for a building. The bricks were necessary, but until they were arranged in an orderly, systematic design into a wall, “they won’t have the value that interdependence and interlocking strength will bring” (Connaughton 1971).

The violent eruption of Mount St. Helens in 1980 and the creation of the Mount St. Helens National Volcanic Monument presented an unprecedented opportunity for researchers, such as Jerry Franklin and James A. McMahon, to test New Forestry ideas by leaving “biological legacy” trees, which would benefit the ecosystem as opposed to traditional forestry practices, such as clearcut and selection

cutting. Meanwhile, in 1989, Chief F. Dale Robertson¹ (fig. 98) was facing both congressional and White House complaints that the Forest Service was not fulfilling its timber harvest projections, and court cases from environmentalists that tied up and derailed Forest Service forest plans and projects with concerns for endangered species. As a solution to these problems, he seized upon the ecosystem concept of New Forestry, which involved a stewardship land ethic that placed a greater emphasis on ecological values, such as biological diversity and ecosystem sustainability. Forest Service Chief Robertson called his program “New Perspectives,” and placed Harold “Hal” Salwasser (later PSW Station Director, 1997 to 2000) in charge of it. During the next 3 years, New Perspectives encountered controversy and criticism from forest industries, who believed it jeopardized timber harvest levels, and from environmentalists who saw it as a public relations gimmick (Lewis 2005). Despite the criticism, the Forest Service as a whole kept its perspective and was able to successfully journey down this new path of ecosystem management.² At the PSW Research Station, Station Director Stewart immediately implemented this shift in Forest Service management philosophy, by forming an interdisciplinary team of PSW scientists under the direction of Barry Noon, and making New Perspectives in Forestry one of the station’s six areas of research for the next decade (PSW 1990b, 1991e).

Pacific Southwest Research Station Ecosystem Research

Naturally, it took time for the PSW Research Station, and national Forest Service research, to swing from problem-organized to ecosystem-organized research. This

¹ In February 1987, F. Dale Robertson succeeded R. Max Peterson as Chief of the Forest Service. Peterson had succeeded John R. McGuire, a former PSW station director, as Chief in 1979. Dale Robertson had been associate chief since 1982 and became the 12th person to become Chief since the office was established in 1905. Robertson, a forestry graduate of the University of Arkansas, earned a graduate degree in public administration at American University. He joined the Forest Service in 1961, and served in the South and Pacific Northwest as well as in Washington, D.C., and upon taking office stressed continuity and a smooth transition (PSW 1987b, 1987k).

² The environmental legislation of the 1960s and 1970s forced the Forest Service to slow its cutting and assess the impacts on the land, which gave it time to gain a new perspective. The broader perspective was needed in order to understand when an ecosystem was healthy or under stress. The strength of legislation like the National Environmental Policy Act (1969), the Threatened and Endangered Species Act (1973), and the National Forest Management Act (1976) was that they recognized that public lands could play an important role in the conservation of biodiversity for the Nation. When biological dimensions were taken together with understanding the constraints of the physical dimensions such as topography, geology, climate, nutrients, and hydrology, a framework for ecosystem management was born. With it, Forest Service management shifted to focusing on issues and concerns relevant to larger spatial and temporal scales (e.g., species viability). It also offered hope for the future resolution of key ecologic questions such as what is sustainable, what do we want, what do we have, and how do we get there? (Godfrey 2005).



U.S. Forest Service

Figure 98—F. Dale Robertson, 12th Chief of the Forest Service (1987–1993). During his administration, he faced the growing controversy about the harvest of old-growth timber and the protection of species of animals and plants that fell under the Endangered Species Act of 1973.

task fell upon not only Robert Z. Callaham, whose directorship ended in April 1983 [when he was offered and accepted a position with the University of California to head the Wildland Resources Center (PSW 1983b)], but also on his successor Roger R. Bay (1983–1988)³ (fig. 99). During their administrations, Reagan-era mandates for economic efficiency often clashed with Forest Service attempts to implement ecosystem management. Meanwhile, Directors Callaham and Bay faced two critical administrative tasks.

Consent Decree, 1980 to 1988

The first critical task was the implementation of the Bernardi Consent Decree. As noted in the previous chapter, in June 1972 PSW Research Station employee Gene Bernardi filed a class action lawsuit against the U.S. Department of Agriculture, alleging that discrimination on the basis of sex was a common practice in the Forest Service. Federal judge Samuel Conti dismissed the suit in June 1981 upon the

³ Roger Bay earned his bachelor's degree in forestry from the University of Idaho (1953), and both his master's (1954) and doctorate (1967) in forestry regeneration and watershed research from the University of Minnesota. He began his full-time forestry career with an assignment on the Flathead National Forest, and his research career in 1956 at the North Central Station, where he served as project leader and research hydrologist. In 1974, he was appointed director of the Intermountain Station, Ogden, Utah, a position he held, except for a short stint in the Washington office, until coming to the PSW Research Station (PSW 1983f, 1988o).



U.S. Forest Service, Pacific Southwest
Research Station

Figure 99—Roger R. Bay, 11th Director of the Pacific Southwest Research Station, 1983–1988. Under his administration, the Bernardi Consent Decree was implemented and he worked hard to bring more women into professional jobs at higher pay grades.

The station worked closely with Region 5 to heighten awareness of the contributions of women and their value and worth to the organization.

approval of the Bernardi Consent Decree, which officially went into effect on July 1, 1981. Under the decree, the Forest Service pledged to eliminate underrepresentation of women within each job series and each grade level. Thereafter, Director Callaham, followed by Director Bay, worked hard to bring more women into professional jobs at higher pay grades. For the next decade, hardly an issue of *For Your Information*, the news organ for the PSW Research Station, was published without containing a needs assessment, committee news, progress reports, monitoring updates, and overviews on the progress being made in meeting the goals set forth by the Bernardi Consent Decree, along with statements by Directors Callaham and Bay in support of affirmative action at the station (PSW 1981a, 1981b).

Meanwhile, the PSW Research Station Consent Decree task force drafted and finalized an implementation plan to meet certain consent decree goals by the court-imposed June 1986 deadline. The station worked closely with Region 5 to heighten awareness of the contributions of women and their value and worth to the organization, while carefully scrutinizing all vacancy announcements and position descriptions for Consent Decree compliance, and training staff in their Consent Decree responsibilities. Furthermore, under the Consent Decree, the station was required to ensure that women employees receive 43 percent of all training, and to periodically report on progress (PSW 1984f, 1984g, 1984i, 1986e). In a short time, women were promoted to administrative jobs, with higher pay, at the PSW Research

Station and within Region 5.⁴ For instance, in October 1985, Susan G. Conard⁵ was named project leader of the newly reorganized Chaparral Ecology and Fire Effects Research Work Unit (RWU)⁶ headquartered at the Riverside Forest Fire Laboratory (PSW 1985f).⁷ Or for example, in mid-1986, during the celebration of the 60th anniversary of the establishment of the California Forest Experiment Station,⁸ scientist Jacqueline “Jackie” L. Robertson was promoted to grade GS-15, becoming the first woman bench scientist and first woman project leader in the Forest Service to achieve that grade (PSW 1986r, 1986s).⁹ Then in March 1987, Shirley A. Moore became the first female assistant director of the PSW Research Station, having transferred from the Washington office (WO), where she had served for the previous 3 years as a staff assistant to the deputy chief of research (PSW 1987i). Additionally, a new program—called Career Pathing—was launched at the station under Roger Bay’s administration to provide station clerical employees with a vehicle for advancement in jobs other than clerical. The program was broken down into an exposure phase, where the participant received intensive career counseling and a chance to examine career opportunities, and a development phase, where the

⁴ In January 1985, for example, Region 5 broke hiring precedents by making Geraldine (Geri) B. Larson supervisor of the Tahoe National Forest, the first woman to be named a forest supervisor in the Forest Service (Godfrey 2005, PSW 1985j).

⁵ Susan Conard joined the station’s former Chaparral Ecology Research Unit in 1983 and had already earned a bachelor’s degree in environment sciences at Antioch College, and her master’s and doctoral degrees—both in ecology—at the University of California, Davis (PSW 1985f).

⁶ At this time, the Chaparral Ecology Research Unit was engaged in prescribed burn studies on the San Dimas Experimental Forest (SDEF) that were designed to compare the hydrologic and ecological effects of fire on chaparral watersheds (PSW 1984q). In 1985, the 17,000-acre SDEF celebrated its 50th anniversary (PSW 1985b, 1985q). For the event, Paul Dunn, Sue Barro, Wade Wells, Mark Poth, Pete Wohlgemuth, and Chuck Colver published *The San Dimas Experimental Forest: 50 Years of Research* (1988) (Dunn et al. 1988, PSW 1988n).

⁷ In 1988, the Riverside Fire Laboratory celebrated its 25th anniversary with the publication of a history entitled *Forest Fire Laboratory at Riverside and Fire Research in California: Past, Present, and Future* written by Carl Wilson and Jim Davis (PSW 1988m, 1988n; Wilson and Davis 1988).

⁸ During the celebration, at the age of 96, A. Everett (“Wies”) Wieslander was the only surviving member of the four-person team that started the California Forest Experiment Station 60 years earlier. He served under four station directors: Edward I. Kotok (1926–1940), Murrell W. Talbot (1940–1945), Stephen N. Wyckoff (1945–1954), and George M. Jemison (1954–1957) (PSW 1986f, 1986u, 1986v). At the same time, a new logo to mark the anniversary was approved (PSW 1986w).

⁹ Jackie Robertson earned her doctorate in entomology in 1973 from the University of California, Berkeley and became a research entomologist with the Insecticide Evaluation Research Unit. Since 1982, she had headed the Improved Technology for Integrated Management of Western Forest Insects Research Unit in Berkeley and as a senior scientist had more than 100 scientific and technical publications (PSW 1986r).

participant received accelerated on-the-job training¹⁰ (PSW 1985l, 1985u, 1986b). By the end of 1986, each issue of *For Your Information* prominently posted in its “New to PSW” column job vacancies that had been filled by women. For example, the December issue announced that the Institute of Forest Genetics at Placerville had recently welcomed three new permanent positions filled by women (PSW 1986m).

Despite these and other efforts, as the station passed the June 1986 deadline, a hearing was held in January 1987 to determine whether or not the Forest Service had met all requirements of the Decree (PSW 1987d). After more than a year of deliberations, in May 1988, U.S. District Judge Samuel Conti upheld a contempt citation that charged that the Forest Service had failed within a 5-year period to implement fully an affirmative action program, after spending more than \$750,000. Judge Conti asserted that the Forest Service had “dragged its feet” in this 15-year-old sex-bias case and affected about 1,500 women employees in California and Hawaii. Although Judge Conti did not levy a fine or impose any penalty, he stated that “if there is no progress” he would hold another hearing in the case. Instead, he extended the implementation period of the Consent Decree for an additional 3 years, and agreed that \$1.5 million more be spent for the program (PSW 1988f).

Shrinking Budgets, Retirements, Competitive Grants, and Relocation

As the PSW Research Station coped with fulfilling the Consent Decree goals in the years 1981 to 1988, it also faced another critical problem, a shrinking budget, which directly affected research projects and programs, facility growth and management, and the station’s personnel. In late 1981, President Reagan signed the first of many appropriations bills that cut the Forest Service research budget. The 1981 cuts, along with recent pay raises, reduced the funds for the station’s research program and general assessment by about 7 percent. As a result, difficult and stringent economy measures had to be taken. Forest Service research budget cutbacks, performance appraisals, merit pay also became familiar topics covered in *For Your Information*. But even with all the economy measures taken, Directors Callaham and Bay found it necessary to implement reduction-in-force (RIF) at the Berkeley Station and at

¹⁰ Its first participant and graduate was Linda Lux, who started out in 1985 as a project clerk for two RWUs (Snow Hydrology and Forest Disease Research) in Berkeley. At that time, Lux had B.A. and M.A. degrees in art history from the University of California, Davis and had done archaeological fieldwork in Greece, England, and California (PSW 1985k, 1985n). In October 1988, Lux became the first “graduate” of the program and filled a newly created Region 5 historian position where she could work on her two broad interests: history and archaeology, and public affairs (PSW 1988i). In 1989, the program was considered successful and was renewed for another 3 years (PSW 1989c).

some field units (PSW 1982b). Budget cuts also often resulted either in the termination of RWUs entirely, such as two RWUs in Hawaii in 1982 that eliminated 12 positions (PSW 1982a, 1982b), or the combining of RWUs at the station, such as coupling the urban forestry with landscape management (PSW 1982g).

Thereafter, as the Reagan administration boosted its military spending, the rest of the budget categories, including Forest Service research declined. The President's fiscal year 1985 budget called for a research budget of \$103 million, down \$6 million from 1984, with timber management and genetics, protection of resources, acid rain, and old-growth wildlife habitat given high-priority research status. This budget decrease of 5 percent, according to Assistant Secretary of Agriculture John Crowell, reflected the administration's objective of improving efficiency and reducing costs by closing research locations, terminating RWUs, and eliminating full-time equivalents (FTEs) at those facilities. The Forest Service also agreed to reduce administration costs by \$4.9 million and 265 FTEs by fiscal year 1987. Forest Service Chief R. Max Peterson (fig. 100) expressed concern over the agency's budget woes. He encouraged station staff to become more "visible" and to tell more people and organizations about the good work being done at the station.¹¹ Peterson also asked them to consider consolidation of support functions with Region 5,¹² which was accomplished in June of that year when fiscal and accounting functions for the station were reassigned to Region 5 (PSW 1984b, 1984f, 1984h, 1984n, 1984p).

During the remainder of his tenure, Director Bay approached the station's budget problem in four ways: consolidation or termination of RWUs, requests for early retirement, an internal competitive grant program, and a change of location for the PSW Research Station. The first RWU consolidation came in late 1984, when two RWUs were terminated. In Honolulu, the Forest Protection Unit led by Charles S. Hodges was merged with the Watershed Management Unit led by

¹¹ To this end, in 1987, the station issued a new series of brochures that described a number of the station's facilities and research units. They were highly useful in making contacts with constituents and others interested in the station's research program. Subjects included a new directory of research programs, the Institute of Forest Genetics at Placerville, Redwood Sciences Laboratory at Arcata, and the Chaparral Ecology Research Unit at Riverside. At this time, the station also held a series of science seminars at its Berkeley headquarters and at the Riverside Forest Fire Laboratory with resident and visiting scientists talking about their research work (PSW 1987f).

¹² By 1987, the station shared many services with Region 5, including personnel management, administrative, fiscal, accounting, law enforcement, and engineering services (PSW 1984v, 1987f).



U.S. Forest Service

Figure 100—R. Max Peterson, 11th Chief of the Forest Service (1979–1987). Peterson served during a period of turbulent criticism of the Forest Service but managed to implement regulations for the National Forest Management Act of 1976.

C. Eugene Conrad. In Riverside, the Wildlife Prevention Research Unit was terminated with the retirement of Elliot L. Amidon and David Olson (PSW 1984d). Many scientists were moved to other locations or RIF'd to technician positions. According to one PSW retiree, “it was a real bloodbath. For example, when I came to the station in 1983, I had a GS-13 scientist in a GS-5 technician slot” (Bell 2007). Still other retirements of key project leader scientists with 30 to 40 years of service followed, such as Douglass F. Roy and Robert L. Neal at the Redding, California, Conifer Types Research Unit, and Robert V. Bega¹³ from the Berkeley Forest Diseases Research Unit (PSW 1984t, 1984u, 1985p). But the Gramm-Rudman-Hollings Act, formally known as the Balanced Budget and Emergency Deficit Control Act of 1985, provided for automatic spending cuts to take effect if the president and Congress failed to reach established targets.¹⁴ Consequently, PSW Research Station employees eligible for early retirement—often called “early out”—were also

¹³ Robert F. Scharpf succeeded Bega as project leader of the Forest Diseases Research Unit.

¹⁴ Because the automatic cuts were declared unconstitutional, a revised version of the act passed in 1987, but it failed to result in reduced deficits. A 1990 revision of the act changed its focus from deficit reduction to spending control.

asked to “voluntarily” request early retirement so the Forest Service could meet its budget targets (PSW 1985t, 1985w). Many obliged under this program.¹⁵

But with ever-declining research funding, Director Bay pilot tested an internal competitive grant fund, whereby the station reserved up to 10 percent of its operating capital after fixed costs and used it to fund solicited project proposals from station scientists. The program was designed to encourage important scientific advances within the station, to create internal competition for funding of innovative research, to be responsive to priority research, to reward good work, and to gather preliminary data to solicit outside funds. The first awards were made in the fall of 1986 (PSW 1986j, 1986o). For several years, this internal program ran alongside the competitive grants program authorized by the Forest and Rangeland Renewable Resources Research Act (F&RRRA) of 1978, from which the PSW Research Station had received research grants almost annually (PSW 1986p, 1987c).

By fiscal year 1987, Director Bay optimistically predicted the station’s budget to rise to \$11.9 million, an increase of \$1.8 million over the previous year. This meant increased funding for several station research programs, including spotted owl research at Arcata and Fresno, biotechnology and related genetics research at Berkeley, forest fire research and atmospheric deposition work at Riverside,¹⁶ timber management research in Hawaii, watershed management research at Arcata, and research in recreation to be started in southern California¹⁷ (PSW 1986q). Like many Forest Service units, to meet budget constrictions, the PSW Research

¹⁵ Interestingly, Forest Service Deputy Chief of Research Robert E. Buckman retired at this time as well. He listed three major accomplishments during his decade-term as deputy chief that he was proud of. One was his work in helping to update the guides to forestry research that culminated in the Forest and Rangeland Renewable Resources Act of 1978. Another was his work that modernized the authorizations for the Forest Service to conduct research, and enabled it for the first time to compete for research grants. This work came to fruition in 1985–1986. And third, he was proud of his work in building relations with forestry schools and the forest industry (PSW 1986b). John H. Ohman initially succeeded Buckman as deputy chief of research, but was soon replaced by Jerry SESCO (PSW 1988p).

¹⁶ In mid-1986, the Washington office announced major changes in the agency’s forest fire research program. These changes strengthened its fire science capability by concentrating all forest fire and atmospheric sciences research at five locations—Missoula, Montana; Riverside, California; Seattle, Washington; Fort Collins, Colorado; and Macon/Athens, Georgia. This meant that the Riverside Laboratory would receive additional funding and scientists from the North Central Station’s facility at East Lansing, Michigan, which was consolidated with the Riverside Laboratory. The reorganization brought three scientists and several professionals, technicians, and programmers, all of whom helped strengthen Riverside in the areas of prescribed fire, fire severity forecasting, and computer systems (PSW 1986i, 1986l, 1987f).

¹⁷ In June 1987, the Urban Forestry/Landscape Research Unit was relocated from Berkeley to the station’s Forest Fire Laboratory, Riverside, and redefined as the Wildland Recreation and Urban Culture Research Unit. The heavy population pressures on national forests in southern California emphasized the need for more effective recreation management there (PSW 1987g).

Station made wide use of temporary employees, who worked at almost all levels and contributed substantially to the station's research mission (PSW 1987l).

Not quite out of the budget problem yet, in early January 1987 Station Director Bay, along with Region 5 Forester Zane Smith, began to explore a proposal to co-locate the station with the Regional office in the Davis/Sacramento area. At this time, the PSW Station had about 100 employees in the Stead Building in Berkeley, and the Regional Office had 380 employees in the Appraisers Buildings in San Francisco. Besides the budget, another concern was that the Stead Building did not meet current earthquake standards according to the General Services Administration (GSA) and it was more economical to seek an alternate site than to upgrade the building. Among several options considered for new office/laboratory space was a proposed move to a building in the Agricultural Research Service (ARS) complex in Albany, California (fig. 101). Director Bay estimated that the station would need about 30,000 square feet of space, and that it would cost about \$1 million to refurbish a building there (PSW 1987a, 1987e).

In June 1987, WO and station staff joined forces in conducting a combined program review of research and administration, which started in Honolulu and concluded at the Berkeley headquarters. This review—the first to be held at the PSW Research Station since 1982—discussed the relocation issue, but its primary



U.S. Forest Service, Pacific Southwest Research Station

Figure 101—Agricultural Research Service Building, Albany, California, current home of the Pacific Southwest Research Station.

purpose was to evaluate the station's overall research program and suggest ways of improving program results. The General Research Inspection (GRI) found that the station had "an excellent record of cooperation with user groups and outside agencies; good stable leadership; and a general desire and willingness to work cooperatively within the station, among stations, and across budget line items where appropriate." The GRI singled out several RWUs for commendation, and recommended that the station be moved to a refurbished building within the ARS complex in Albany (PSW 1987f). A year later, Congress earmarked \$2.3 million for funding a move to the ARS complex as a cost-saving alternative to remaining in the Stead Building. With the appropriation of funds, architects were set to work designing the new space. The move took several years to complete (PSW 1988d), but Director Bay, after 32 years in the Forest Service, was not to oversee the move to Albany, for he retired shortly after the announcement of the move. In reflection, Director Bay stated that the biggest challenge he faced as station director was to:

...build back the confidence in people and programs with PSW (and from cooperators and customers) after the Station received major reductions in budgets, programs, and people in the early 1980s. It seems that PSW had faced greater reductions than most other Stations, with corresponding displacement of programs and people [PSW 1990f].

With the help of many people, the station built its budgets back up with internal and outside funding, strengthened a number of programs, and started new ones. Under Director Bay, the station was also able to maintain its good relationships with long-time cooperators, such as Region 5, the California Department of Forestry and Fire Protection, Los Angeles County, industry, university partners, and others (PSW 1990f).¹⁸

Thus, to the new Station Director Ronald Stewart fell the task of moving the station to another location, and reprogramming the station's research efforts because of changing national priorities (PSW 1988q).

Pacific Southwest Research Under Directors Callaham and Bay

Despite the upheavals caused by both the Consent Decree and the Reagan-era budget cuts, a great deal of research was accomplished during the Callaham and Bay administrations. Pacific Southwest Forest and Range Experiment Station scientists worked in 20 RWUs, specializing in research in such areas as timber management, silviculture, and forest genetics; control of forest insects and diseases; and wildfire

¹⁸ Interestingly, when Roger Bay was asked what he considered to be the biggest challenge he faced as station director, he did not mention the implementation of the Consent Decree (PSW 1990f).

Using DNA technology, geneticists at IFG believed that the prospect of designing a tree was just around the corner.

management and related fire sciences. Forest fire economics, management of watersheds, range, and wildlife, and landscape and urban forestry were also included. For administrative purposes, PSW Research Station's programs were grouped as "Research in Northern California," "Research in Southern California," and "Research in Hawaii" (McDonald 1985).

There were seven RWUs in Research in Northern California that operated from the Berkeley Station. One was the forest genetics RWU in Berkeley and at the Institute of Forest Genetics (IFG) in Placerville,¹⁹ which studied the application of isozyme analysis²⁰ to the genetics and genetic engineering of conifers (PSW 1982d). The unit made significant headway in determining the genetic mechanisms that enabled sugar pines (See "Scientific and Common Names" section) to resist white pine blister rust and western yellow pine to be resistant to western gall rust. They also conducted work on seed source trials of pine and fir and on improved forest nursery practices that contributed significantly to tree improvement programs. This allowed Region 5 nurseries to produce Douglas-fir seedlings with survival rates of 90 to 99 percent in the first year (McDonald 1985, Wood 1983).

However, by 1986, thanks to a technology invented by American scientists in the early 1970s and perfected by a consortium of industry, entrepreneurs, and government, it became increasingly possible to endow important tree species with the outstanding characteristics of others and to do so in a fraction of the time that it took using conventional methods. That technology was working with recombinant DNA—popularly known as gene splicing. Using DNA technology, geneticists at IFG believed that the prospect of designing a tree was just around the corner. According to Thomas Ledig, leader of the research unit managing the IFG, "Reaping the benefits of recombinant DNA technology as applied to forestry is coming close to reality." At this time, Ledig and his genetic research unit, which included Ronald Sederoff²¹ and Thomas Conkle, began an adventurous 5-year plan for the isolation and mass production of disease-resistant genes from sugar pine, the testing of various schemes designed to insert these and other genes into the DNA of

¹⁹ As noted in previous chapters, the Institute of Forest Genetics (IFG), founded in 1925 by Seattle lumberman James G. Eddy, was the first facility for forest genetics research in the world. In 1985 it completed its 60th year of research, an event marked by having IFG nominated to the National Register of Historic Places (PSW 1985i, 1988g).

²⁰ In isozyme research, the proteins, or enzymes, in the tree seeds are analyzed. Because protein formation is a function of genes, information gained from analyzing the proteins provides, in turn, clues to the genetic makeup of the tree.

²¹ In 1985, project leader Tom Ledig received a competitive research grant from the Office of Grants and Program Systems, USDA, to conduct a workshop in forest biotechnology, and Ronald Sederoff was awarded a similar grant to investigate DNA transfer systems for pines over a 3-year period (PSW 1985v).

tree cells, and finding ways of getting the freshly transplanted genes expressed in adult trees. As the researchers would learn, however, getting genes into pine cells, determining which genes to insert, and isolating valuable genes was not as easy as assumed. Furthermore, even if valuable genes were isolated and a sure-fire way devised to introduce them into pines, there remained one last and formidable hurdle—developing ways of growing whole trees from single cells in culture. Discovering a way to coax single cells to grow into plantlings would provide the final link in the attempt to genetically engineer forest trees. But techniques like DNA transfer, the regeneration of trees from cells, and somaclonal selection were certain to have a profound impact on the way trees were utilized as a natural resource (Pearce 1986).

Studying the hydrology of the snow zone in the Sierra Nevada was assigned to station scientists at the Central Sierra Snow Laboratory. Research Work Unit 4301, called “Environmental Hydrology of the California Snow Zone,” continued to work on techniques to more accurately predict the water-holding capacity of the snowpack, and the changes that occur in the moisture content of snow zone soils. However, by 1985, the unit’s scientists, in close cooperation with station scientists in Riverside, were increasingly emphasizing research on acid rain (McDonald 1985, PSW 1981d). Pressured by the Environmental Protection Agency and the public,²² in 1984, President Reagan announced plans to seek “substantial” spending increases for acid rain research. Given a higher priority than other research, Neil Berg, project leader for the snow zone hydrology RWU, attended workshops to guide PSW Research Station planning efforts for future Forest Service research programs on acid rain and acid deposition. By December, PSW Research Station scientists at the Snow Laboratory and the Forest Fire Laboratory at Riverside were working closely with the National Acid Precipitation Assessment Program on the problem over the next few years (PSW 1984c, 1984h, 1984k, 1984r, 1989l).

Meanwhile, in October 1980, the Forest Insect and Disease RWU at Berkeley was renamed the Forest Pest Management RWU with the responsibility for providing leadership in integrated pest management (IPM) and for maximizing pest management effectiveness and efficiency while minimizing adverse impacts on people and the environment. At this time, this unit continued its research to reduce losses caused by root diseases in forest nursery seedlings, to develop methods for

Researchers would learn, getting genes into pine cells, determining which genes to insert, and isolating valuable genes was not as easy as assumed.

²² Groups like the Environmental Defense Fund reported that if acid rain continued to fall at current levels, it would affect more lakes and streams, kill more fish and plants, and cause irreversible damage to the environment. Meanwhile, in California, researchers and scientists recorded acid rain and acid fog hundreds of times more acidic—and on some occasions thousands of times more acidic—than normal rainfall. Although the problem was most severe in southern California in or near the congested urban air basins, it had been documented in northern California as well (PSW 1984a, 1984o, 1984s).

predicting potential losses from root diseases in young stands, to understand root strengths and weaknesses, and to develop information leading to the control of mistletoes (McDonald 1985; PSW 1980b, 1983c; Wood 1980d, 1981c). Robert F. Scharpf continued his research on the western dwarf mistletoe, which was a widespread and damaging parasite of ponderosa and Jeffrey pines in the Western United States. By 1987, Scharpf and his colleagues pointed out that from both financial and economic standpoints, living with some mistletoe in the forests was a more reasonable goal than trying to completely eliminate it, especially as not all of the trees infected were accessible or displayed symptoms of the disease. However, they also felt that through a conscientious IPM program, both valuable timber areas and high-value campsites could have trees that were relatively healthy and safe for users (PSW 1988d).

During this same period two research units at Berkeley concentrated their attention on the biology, control, and management of forest insects. They continued to assess chemical insecticides proposed for use in forests in terms of not just their effectiveness, but also whether they might damage beneficial predators or parasites or other forest organisms. A new computer program entitled POLO2 made it easier and more convenient for scientists to test more variables in experiments with insecticides. The PSW Research Station Pest Management RWU made significant contributions to the Western United States program of controlling the devastating Douglas-fir tussock moth (fig. 102) and to a joint U.S./Canadian effort to control the



U.S. Forest Service, Pacific Southwest Research Station

Figure 102—Defoliation by the Douglas-fir tussock moth kills or top-kills many trees and weakens additional trees that are eventually killed by bark beetles.

western spruce budworm. They also developed guidelines for protecting Douglas-fir seeds and cones from insect damage through an injection technique (McDonald 1985: 18, PSW 1982e, Wood 1981b), and in 1986, provided guidelines for testing insecticides on coniferous forest defoliators (PSW 1986k).

Finally, there was the landscape and urban forestry unit. This unit worked to provide more cost-effective techniques for predicting the effects of land management activities on visual aesthetics of forest landscapes and to develop procedures for reducing the costs of managing urban forests (McDonald 1985). Two California landscape architects, R. Burton Litton (a part-time station scientist), and Robert J. Tetlow at the University of California, Berkeley, developed a landscape inventory system for scenic resources in wildland areas, which could be used to describe everything from small settings of several square miles to regions covering thousands of acres (PSW 1980b). The RWU also developed a user-friendly computer program called SOLPLOT, which helped landscape architects, arborists, homeowners, and others use trees and vegetation to control sunlight and shade at various times of the day and season on buildings, homes, and other structures, including solar panels, patios, swimming pools, and other features (Wagar 1985).

Outside Berkeley, there were two RWUs at the Redding Silviculture Laboratory and two more at the Redwood Sciences Laboratory in Arcata. One RWU in Redding was a closely integrated program on the regeneration and maintenance of California conifer types, including the study of clearcutting and natural regeneration in the northern Sierra Nevada region through work at the Challenge and Blacks Mountain Experimental Forests (PSW 1984e). The other, based on research at the Swain Mountain Experimental Forest, had since 1958 concentrated on growth and yield of valuable red fir and white fir forests and their management, including natural regeneration of true fir forests (Pearce 1987a, PSW 1984l). A long-term concern was the impact of competitive brush on timber growth, so toward this end, Redding Silviculture Laboratory studies produced guidelines for optimum tree densities and brush control strategies that markedly increased the productivity of ponderosa pine and Douglas-fir on a variety of sites in northern California (McDonald 1985, PSW 1985c, Wood 1982c). Preharvest prescribed burning on the Lassen National Forest was also evaluated at the Redding Laboratory as a practical alternative for controlling shrubs and other competing vegetation in regenerating forests. Early data in 1987 indicated that this method could reduce the density or vigor of postharvest shrubs to the point that the need for later treatments would be lessened or even eliminated (Pearce 1987b).

In Arcata, the Redwood Sciences Laboratory (fig. 103) research units concentrated on the management of Pacific coast forests on unstable lands and on the



U.S. Forest Service, Pacific Southwest Research Station

Figure 103—Main building of the Redwood Sciences Laboratory, 1976.

relationships between timber management practices and wildlife interactions, particularly in old-growth habitat. The first Arcata RWU under project leader Raymond Rice developed guidelines for predicting and monitoring the effects of logging, road building, and other forest management activities on soil stability²³ and non-point-source pollution. For the previous two decades at Caspar Creek, in cooperation with the California Department of Forestry (CDEF), the PSW Research

²³ In the Forest Service's 1984 *Research Accomplishments* (USDA FS 1985), nine areas of the station's research were highlighted, one of which dealt with research in landslides in West Coast forests conducted at the Redwood Sciences Laboratory by project leader and outstanding scientist Raymond Rice. Other highlights reported by the station included studies of the effects of atmospheric pollutants on trees and forest ecosystems, and the cost of multiple-use management resulting from changes in timber value because of wildfire (PSW 1985a, 1986n).

Station had been studying the effects of logging on the integrity of northern California watersheds. Their findings from the 1962–76 study greatly illuminated the extent and nature of the hydrological impact, erosion, and stream sedimentation on this northern California basin undergoing a “typical” logging operation. But forest practices change over time. Therefore, in 1985, the PSW Research Station and the CDEF launched a second study to cover the next decade—this time to monitor cumulative, not just isolated, effects. They hoped that two long-term investigations would give forest managers, public policy managers, and private enterprise an empirical basis on which to formulate sound logging practices (McDonald 1985, Pearce 1987a).

The second Arcata RWU began to study closely the interconnectivity between the northern spotted owl and old-growth habitat,²⁴ and station scientists were active participants in the Forest Service Westside Old-Growth Forest/Wildlife Habitat Research and Development Program²⁵ (McDonald 1985). In early 1987, a new Spotted Owl Research, Development, and Application RWU was established in Portland. Its mission was to conduct a 5-year research program to develop, apply, and integrate new information about the spotted owl into guides and procedures for managing suitable spotted owl habitat in the national forests of Washington, Oregon, and California. At this time, the PSW Station’s Timber/Wildlife Habitat Research Unit, at Arcata, and the Wildlife Population Monitoring Research Unit at Fresno supplemented the program with limited research on California’s spotted owl (PSW 1987h).

Research units in southern California by 1985 were located in the Forestry Sciences Laboratory, Fresno, and the Forest Fire Laboratory (FFL) at Riverside. At Fresno, there were two RWUs. One concentrated on range management research, and the other on understanding and monitoring wildlife populations. The range research RWU aimed to develop ways to determine the timber-range relationships in forests on the west side of the Sierra Nevada, to provide guidelines for maintenance of mountain meadows, and to better understand the competitive interactions between cattle and deer in the same region (McDonald 1985, PSW 1983a). However,

The Arcata RWU mission was to conduct a 5-year research program to develop, apply, and integrate new information about the spotted owl into guides and procedures for managing suitable spotted owl habitat.

²⁴ For instance, in July 1982, Reg Barrett, professor of wildlife management at the University of California received a grant from the PSW Research Station for a 3-month study of young spotted owls. The purpose of his research was to determine where 2- to 6-month-old owls set up their nesting territory, after they leave their parents. Earlier observations indicated that spotted owls prefer to nest in the large trees of old-growth forests or in the biggest trees of younger stands (PSW 1982f).

²⁵ This research program in 1983 came in the midst of an acrimonious controversy over the northern spotted owl and old-growth forests. The debate centered on whether old growth was a unique stage of Douglas-fir/western hemlock forest development that provided critical habitat for a broad array of associated species, such as the northern spotted owl.

The PSW Station took a new approach—inventorying everything in a wildlife guild—“a group of species that exploits the same class of environmental resources in a similar way.”

by 1985—the 50th anniversary of the San Joaquin Experimental Range (SJER)—previous studies conducted on the effects of range fertilization on herbage production and livestock gains, range improvement of brush and tree species, and grazing systems for natural and fertilized ranges were largely phased out (PSW 1985r). Nonetheless, the SJER continued to be the site of some wildlife population monitoring work in managing Sierra Nevada wildlife habitat conducted by Jared “Jerry” Verner, project leader of the Protection and Management of Sensitive Species in California RWU in Fresno, and Allan S. Boss, formerly of the Eldorado National Forest, who jointly published *California Wildlife and Their Habitats: Western Sierra* (Verner and Boss 1980) in which they argued that the key to managing wildlife was to manage its habitat. This book, along with a computerized database and matrix system, served as a practical working reference on the habitat requirements of some 355 wildlife species, from the alpine chipmunk to the yellow-headed blackbird. This information was needed to give land managers the ability to predict the potential impacts of logging, prescribed burning, brushfield conversion, or any other manipulation of vegetation on wildlife species with the Sierra Nevada (Wood 1980b). The wildlife RWU also focused on developing safer methods for sampling and monitoring wildlife populations, using such innovative techniques as “voice-printing” bald eagles and peregrine falcons so that their movement and habitats could be studied with minimal disturbance to the birds (McDonald 1985, PSW 1983e).

Furthermore, to meet National Forest Management Act requirements that all wildlife resources on national forests be monitored by means that were not only comprehensive, but also biologically and statistically sound, the PSW Station took a new approach—inventorying everything in a wildlife guild—“a group of species that exploits the same class of environmental resources in a similar way.” The whole-guild approach, according to Verner, who was in charge of the station’s research on protection and management of sensitive species in California, would define the capability of habitat to support wildlife populations more efficiently than the traditional use of single indicators. By counting everything in the defined guild, the approach also reduced the possibility of losing a species from the area. It also permitted the researcher to look separately at any trends among permanent residents, winter residents, migrant feeders, and spring or fall residents (Hanson 1983). Jerry Verner’s work was acknowledged among four other significant PSW Research Station activities in the Forest Service’s *Research for Tomorrow’s Forests: 1983 Research Accomplishments* (USDA FS 1984) (PSW 1984j).

Elsewhere in southern California, RWUs were located at the Forest Fire Laboratory in Riverside (fig. 104). They were concerned with the ecology of chaparral



Figure 104—Riverside Forest Fire Laboratory, 1988.

and associated ecosystems; meteorology for forest and brushland management; fire management planning and economics; and prescribed burning in chaparral and related ecosystems. In 1978, the station began a 5-year program on chaparral management. For decades prior to that time, management of California's chaparral was concentrated on watershed protection and protection from fire, particularly for the urban areas that were rapidly encroaching on the hills and mountains. The program staff was brought in from Region 5 to provide linkage between researchers and practitioners, and by the close of this program, this RWU had 11 full-time professionals with a supporting staff that ranged from 11 to 8 technicians and clerical personnel. Through new findings or through interpretive applications of existing information, they significantly contributed to a better understanding of chaparral ecosystems in several problem areas (PSW 1985h, McDonald 1983). The objectives of the new Ecology of Chaparral RWU included research to determine chaparral moisture content (PSW 1980c); to understand the effects of fire on soils in southern California chaparral (PSW 1980a); to develop a better understanding of erosion processes to minimize the hydrologic impacts of land treatments; to determine the dynamics of nitrogen in the chaparral ecosystem; to determine the processes of deposition and transfer of air pollutants and their influence on ecosystems and on

forest resources in general²⁶ (Miller 1985, Wood 1981a); and to develop an understanding of the ecology of oak woodlands, as well as postfire management through emergency ryegrass reseeding (PSW 1981c, 1984m, 1988e).

Research forester Tim Paysen also took a new ecosystem approach to classifying plant communities in California, so that colleagues from other wildland management agencies and different disciplines could communicate better (Wood 1982a). Toward this same end, in 1987 C. Eugene Conrad published a keyed and illustrated guide entitled *Common Shrubs of Chaparral and Related Ecosystems of Southern California* (Conrad 1988, Pearce 1988a). In the meantime, station research aimed at developing techniques for using meteorological information in predicting fire behavior, determining fire effects, and maintaining air quality through a network of telemetering weather stations. The Fire Economics RWU developed and pilot-tested FEES (Fire Economics Evaluation System), a model that screened budgets and options for fuel treatment, initial attack, aviation operations, and large fire suppression, and evaluated the economic efficiency of each option, estimated program performance, and predicted potential fire-related changes in natural resource outputs (McDonald 1985 PSW 1985e, Wood 1982b). By late 1986, the station had developed and tested a computer program to find the optimum fire management program level for a given situation (PSW 1986g). Called FIRECAST,²⁷ it estimated six fire behavior parameters—rate of spread, fireline intensity, flame length, perimeter and area, scorch height, and ignition component—to determine a particular fire’s behavior (PSW 1986h). Finally, the Chaparral Prescribed-Fire RWU was charged with developing guidelines for prescription burning for Region 5 and the California Department of Forestry on national forests, state lands, and cooperatively on private lands in southern California. Part of this research included gauging the amount of forest fuels on the ground as natural fuel for wildfires, and was conducted on the San Bernardino National Forest in cooperation with Region 5 (McDonald 1985; PSW 1981e, 1982c, 1985m).

²⁶ In 1985, Paul H. Dunn was named project leader of a new RWU called Atmospheric Deposition Effects in the Western United States. The new RWU was a spinoff of a research unit that Dunn headed from 1982 to 1985. It was headquartered at the Riverside Forest Fire Laboratory, and its mission was to conduct research on nutrient cycling and on smog deposition and its relation to tree physiology and pathology. Fieldwork was done on the San Dimas Experimental Forest and the San Bernardino National Forest north of Riverside (PSW 1985g).

²⁷ The FIRECAST program was one of five PSW Station projects mentioned in the Forest Service’s *1985 Research Accomplishments* (USDA FS 1986a). Other projects noted in the publication included station work on airborne nitrate pollutants, protecting white pine seed from infestations of pine cone beetles, coneworms, and cone moths, designing fire weather networks, and transferring genes from bacteria into pines (PSW 1986n).

In 1980, the Institute of Pacific Islands Forestry (IPIF) in Hawaii had 40 scientists, technicians, and others working on four different teams specializing in research on timber and watershed management, insects and diseases, native Hawaiian ecosystems, and forest management in Micronesia and nearby areas (Woods 1980a). But by the end of President Reagan's first term in office, because of budget cuts, it had been reduced to two RWUs, each of which worked closely with Hawaii's Department of Lands and Natural Resources, Division of Forestry and Wildlife, other state and federal agencies, the University of Hawaii, and private forestry and associations. The Hawaii Forest Management RWU continued working to develop information on and techniques for reforestation of koa, to determine productivity of biomass in relation to the site, and to develop biological controls of noxious weeds. Hawaii's second RWU was engaged in forestry research in the American Pacific Islands, assessing the forest resource to produce an accurate database for use in planning land management options, and to enhance forest productivity there (McDonald 1985).

Directors Stewart and Weber and the Consent Decree

Complying with Judge Conti's 1988 order to extend the implementation period of the Consent Decree for an additional 3 years initially fell to Ronald E. Stewart (fig. 105), who replaced Roger Bay as station director in April of 1988 (PSW 1988b, 1988o). A native of San Mateo, California, Stewart became the station's 12th director,²⁸ and made meeting the Consent Decree requirements and diversifying the station's workforce a major priority. To achieve this goal, Director Stewart reorganized the station's approach so that all Consent Decree matters were reported directly to him, a change made to ensure that the station maintained a balanced civil rights program that was not a problem for research (PSW 1989b). The PSW Station Director continued to pursue its civil rights/Consent Decree goals in a number of ways to meet Judge Conti's deadline. For instance, in the sixth quarter

²⁸ Ronald E. Stewart graduated from Oregon State University with a forestry degree (1964) and doctorate in forest ecology (1970). In 1969, he joined the Forest Service as a research forester in the Brushfield Reclamation Research Unit, Pacific Northwest Station, at Roseburg, Oregon. In 1977, he was assigned to the Washington office as a staff specialist, and in 1984 joined the PSW staff as assistant director, supervising two research units in Arcata, six in Berkeley, and two in Redding (PSW 1988r).



U.S. Forest Service, Pacific Southwest Research Station

Figure 105—Ronald E. Stewart, 12th Director of the Pacific Southwest Research Station, 1988–1990, a native Californian who continued and extended implementation of the Bernardi Consent Decree.

Barbara Weber
assumed the duties of
acting station director,
becoming the first
woman to head up a
research station in the
agency.

of the Consent Decree extension, women employees at PSW received 70 percent of the overall station training opportunities, and women in the professional series made the largest gains, receiving 61 percent of the opportunities and 42 percent of the training hours²⁹ (PSW 1990r).

However, in mid-December, Station Director Stewart left to become Regional Forester for the PSW Region (Region 5) in San Francisco, having held the station director position for only 2 years (PSW 1990q). In February, Barbara Weber³⁰ (fig. 106) assumed the duties of acting station director, becoming the first woman to head up a research station in the agency. However, Forest Service Chief F. Dale Robertson at that time changed the position of PSW director, which until then had

²⁹ Women in general had progressed in the Forest Service in the 1980s. In 1980, they made up 27 percent of the agency's workforce. By 1990, that figure had risen to 37 percent. In average grade, during the decade, they jumped from grade 5.83 to 6.8. On the other hand, women represented less than 20 percent of the Forest Service professional workforce and 93 percent of its administrative/clerical force. As further sign of change, in 1980, women represented less than 5 percent of the employees in the agency's four largest occupations—forester, forestry technician, civil engineer, and engineering technician. By 1990, women constituted more than 15 percent in each of these four occupations (PSW 1990s).

³⁰ Barbara Weber was a native of Prairie du Chien, Wisconsin, and started her Forest Service career in 1975 as a researcher at the North Central Station's Hardwoods Research Unit at Carbondale, Illinois. Upon assignment to the Washington office in 1987, Weber served as staff assistant in the Legislative Affairs staff, and then assistant to the deputy chief of research before taking the PSW assignment (PSW 1991o).



Figure 106—Barbara C. Weber, 13th Director of the Pacific Southwest Research Station, 1991–1994. The station's first female director, Weber successfully completed the Consent Decree program and oversaw the station's move to the USDA West Annex Building, Albany, California—the first time that offices and laboratories were built to the station's own specifications.

been a Senior Executive Service slot, to an open competitive position—another “first” in the Forest Service (PSW 1991o). Director Weber’s first priority was to work toward a successful conclusion of the Consent Decree, which was scheduled to end in May, if its programs and goals were met. This goal was accomplished in June 1988, when a Consent Decree milestone hearing was held. Although Judge Conti ordered that the decree be extended for another 2 years for Region 5 compliance, the PSW Research Station was exempted from his decision (PSW 1991e, 1991f, 1991g, 1991h, 1991n). It had been 25 years, but at last the PSW Research Station was out of the shadow of this court action. In recounting the many years under the Consent Decree, Assistant Station Director Enoch Bell commented that the station went through a series of evolving emotions during those years: first “denial,” then “isolation,” then “grudging compliance,” and finally, “adoption,” and believed that while the Forest Service would never be the same, it would be a much better place. “We lead the nation in dealing with our people in a positive and upright manner,” said Bell. “Perhaps the rest of the Forest Service should consider some of these Consent Decree programs” (PSW 1991e). Several months later, in September 1991, Barbara Weber, who had applied for the station director position in February, was appointed to the office, becoming the station’s 13th director (PSW 1991l).

“The new laboratories are palaces, when compared to the old, dark, dirty Stead Building labs.”

More on Budgets, Workforce, and Relocation

Barbara Weber held the station director post until May 1994, a 3-year period that not only saw the successful conclusion of the Consent Decree issue, but several other key events in the station’s history. For instance, overseeing the relocation of the station to a refurbished ARS facility at Albany fell to her administration. New laboratories and new open working space had to be designed for the first and second stories, a new library/publications center created, old equipment disposed, rooms assigned, records retired to the Federal Records Center, and delays in construction by ICF Kaiser’s Albuquerque unit and Page Construction Company overcome. Because the station had not intended to keep its headquarters in the Stead Building beyond January 1992, the later problems caused work disruptions and extra months of rent. Although the second-floor laboratories were still incomplete, on March 9, 1992, 113 PSW Station employees said goodbye to their former Berkeley headquarters and used “Albany” as their new work address. The station’s relocation to the USDA West Annex Building, at 800 Buchanan Street, Albany, which had originated nearly 6 years earlier, marked the station’s fourth move in its 66-year history. However, its move to the West Annex Building was its first occupancy of a government-owned building, and the first time offices and laboratories had been built to the station’s own specifications. There was an additional need for space, and employees had to get used to new commute routes and to the roar of the Amtrak train streaking past the building in the back, but the station scientists were very happy with their new laboratories. Tom Conkle sized up the situation this way: “The new laboratories are palaces, when compared to the old, dark, dirty Stead Building labs.” Four research units maintained laboratories on the second floor: Forest Genetics, Insect Ecology, Insect Population, and Forest Disease. They shared use of preparation rooms, cold rooms, dark rooms, and equipment rooms. By September of the next year, Director Weber declared that any move to the Sacramento area in co-located headquarters with Region 5³¹ was no longer a consideration (PSW 1991a, 1991b, 1991c, 1991m, 1992a, 1992b, 1992c, 1992m, 1992n, 1993l, 1994d).

³¹ In mid-1994, there still remained the question of whether or not the station should join Region 5’s proposed move to Mare Island, Vallejo. The Mare Island Naval Complex was scheduled to close down by 1996. Forest Service Chief Jack Thomas had approved Region 5’s move, and had said he favored PSW relocating there as well, so as to strengthen the collaboration between the two organizations. However, Station Director James Space made a case for why the station should not relocate at Mare Island, quickly pointing out that it would be impractical, even though the move from the Stead Building to a government building had not realized the anticipated savings because the building’s maintenance costs had continued to escalate rather than drop. By August, Station Director Space convinced Thomas that closer collaboration with Region 5 and cost reduction could be achieved without the trouble and expense of relocating to Mare Island (PSW 1994c, 1994f).

Besides the relocation of the station headquarters from Berkeley to Albany, Station Director Weber also dealt with several other critical issues that had been building during the previous decade. Dramatically apparent changes as well as subtle changes characterized the PSW Research Station during the decade prior to Weber's tenure. A comparison of budgets, size, and composition of the workforce, and number of scientists and of publications suggested these differences. In fiscal year 1980, or the start of the Reagan administration, the station's total funds amounted to \$9.2 million; in fiscal year 1990, the amount was \$14.7 million. But although the sum appeared to be a substantial increase, funds in terms of constant 1990 dollars were nearly identical for the two fiscal years: \$9.2 million in 1980, and \$9.12 million in 1990. However, if the publication numbers demonstrate the research results of station scientists, there was an upturn. In fiscal year 1980, the PSW Research Station issued 162 publications, or 1.6 per scientist, and in fiscal year 1990, an estimated 170, or 2.6 per scientist. Owing to changes in the budget, the station's permanent workforce underwent significant transformation. In fiscal year 1980, there were 91 persons classified as scientists; in fiscal year 1990, that figure had dipped to about 64, and the entire permanent workforce declined from 290 in fiscal year 1980 to 210 in fiscal year 1990. Not only was the new workforce more productive, perhaps because of the introduction of desktop computers, but also during the decade, it had become more diversified through the hiring of women and minorities. In fiscal year 1980, women made up 39 percent of the station workforce; in fiscal year 1990, they composed 55 percent. In the same period, ethnic minorities made up 22 percent of the workforce in fiscal year 1980, and 24 percent in fiscal year 1990 (PSW 1991i).

In fiscal years 1991–1993 the PSW Research Station budget inched up with small add-on amounts for 10 RWUs: Global Change, Insect Chemical Ecology, Urban Forestry, Recreation, Forest Genetics, Vegetation Management, Conifer Silviculture, Watershed/Inland Fishery and Aquatic Ecosystems, Wildlife/Range, and Timber/Wildlife (PSW 1991l, 1992o). President George H.W. Bush proposed an additional \$10 million increase in Forest Service research for fiscal year 1994.³²

Owing to changes in the budget, the station's permanent workforce underwent significant transformation.

³² In fiscal year 1994, Forest Service Region 5, unlike the PSW Station, faced enormous downsizing owing to restrictions in timber cutting brought about by the courts and related decisions on preserving the northern spotted owl in Region 6, and in Region 5's decision to manage California spotted owl habitat in 10 national forests in northern California. These reductions in timber cutting resulted in budget cuts and in the need for a smaller workforce. Although Station Director Weber predicted that the station would not have any unfunded positions for the next 3 years because of budget levels and vacancies expected to take place in the permanent workforce over the same period, Region 5 was projected to have an estimated 220 unfunded positions because of the action related to the spotted owl habitat protection (PSW 1993h, 1993k). As a result of Region 5's downsizing, some of the fiscal services provided by Region 5 to the station in a 1985 transfer were reassumed by the station (PSW 1994i).

Forest Service Chief F. Dale Robertson called the study “one of the most significant science-based assessments of resource options in recent years and will form the basis for important and complex decisions regarding management of this vast and diverse region.”

The increased funding in Forest Service research was to be added to a base program of \$17.9 million for continuing research aimed at developing an ecological basis for managing the national forests and other forest lands (PSW 1993d). Part of this increase went to the PSW Research Station, to conduct a major study of the Sierra Nevada ecosystem as mandated by Congress.³³ This study was to be completed in 2 years, and provide a detailed look at old-growth ecosystems as well as other ecosystems found in the Sierra Nevada. Forest Service Chief F. Dale Robertson called the study “one of the most significant science-based assessments of resource options in recent years and will form the basis for important and complex decisions regarding management of this vast and diverse region.” A steering committee appointed and headed by Station Director Weber directed the study and an independent scientific panel gathered state-of-the-science knowledge on the biological, physical, and human environment of the region for future use by policymakers (PSW 1993e, 1995f). However, before the Sierra Nevada Ecosystem Study, could be completed, in November 1993, Jack Ward Thomas³⁴ succeeded Dale Robertson as the 13th Chief of the Forest Service (PSW 1993n). At this time, Thomas, the first chief whose entire career had been steeped in science and research, called for “new leadership” to “reinvent” the conservation principles of Gifford Pinchot and take the agency into the 21st century (PSW 1993o, 1994k, Thomas 2000). At that time, the National Performance Review, headed by Vice-President Al Gore, issued its report, which called for sweeping reforms in the federal government. It sought to create a government that worked better and cost less—a government that served its customers better by cutting red tape and putting customers first. Among its major

³³ Congress mandated the Sierra Nevada Ecosystem Project in 1993, when it enacted HR 5503 (1992 Congress) and allocated \$150,000 for an assessment of old-growth forests in the Sierra Nevada. The U.S. House of Representatives’ Committee on Agriculture also approved a separate bill (HR 6013), specifying that the study should be a comprehensive ecosystem assessment of the entire range. Though HR 6013 fell victim to adjournment, the Forest Service considered the requirements of HR 5503 and HR 6013 as the basis for this study, which was to be completed by December 31, 1995. The study area included both public and private lands (PSW 1995f).

³⁴ Jack Ward Thomas, a native of Fort Worth, Texas, earned an M.S. degree in wildlife biology at West Virginia University and a Ph.D. in forestry at the University of Massachusetts. He joined the Forest Service in 1966 as a research wildlife biologist at the Northeastern Station in Morgantown, West Virginia, and later at Amherst, Massachusetts. Since 1974, Thomas had been a chief research wildlife biologist and project leader at the Pacific Northwest Research Station at La Grande, Oregon. Thomas had authored an estimated 250 publications and was probably best known for heading up an interagency scientific team that in 1990 issued the report *A Conservation Strategy for the Northern Spotted Owl* (Thomas et al. 1990) that elicited considerable interest as well as controversy. Thomas was the second person whose career had been primarily in forestry research to head the Forest Service—the first was John R. McGuire (PSW 1993n).

proposals to move the federal government into the 21st century was a smaller federal workforce, reformation of the personnel system, simplification of the contracting process, closing or consolidating field offices, and instituting major changes in management of the work environment. In return, the Forest Service offered to “reinvent” itself and to serve as an agency for change, innovation, experimentation, and reform in the way it organized, structured, and functioned (PSW 1994i). The National Performance Review (Gore 1993) and Thomas’ appointment signaled a time of unprecedented change that was sweeping over resource management, the whole federal government, and the Forest Service in particular. Nowhere was this more evident than when PSW Station Director Barbara Weber held an all-employee conference in Sacramento, “Reawakening the Spirit in PSW.” With 200 people in attendance, Weber held the meeting to ensure that the station turned in the right direction and positioned itself to withstand even greater changes (PSW 1993n). However, within 3 months, Thomas announced that Barbara Weber would relocate to the WO as associate deputy chief of research, succeeding Eldon Ross, who retired. Thomas named James C. Space as her replacement (PSW 1994a).

The locations of individual research scientists was no longer important because projects often spanned several regions of the state or were part of larger national forestry concerns.

Ecosystem Research Under Directors Stewart and Weber

From 1988,³⁵ when Ronald Stewart became director of the PSW Research Station, to 1994, when Barbara C. Weber took over, a need developed for large-scale synthesis of information for land managers and planners and involvement of scientists in national forest planning—in other words, ecosystem research based on interdisciplinary research (Stewart 2004). The locations of individual research scientists was no longer important because projects often spanned several regions of the state or were part of larger national forestry concerns. To meet this new approach, the PSW Research Station and the Forest Service research program moved to a research attainment reporting system. Under this arrangement, each research station produced an attainment report as one basis on which to evaluate its research program and work unit performance. The WO aggregated the PSW Research Station report with reports from other forest experiment stations to prepare a national report on research programs and accomplishment as required by Congress, the Department

³⁵ In 1988, the PSW Research Station listed 18 active RWUs (PSW 1988l) and had a healthy budget. For fiscal year 1988, the PSW Station had a 61-percent increase in total funding from other agencies and organizations over the previous year (from \$1.6 million to \$2.5 million), and a 47-percent increase in extramural research funds from the previous year. In addition, the Forest Service’s 1986 *Research Accomplishments* (USDA FS 1987) highlighted 16 PSW Research Station achievements (PSW 1988c). However, in the fall of that year, the PSW Research Station lost the Management Sciences Staff (PSW 1988j).

of Agriculture, and the Office of Management and Budget (OMB). In return, they used the national research report to evaluate Forest Service research progress. Each yearly PSW Research Station research attainment report contained two parts. Part I broke down the station's research program into four general functional categories: forest management, environment, protection, and resource analysis. Within each category, the attainment report provided a research work unit description (RWUD) that defined each RWU's mission, described the problems to be studied that year, and discussed how RWU scientists intended to accomplish their goal. Part II provided a bibliography of all the publications produced as a result of research.

Forest Management Research in California, 1988 to 1994

Essentially, during these 6 years, forest management research had five research work units. Three were located in California. They were Institute of Forest Genetics, Silviculture of California Conifer Types, and Establishment and Maintenance of Regeneration for California Forests.

In 1988, project leader Tom Ledig led the IFG. In that year, the big event at IFG was hosting a national genetics workshop that attracted nearly 50 geneticists and other specialists from all the Forest Service regions, three Forest Service experiment stations, the WO and three universities. The PSW Station staff discussed applied uses of isozymes and established procedures for working with the Forest Service National Forest Genetics Electrophoresis Laboratory (NFGEL), recently opened on the Lassen National Forest about a mile from the IFG.³⁶ Analyses by the NFGEL made it possible to map patterns of genetic variation, check compliance of cone collectors, and check on commercial seedlots. This work also permitted ramets, families, provenance, and seedlots to be identified; specific crosses to be verified; and pollen dispersal and seed orchard contamination to be estimated (PSW 1988h). In the same year, research plant geneticist Connie Millar joined the Forest Genetics Research Unit at Berkeley. Millar, who earned her M.S. and Ph.D. in forest genetics at Berkeley and who had worked as a summer employee at PSW, helped establish the Center for the Conservation of Genetic Diversity at IFG. A winner of a prestigious Pew Scholars Program in Conservation and the Environment (1991), she established an innovative program at IFG to create opportunities for forest managers to have "mini-sabbaticals" at the institute where they could focus on educating themselves about specific biodiversity issues (PSW 1991k, 1992l).

³⁶ Sharon Friedman, a full-time technician, directed the NFGEL, which processed seeds and tree samples to provide genetic information about relative amounts and geographic patterns of natural variation and performed analyses that identified different forms of enzymes called isozymes (PSW 1988h).

However, by 1992, Ledig had stepped down and M. Thompson Conkle was made project leader. Under his leadership, the IFG focused most of its time and research budget³⁷ on two other problem areas: quantifying the level and pattern of genetic variation for adaptive growth traits in conifers, and molecular forest biology. Analysis of the evolutionary histories of pines provided knowledge necessary for managing ecosystems to maintain high levels of adaptive variations (USDA FS 1992, 1993). By 1994, IFG scientists were involved in cooperative trials of Douglas-fir representing the West Coast from British Columbia through California, and sugar pines in Spain, that yielded important data about growing adaptations for different seed sources (USDA FS 1993, 1994, 1995). On the other hand, the study of molecular forest biology was a more focused discipline, and was conducted both at Albany and the IFG in Placerville. Together with the NFGEL—which by 1992 had been renamed the Molecular Genetics Laboratory (MGL)—they made significant progress in mapping the key genome and DNA sequences of various pines (USDA FS 1992, 1993, 1994).

At the Redding Silviculture Laboratory, project leader William Oliver, who had succeeded Douglass Roy in 1984, forged ahead with investigations of three problem areas in the Silviculture of California Conifer Types. This RWU was one of two that formed the Vegetation Management Research and Development Program.³⁸ Besides project leader Oliver, the unit consisted of researchers Bob Powers and Leroy Dolph, forester Kathy Harcksen, and biologist Rose Leonard. This RWU was responsible for three experimental forests in northern California. Active research studies were conducted in the ponderosa pine and Jeffrey pine stands at Blacks Mountain Experimental Forest, but no active studies were being conducted on the Challenge Experimental Forest or at the Stanislaus-Toulumne Experimental Forest at this time (PSW 1994f).

The unit's primary research goal involved growth and yield projection systems needed for managed forests of California. Oliver and his staff aimed to develop the necessary equations and integrate them into simulators that would help predict growth and yield of managed stands in the major timber types. Oliver worked on the relationship of tree growth and stand development to initial spacing

³⁷ Other research problem areas included studying the mechanisms and inheritance of disease resistance, investigating exotic species for biomass, and the study of gene conservation.

³⁸ Chartered in 1987, the Vegetation Management Research and Development Program was located in Redding and was managed by Phil Aune. In 1994, a Forest Service WO review of the station's program resulted in a series of commendations for the program's progress toward solving problems selected by its two units through interdisciplinary research (PSW 1994e).

The Secretary of Agriculture was required to ensure that management systems “will not produce substantial and permanent impairment of the productivity of the land.”

and thinning in stands of ponderosa pine and true fir. He and Powers also investigated predictions of growth responses to soil fertilization, and along with researcher Leroy Dolph, he studied the influence of shrub competition on growth of true fir. Such records proved invaluable for validating computerized growth and yield projection systems and monitoring the health of forests in response to disease, insect attack, and global climate change. From this cumulative work came SYSTUM-1, an individual-tree/distance-independent computer program developed for use in young tree plantations in all parts of California, described in the PSW Research Station publication *User’s Guide for SYSTUM-1: A Simulator of Growth Trends in Young Stands Under Management of California and Oregon* (Ritchie and Powers 1993) (PSW 1994f; USDA FS 1992, 1993, 1994).

The second research goal of this RWU concerned developing better information on soil processes that affect forest productivity, and was related to the national Long-Term Soil Productivity Cooperative Study (LTSP) begun in 1989. Initiated by the Forest Service because of public concern about the effects of management activities on forest ecosystems in national forests, the LTSP study provided for a network of installations and research data across a broad range of forest ecosystems throughout the United States and Canada. Under Section 6(g) of the National Forest Management Act of 1976, the Secretary of Agriculture was required, through research and continuous monitoring, to ensure that management systems “will not produce substantial and permanent impairment of the productivity of the land.” This project was initially established to evaluate timber management impacts on long-term soil productivity, but the importance of the issues involved eventually led the Canadian Forest Service, the British Columbia Ministry of Forests, universities, and industry groups to cooperate on the program. Bob Powers chaired the Forest Service LTSP study. California’s first LTSP experimental site, the Nation’s second, was established in 1991 at the Challenge Experimental Forest and operated by the PSW Research Station. After that, other sites were established, and by 1995, five other installations were operating across the western slopes of the Sierra Nevada. Partners included the Eldorado, Plumas, Sierra, and Tahoe National Forests, and the University of California’s Blodgett Research Forest (PSW 1994f; USDA FS 1992, 1993, 1994).

Finally, the third research goal for Oliver’s RWU involved interdisciplinary evaluations of the effects on forest resources of alternatives to even-age silviculture. Forester Kathy Harcksen led the team that researched how ecosystems function, particularly in response to management. To this end, in January 1992, a team of scientists from a number of appropriate disciplines and different RWUs were assembled to conduct research at BMEF on the effect of management practices

on plant, animal, genetic, and biological diversity, on which ecosystem processes were sensitive to disturbance, and on the consequences of disturbance on biological diversity (PSW 1992d). The team also included key personnel from the Forest Regeneration Research Unit in Redding, the Wildlife Monitoring Unit in Fresno, the Insect Chemical Ecology Unit at Davis, and Region 5's Genetics Electrophoresis Laboratory in Placerville. The Blacks Mountain researchers sought information on the health and vigor of wildland ecosystems, their resilience to natural and human-induced disturbances, and the implications for managing Forest Service lands. The effects of three common management practices—high and low structural diversity, cattle grazing, and prescribed fire—on east-side pine ecosystems were of particular interest. By 1995, the scientists had collected baseline data on the vegetation and wildlife at BMEF prior to the installation of treatments for the investigation (PSW 1994f; USDA FS 1992, 1993, 1994).

The second component Vegetation Management Research and Development Program was the Forest Regeneration Research Unit. It was unique at PSW, and was led first by Jim Laacke (PSW 1988l), and then by project leader Charles “Phil” Weatherspoon. Besides Weatherspoon, the RWU consisted of silvicultural researchers Jim Laacke and Philip M. McDonald, research entomologist George Ferrell, and mathematical statistician Martin Richie. Headquartered at the Station's Silviculture Laboratory at Redding, California, the unit worked closely with Region 5's unique Silvicultural Development Unit staffed by foresters Gary Fiddler and Walter Leonard. Their mission was to bridge the gap between the station and region in areas of developing studies with both scientific and operational objectives, and in sharing technology transfer. Together, the station's RWU and Region 5 provided an extra boost to technology transfer and the application of research beyond that usually associated with research units. The RWU maintained the Swain Mountain Experimental Forest and oversaw cooperative studies on 10 national forests in California (PSW 1994g).

The RWU divided its research time between three problems, the most noteworthy being how to systematically control competing vegetation during stand regeneration.³⁹ From 1988 to 1994, steady progress was made toward solving this problem through either controlling undesirable plant species or by stimulating the growth of seedlings through fertilization or genetic enhancement. By 1994, Phil McDonald and Gary Fiddler had more than 40 studies that quantified the major techniques for manipulating vegetation in planted and naturally seeded areas. These

The Blacks Mountain researchers sought information on the health and vigor of wildland ecosystems, their resilience to natural and human-induced disturbances, and the implications for managing Forest Service lands.

³⁹ From 1992 to 1994, the other two problems of this RWU were to better understand plant, insect, and disease responses to predict effects, and to assess competition and tree growth development to alternative treatments.

included methods that directly affected competing plant species and those that indirectly affected conifer seedlings through boosting seeding growth or modifying the environment to the detriment of the competing species. Direct manipulations included using grazing animals, applying selected herbicides, manual release, installing mulches, and deploying large machines with rotary heads. Indirect methods included evaluating enhanced seedlings and taking advantage of the shade produced by different-sized openings in the forest. Information from these studies was valuable for helping forest managers establish rapidly growing plantations. Furthermore, in a series of publications, researcher Philip M. McDonald addressed the reasons that a sustained hardwood industry had failed to develop on California's forest-zone hardwoods. Later, his research broadened PSW's perspectives on hardwood management, culminating in *California's Hardwood Resource: Managing for Wildlife, Water, Pleasing Scenery, and Wood Products* (McDonald and Huber 1995) (PSW 1994; USDA FS 1992, 1993, 1994).

Forest Management Research in Hawaii, 1988 to 1994

The Forest Management Research in Hawaii, and American/Pacific Islands Forestry Research⁴⁰ were the fourth and fifth RWUs in forest management research, which was reorganized and strengthened in Hawaii and the Pacific Islands from 1988 to 1994. In 1990, the Institute of Pacific Islands Forestry, which had been formed in 1967 and oversaw both RWUs, became established by statute under the International Forestry Cooperation Act (IFCA). This act authorized the Agriculture Secretary to provide assistance that promoted sustainable development and global environmental stability in support of forestry outside the United States. The secretary was also authorized to expand the capabilities of the IPIF and, at the request of the Governor of Hawaii, to establish and administer a Hawaii Experimental Tropical Forest as a model of tropical forest management, a site for research, and a center for demonstration, education, training, and outreach. Then, in September 1992, Hawaii Forest Management Research (PSW 1988l) took a significant turn again when the Hawaii Tropical Forestry Recovery Act (HTFRA) amended IFCA. The HTFRA established the Hawaii Tropical Forest Recovery Task Force with a mission to develop strategies for the long-term management, protection, and use of the existing and potential forest resources of the state of Hawaii. Pacific Southwest Research Station Director Barbara Weber served as one of two Forest Service members of the

⁴⁰ In May 1987, the Pacific Islands Research Unit was renamed the American/Pacific island Forestry Research Unit to show that many of the new governments in the Pacific islands were semi-independent (PSW 1987j).

task force.⁴¹ The HTFRA also expanded IPIF and other tropical facilities in Hawaii. In September 1994, the task force presented the Hawaii Forest Recovery Action Plan to Hawaii Governor John Waihee (PSW 1994j, 1995a).

Prior to HTFRA, the PSW Research Station had two RWUs in Honolulu, which were under the IPIF. The first was Forest Management Research in Hawaii. Prior to 1994, project leader Eugene Conrad, who had been responsible for such research since 1988, had concentrated the unit's attention on gathering data in Hawaii to understand the organization and dynamics of koa and koa-ochia, develop techniques to restore mixed-species native forests, and control noxious weeds in Hawaii using insect biological control agents (Conrad and Gill 1996; USDA FS 1992, 1993, 1994). The second RWU, American/Pacific Islands Forestry Research, was led by Craig D. Whitesell. Whitesell focused most of this RWU's work on gathering necessary resource information for management purposes and strategies. Permanent growth plots were established in the tropical forests, and forest inventories of these islands were undertaken (fig. 107). However, RWU also performed long-term studies pertaining to establishing and managing eucalyptus biomass plantations (USDA FS 1992, 1993). By 1994, Whitesell moved the unit into new areas, such as exploring the biological, social, and economic aspects that limit agroforestry expansion, studying the ecology of native and exotic species that limit forest productivity, and gathering knowledge to protect, manage, and restore critical ecosystems, such as mangrove forests (USDA FS 1994).

After the passage of HTFRA, the PSW Research Station still had three principal RWUs to guide the unit's activities. However, three research teams now conducted studies formerly undertaken by the RWUs. They were Restoration of Ecosystem Processes, Control of Invasive, Nonindigenous Weeds, and Forested Wetlands with Jack Ewel as Institute Director.⁴² The Restoration of Ecosystem Processes team continued more than 12 years of research into understanding the structure and function of Hawaii's endangered koa forest and developing techniques

⁴¹ Associate Deputy Chief of State and Private Forestry Michael Rains was the other task force member representing the Forest Service.

⁴² In addition to this major PSW Research Station program change, Region 5 and the Forest Service's State and Private Forestry Branch reorganized as well. In 1980, a full-time position of Pacific Islands Forester at Honolulu was established in Region 5 to work with landowners in Hawaii and the other Pacific Islands. Under the 1994 reorganization, Region 5's Pacific Islands Forester and Associate Pacific Islands Forester were assigned to work under the PSW Research Station to coordinate research with its eventual users, and to provide consistent leadership with the Pacific region. Staffing the new unit were Len Newell, Pacific Islands Forester; Katie Friday, Associate Pacific Islands Forester (both of whom were based in Honolulu); and Pacific Basin Agroforester Robert Westcom, who was based in Guam. Besides Hawaii, they worked also in the Territories of Guam and American Samoa, the Commonwealth of the Northern Marianas, the Federated States of Micronesia, the Republic of the Marshall Islands, and elsewhere in the region (PSW 1995d).



U.S. Forest Service, Pacific Southwest Research Station

Figure 107—Netting forest birds, Keauou Ranch, Hawaii, 1979.

Hawaii's native forests became a major concern for a loosely based cooperative group that had one goal: stop an invasion of weeds.

to restore them. Logging, cattle grazing, invasion by feral pigs and weeds, and other disturbances had degraded these native ecosystems. Key members of the team included forest ecologist Gene Conrad, research forester Paul Scowcroft, and biologist Janis Haraguchi. Studies were conducted throughout the state, with many projects taking place on the island of Hawaii, site of IPIF's research laboratory in Hilo and the state's largest remaining forests (PSW 1995a).

The Control of Invasive, Nonindigenous Weeds team consisted of research entomologists Rosemary Leen and Rex Friesen, supported by several technical assistants. When Captain Cook arrived in the islands in 1778, there were at least 1,400 native species of seed-bearing plants. Since then, more than 4,000 new species had been introduced, with many of them becoming naturalized. Europeans also brought hoofed animals—cattle, goats, pigs, sheep, and horses—which consequently ran wild. As a result, many native plants and birds had been lost and the ecosystems disrupted. By the early 1980s, only a small portion of Hawaii's original rain forest remained. For the most part, these relic rain forests were protected in national parks, state forests, and other reserves, but some predicted that if the invasion of plants could not be stopped, Hawaii's native forests would be gone in a hundred years. Starting in 1984, saving Hawaii's native forests became a major concern for a loosely based cooperative group that had one goal: stop an invasion of weeds that threatened to destroy what was left of Hawaii's rain forest. However, it

was decided instead of chemicals or mechanical means, only the natural insect and disease enemies of the plants themselves were to be used. This approach broke new ground because it was the first time biological control had been used in an attempt to save a native ecosystem (Mastrantonio 1989).

Since the IPIF first began its biocontrol program under the direction of George Markin, who created the program, its work was primarily concentrated on four target weeds: banana poka,⁴³ gorse,⁴⁴ faytree,⁴⁵ and strawberry guava.⁴⁶ Efforts were also concentrated on Koster's curse,⁴⁷ a vine officially classified as a "noxious weed" throughout the Hawaiian Islands, and considered an aggressive invader in Hawaii. All of these weeds had a destructive impact on Hawaii's native forests, mid-elevation rangelands, and other ecosystems, where they suppressed native plants or prevented their regeneration. Biological control was considered the only long-term means of control of forest weeds in Hawaii.⁴⁸ The battle plan was to develop an understanding of the target weeds and their native habitats, identify promising control agents in the countries of origin and study their biology, screen candidate control agents for effectiveness and obtain permission to release them, and evaluate their effectiveness and release them in large quantities. Eventually, insects were imported from the homelands of these weeds and released in Hawaii to

The battle plan was to develop an understanding of the target weeds and their native habitats.

⁴³ Banana poka is a climbing vine that threatens much of Hawaii's koa forests. This tendriled, woody vine comes from the tropical montane forest of the high Andes in South America. Brought to Hawaii around 1900 as an ornamental, by 1989, banana poka had become well established on the Big Island, and on Kauai and Maui, affecting some 120,000 acres. In dense growth, this vine could smother and kill the tallest trees (Mastrantonio 1989).

⁴⁴ Gorse is one of the most damaging exotic weeds in Hawaii. This spiny European shrub was probably introduced in Hawaii around 1900, along with sheep ranching. By 1989, gorse was established on about 50,000 acres on the island of Hawaii and on Maui. A remarkably hardy and aggressive plant, gorse commonly invades areas disturbed by fire and cattle grazing (Mastrantonio 1989).

⁴⁵ Fayatree, a small deciduous tree of the Azores, Madeira, and Canary Islands, is an aggressive invader of Hawaii's dry forests and lava fields. Once considered for reforestation purposes, it soon was recognized as a weed. In 1989, it posed a major threat within Hawaii Volcanoes National Park (Mastrantonio 1989).

⁴⁶ Strawberry guava, also known as Asian raspberry, is a very serious, habitat-altering pest in many parks and preserves in Hawaii, where it poses a major threat to Hawaii's rare endemic flora and fauna. This thorny cane, native to the Himalayas, is related to but more aggressive than the domestic raspberry. It forms impenetrable stands and is a threat even to undisturbed forests because it is spread by birds and can grow in the understory (Mastrantonio 1989).

⁴⁷ Also known as "soap plant," Koster's curse is a dense growing ornamental shrub native to Central and South America. It forms thickets and smothers other vegetation and by 1989 was established on all the islands (Mastrantonio 1989).

⁴⁸ Chemical and cultural control methods (the latter included shading out weeds by replanting trees) were hindered by the inaccessibility of forests degraded by weeds and the cost of herbicide spraying programs. Herbicides also posed a danger to Hawaii's sensitive ecosystems (PSW 1995b).

One research project involved establishing permanent plots in mangrove swamps throughout the Federated States of Micronesia to provide valuable information on species abundance and growth rates.

attack a number of these species. But by mid-1995, only the impact of insects, such as spider mites, on gorse was shown to be successful (Mastrantonio 1989, PSW 1985d, 1995b).

Finally, there was the Forested Wetlands team, which worked to understand how wetlands in Hawaii and the other Pacific Islands functioned. Staffing the new unit were researchers from the American/Pacific Forestry Research Unit, which was phased out. Specialist Craig Whitesell, research ecologist Kathy Ewell, and forester Tom Cole (both based in Honolulu) worked as a team on research projects that were expected to have implications for designing and evaluating management practices in wetlands. For instance, one research project involved establishing permanent plots in mangrove swamps throughout the Federated States of Micronesia to provide valuable information on species abundance and growth rates. Another project studied the distribution and physical characteristics of three kinds of swamps in this region: fringing, riverine, and interior. Understanding the variation among swamps and its effect on the distribution of tree species helped the Forested Wetlands team determine how upland management practices that divert freshwater, such as reservoir or road construction, might affect these swamps (PSW 1995c).

Forest Environment Research, 1988 to 1994

Forest environment research also involved five separate RWUs, but over a space of years they often changed their formal titles to match emphasis on new problems. Essentially, during these 6 years, forest environment research included: Methods and Guidelines for Monitoring Wildlife Populations, headed by Jerry Verner; Timber Management/Wildlife Interactions in Northern California Forest Types led by Barry Noon; Environmental Hydrology of the California Snow Zone, with Neil Berg as project leader, Effects of Forest Management on Hillslope Processes, Fishery Resources and Stream Environments, with Robert Zeimer as project leader;⁴⁹ and Ecology and Fire Effects in Mediterranean Ecosystems, led by Susan Conard.

⁴⁹ In 1989, Raymond M. Rice, long-time project leader in the areas of watershed and hydrology, retired after 42 years of service. He served as project leader at Glendora (1960–1973) and at Arcata (1973–1982), and was a hydrologist in the Hillslopes Process/Fishery Research Unit at Arcata until 1989. Floods, sedimentation, and erosion had been the focus of much of his research career as they related to brush fires in southern California and to logging in northern California, and Rice's work was instrumental in the development of principles and guidelines for implementation of the State Forest Practices Act and practices to protect water quality. In 1989, the California Board of Forestry awarded Rice the Francis H. Raymond Award, the highest honor the organization could bestow on a member of the forestry profession. Rice was the second PSW Station scientist to receive this award, the first being James Jenkinson (PSW, 1989j, 1989k).

Verner's team was headquartered at the Forestry Sciences Laboratory (FSL) in Fresno, which from 1988 to 1993 conducted wildlife, range, and monitoring research (PSW 1988l; USDA FS 1992, 1993, 1994). One of their main assignments was to continue to identify cost-effective, biologically defensible, and statistically reliable methods to monitor trends in bird and deer populations—a subject Jerry Verner had been investigating since the early 1980s as a requirement of the National Forest Management Act (USDA FS 1992, 1993). But during Director Stewart's 2-year tenure, two other projects were also underway. First, PSW research wildlife biologist John Kie investigated whether or not cattle adversely impacted native deer populations in the Western Sierra Nevada ranges by competing for, and trampling, various resources. In cooperation with scientists from the University of California, Davis and the California Department of Fish and Game (CDFG), in 1984–1985, Kie studied the McCormick Creek Basin, a mountain basin within the Stanislaus National Forest, to find the answer. By 1988, their findings indicated that with higher cattle stocking rates, deer spent more time feeding and less time resting than they did when no cattle were present. However, the study could not precisely determine what level of cattle stocking improved overall forage conditions for deer, and anticipated further analysis and studies to better understand the relationships between cattle and deer (Pearce 1988c).

Another cooperative study between the PSW Station and CDFG at this time involved understanding the role of predators in declining deer numbers along the west slope of the Sierra Nevada. Don Neal, research scientist at the Fresno Laboratory, along with George Steger (also with PSW), collected data from 1970 to 1985 for this study in North Kings area, where apparently the deer population was declining as mountain lion numbers increased. To learn whether mountain lions benefited mule deer herds by keeping their numbers in balance with their habitat, the researchers attached radio collars to 14 cats and 25 does to track them as they roamed their home ranges. In 1988, detailed information from the study revealed that lions were not benefiting the population by taking only the weak and old, but were preying upon an already depressed herd. Interestingly, however, the data indicated that some lions were not following herds as they migrated to higher elevations in the summer, but remained at lower elevations. At these levels, they preyed upon livestock, small mammals, and pets—a good way for a mountain lion to get into trouble. Neal and Steger expected livestock predation to continue at a high level or even increase, and deer to continue to decline in all but the most favorable years (Harrison 1989).

Meanwhile, in 1991–1992, the PSW Research Station became ever deeper involved in the spotted owl controversy.⁵⁰ In January 1992, the Forest Service released its final environmental impact statement on the northern spotted owl. The management plan preferred by the Forest Service aimed at maintaining the viability of the species and saving it from extinction by increasing the area of its habitat—at the time, 6.1 million acres in Washington, Oregon, and California—by 12 percent over the next 150 years (PSW 1992i: 10 February: 1–2).

Thereafter, Verner, along with Barry Noon and Kelvin McKelvey of the Timber/Wildlife Research Unit at Arcata were assigned to study the geographic variability in habitat use by California spotted owls⁵¹ (fig. 108). For instance, one objective of the RWU was to compare owl populations in managed and unmanaged forests on the Sierra National Forest and the Sequoia/Kings Canyon National Parks (PSW 1991m; USDA FS 1992, 1993). Their work at the Fresno Sciences Laboratory and elsewhere eventually resulted in an important publication on the subject, *The Spotted Owl: A Technical Assessment of Its Current Status* (Verner et al. 1992). Supplies of this report, which was spotlighted in the 1993 Forest Service Annual Report, were quickly exhausted. Owing to heavy demand, Verner and his team also produced important studies on the major prey species of the California spotted owl, and on identifying other birds associated with older forests, such as the habitat ecology and distribution of the marbled murrelets in northwest California and southwest Oregon (PSW 1993m, 1994b; USDA FS 1993, 1994).

However, by early 1994, the unit had completed its original mission of developing methods for monitoring wildlife populations, documenting the size and composition of spotted owl populations, and characterizing the effect of grazing on sensitive plants in montane riparian zones. In February, under an RWU description approved by the WO, the research unit was renamed Sustaining Wildlife Communities and Key Ecosystem Linkages in Montane Forests of the Sierra Nevada. Their new mission was twofold: to sustain viable populations of California spotted owls, and, in cooperation with the Sierra National Forest, to monitor responses of plant

⁵⁰ By this date, the Portland Spotted Owl Research, Development, and Application RWU studies found that the northern spotted owl was dependent on old growth for its survival, and a court injunction forced the Forest Service to reduce logging in its remaining patches of old-growth forest along the Pacific Coast. The northern spotted owl was seen as an “indicator species” of old growth, and to environmentalists, its plight represented that of the many species associated with that increasingly rare habitat. Ultimately, the spotted owl issue affected timber harvests in the Pacific Southwest Region, reducing them from the 1.5 billion board feet in the 1980s to just 500 million or fewer by the early 1990s (Godfrey 2005).

⁵¹ The California spotted owl inhabits forests and woodlands from north-central California to the Mexican border. It is a “cousin” to the northern spotted owl, which the U.S. Fish and Wildlife Service in 1990 listed as a threatened subspecies (PSW 1991m).



U.S. Forest Service, Pacific Southwest Research Station

Figure 108—Tagging a spotted owl during California habitat study.

and animal communities to ecosystem management. The unit had 16 permanent, full-time employees. Research wildlife biologist Jerry Verner continued as project leader. Other key wildlife biologists included John Kie and Bill Laudenslayer, and range scientist Ray Ratliff. The unit continued to manage the San Joaquin Experimental Range (SJER)⁵² (fig. 109) and the Teakettle Experimental Range (TER) (PSW 1994h) (fig. 110).

Timber Management/Wildlife Interactions in Northern California Forest Types, first led by Barry R. Noon (PSW 1988l), and later by Cynthia J. Zabel, was another important RWU within forest environment research. At the Redwood Sciences Laboratory, they investigated the habitat requirements of select wildlife species within mature and old-growth forests in northern California and southern Oregon, studied the habitat necessary for the spotted owl's survival and reproduction, and then integrated that information with results from other experiment stations and federal agencies, such as the U.S. Fish and Wildlife Service and the Bureau of Land Management. These studies contributed significantly to the understanding of the habitat requirements of spotted owls, and ongoing studies of spotted owl biology by PSW researchers proved important in pending litigation and various evidentiary hearings (USDA FS 1992, 1993, 1994).

⁵² By this date, SJER had been designated a Man and the Biosphere Reserve, and was the only site used for research in annual grasslands under the International Biological Program (PSW 1994h).



U.S. Forest Service, Pacific Southwest Research Station

Figure 109—San Joaquin Experimental Range building, 1971.



U.S. Forest Service, Pacific Southwest Research Station

Figure 110—Cattle grazing on the San Joaquin Experimental Range, 1971.

At the same time, the RWU under project leader Neil Berg, whose mission had been to study the cumulative environmental hydrology of the California snow zone, had been redirected to a new mission and given a new title, Cumulative Effects of Resource Management on Forest Watersheds, Aquatic Ecosystems, and Fish Communities in California. Berg continued as project leader, but the unit was charged with investigating problem areas related to forest environmental research on the inland mountains of California, primarily the Sierra Nevada. By 1992, the RWU had three primary goals: to develop and test cumulative effects models that related land management practices to watershed responses over time and space and to changes in diversity and integrity of aquatic ecosystems; to develop monitoring procedures that defined the spatial and temporal variability of physical and biological systems so that changes owing to land management might be detected; and to understand the recovery of channel systems in disturbed watersheds in order for stream restoration and enhancement efforts to be cost effective and successful. Besides Berg, the unit consisted of several fish biologists, hydrologists, and other specialists who maintained two field facilities in the central Sierra Nevada: the Central Sierra Snow Laboratory (CSSL) and the Onion Creek Experimental Forest. The CSSL was part of the California Acid Deposition Monitoring Network, the USDA Soil Conservation Service's snowpack monitoring network, and the National Oceanic and Atmospheric Administration's weather monitoring network. Snow accumulation records at CSSL and nearby sites made up the longest known record of snowfall west of the Mississippi River (PSW 1993g).

Some of the RWU's studies focused on the effects of cattle grazing on aquatic ecosystems (fig. 111). Others explored stream channel dynamics because there was a general concern that construction of dams modified downstream channels with increases in riparian vegetation, reduction of aquatic habitat, and other ramifications. Biologists and hydrologists with the RWU also established a regional database for fisheries inventories (PSW 1993g). Another notable project came in 1992, when the unit collaborated with the Sierra Nevada Ecosystem Project (SNEP). In that year, Congress mandated that the Forest Service study the entire Sierra Nevada ecoregion (California and western Nevada) for planning purposes. The overall goal of SNEP was to scientifically review late-successional forests, key watersheds, and significant natural areas on federal lands of the Sierra Nevada ecoregion, and provide Congress with an accurate, multidimensional ecosystem assessment so that key structural components and functional processes could be identified and adequately described to enable the management of these systems at sustainable levels for the future. In support of SNEP, the RWU made a critical review of cumulative watershed effect methodologies used by states and the Forest Service. This was



U.S. Forest Service, Pacific Southwest Research Station

Figure 111—Forest environmental research included the study of fishery resources and stream environments.

completed in June 1996. Other forest environmental studies involved regionwide studies on trout habitat and understanding the recovery of disturbed watersheds and aquatic ecosystems from impacts, such as cattle grazing (USDA FS 1992, 1993, 1994).

A related area of study was Effects of Forest Management on Hillslope Processes, Fishery Resources, and Stream Environments, which had been led by Robert Zeimer at the Redwood Sciences Laboratory at Arcata since 1988 (PSW 1988). His research unit concerned itself with evaluating erosion, timing, and routing of sediment and related cumulative effects on fish habitat and the effects of stream structure, processes, and stream ecology on anadromous and resident fish. Fishery biologists and hydrologists in land management agencies lacked practical, quantitative methods for evaluating and monitoring effects of sediment on stream habitats, and Zeimer's research aimed to meet this need (USDA FS 1992, 1993, 1994).

Susan Conard's RWU, Ecology and Fire Effects in Mediterranean Ecosystems, was the last but not the least of the forest environmental research units. In the years from 1988 to 1994, this was one of the largest units at PSW, numbering more than 25 employees, and had the management responsibility for the San Dimas Experimental Forest (SDEF). The SDEF, which had opened its doors 50 years earlier in a building built with funds donated by the citizens of Glendora, investigated many fire and ecology problems (PSW 1990a, 1992e). One interesting study was begun in 1987 when PSW research forester Hulton B. "Hutch" Wood and soil scientists from the University of California, Riverside, and Oregon State University won an internal PSW Station competitive grant to study the effects of air pollution on soils in the watershed using the old lysimeters at Tanbark Flats at SDEF that had not been used since fire struck the area in 1960. In this study, they compared archived soils with present-day soils that had been exposed to high levels of atmospheric pollution to determine the presence of toxic metals such as lead, copper, cadmium, arsenic, and mercury, and compare sulfate concentrations from smog (fig. 112) with earlier basic chemical characteristics of lysimeter soils. Naturally, they found excessive amounts of toxic metals, particularly zinc and lead, and sulfates from smog, but

They compared archived soils with present-day soils that had been exposed to high levels of atmospheric pollution.



U.S. Forest Service, Pacific Southwest Research Station

Figure 112—Scientist taking air samples, 1981.

Researchers who spent so many years designing the lysimeters and carrying out the original study in the late 1930s would have been gratified to find out that their lysimeters were still producing useful results and lessons long after the original study had been terminated.

they also inadvertently discovered other interesting data regarding soil genesis under different plant species and regarding site stability that was useful to builders and engineers. Researchers who spent so many years designing the lysimeters and carrying out the original study in the late 1930s would have been gratified to find out that their lysimeters were still producing useful results and lessons long after the original study had been terminated (Mastrantonio 1990).

Meanwhile, another interesting Fire Ecology Unit project at SDEF and nearby sites was conducted in 1990, in cooperation with Region 5, the California Department of Forestry, and Los Angeles County. In this study to determine the effects of postfire treatments, a prescribed burn of about 500 acres was set in Bedford Canyon, in the Santa Ana Mountains in southern California, with the objective of reducing fire hazard, managing wildlife habitat, and evaluating the effects of fire and postfire seeding on chaparral systems (PSW 1990c, 20). The experimental burn actually turned into a wildfire that scorched about 3,200 acres before it came under control, and other areas were also burned. Station personnel gathered needed data on dynamic responses of chaparral to fire and concluded that seeding grasses after a fire could severely inhibit regeneration of native postfire herbaceous flora (USDA FS 1992, 1993, 1994).

Forest Protection Research, 1988 to 1994

Fire research had been a priority for the PSW Research Station and Region 5 in the past, and California's 1987 fire season, one of its worst ever, once again brought forest protection research to the fore⁵³ (PSW 1988c). The Riverside Fire Laboratory, which was the PSW Station's largest single field facility, celebrated its 25th anniversary in 1988. It housed four fire-related RWUs: Meteorology for Fire Severity Forecasting; Fire Management Planning and Economics (renamed Fire Management in the Wildland-Urban Interface in 1993); Site-Specific Fire Prescriptions for Chaparral and Related Ecosystems, which was renamed Prescribed Fire Research the same year; and Sue Conard's Ecology of Chaparral and Associated Ecosystems, which was discussed earlier in this chapter in the section on forest environment research.⁵⁴

⁵³ In the year after the devastating 1987 fire season, the Riverside Laboratory held a major symposium on wildland fire management and expanded its program through additional funding from Washington.

⁵⁴ Between 1988 and 1990, the Riverside laboratory shifted its program to the integration of fire management with other resource management problems (PSW 1990p). In this regard, Conard's unit was recategorized as forest environment rather than forest protection research, and therefore was discussed in an earlier section.

The Meteorology for Fire Severity Forecasting RWU was led by Francis Fujioka (PSW 1988l). Until 1994, it had steadily addressed two meteorological problems related to fire: discovering statistical relationships between forecast weather elements and fire severity, and gathering data on seasonal temperature and precipitation to forecast the magnitude, duration, and spatial variation of fire severity in parts of California and other regions of the United States. In 1994, this RWU was renamed Meteorology for Forest and Brushland Management. Francis Fujioka continued as project leader for this long-range fire weather forecasting unit. But before the unit moved on to its new mission, Fujioka summarized the major accomplishments of the unit's previous work. Among its accomplishments, the RWU had over the years developed baseline data upon which related research on fire weather forecasting could be built, and developed the means to forecast monthly weather conditions across the United States from this operational forecast data. From their work, others could correlate weather information with other fire activity data and predict potential fire weather. Furthermore, the unit derived probability measures of fire potential from over 120 locations across the contiguous United States, which could be used to predict fire severity 3 months in advance (USDA FS 1992, 1993, 1994).

Another fire-related research unit at Riverside in 1988 was Fire Management Planning and Economics with Jim Davis as acting project leader (PSW 1988l). Richard Chase replaced him as project leader in 1989⁵⁵ (PSW 1989a). In early 1990, one pressing Forest Service issue was the study of catastrophic fires and the environmental change that set the stage for such fires (PSW 1990l). In response, the RWU undertook research to develop a conceptual model for assessing fire risk in the wildland-urban interface. By May 1992, with the approval of the WO, the unit was terminated, and its personnel shifted to a new unit entitled Fire Management in the Wildland-Urban Interface (PSW 1992k). Chase served as project leader until May 1993, when he retired after 39 years of service (PSW 1993a).

By the time Chase retired, the RWU staff was investigating two problem areas. In the first, they developed a computer model to assess the potential for structures to ignite from fire in wildland fuels based on the physics of combustion, heat transfer, and ignition characteristics of various external structural materials. They tested

In early 1990, one pressing Forest Service issue was the study of catastrophic fires and the environmental change that set the stage for such fires.

⁵⁵ Twenty years earlier, Chase had come to the Forest Fire Laboratory at Riverside to work in the Fire Management Systems Research Unit, then led by Jim Davis. In 1972, Chase had helped manage the FIREScope program headquartered at the Riverside Laboratory, but in 1975, when the program was transferred to Region 5 for implementation, he became its project leader and completed the program's research phase there. Building on this experience, in 1980, Chase transferred to the Washington office, and became a national fire-planning specialist in the Fire and Aviation Management Staff (PSW 1989g, 1990m).

Their mission did expand from developing site-specific prescriptions for fire use in southern California chaparral country to studying ecosystems in the Southwestern United States, and to studies in Latin American, European, and Middle Eastern countries.

their theories on the San Jacinto Ranger District of the San Bernardino National Forest. In the second research area, RWU staff worked to improve information and decision-support systems for fire program planning and implementation. In this regard, the unit worked closely with Fujioka's unit (USDA FS 1992, 1993, 1994).⁵⁶

In 1982, a RWU was established at the Riverside Laboratory with prescribed fire research as its focus. Before 1993, it had been entitled Site Specific Fire Prescriptions for Chaparral and Associated Ecosystems, and headed by project leader Andrea "Andi" Koonce. From 1988 to 1993, the unit steadily researched a number of problems, such as gathering knowledge on prescribed fires and the effects of fire on ecosystem structure and function, and predicting prescribed fire effects on chaparral and associated vegetation in southern California (USDA FS 1992, 1993). However, in 1993, David R. Wiese took over as project leader and the unit was renamed Prescribed Fire Research. However, the new title and new leadership did not change the general focus of the unit. Most of the work of the unit continued to measure fire effects that occurred during and after a fire, including fuel consumption, soil heating, soil nutrient changes, plant responses (sprouting, growth, and morphological), species composition, invertebrate responses, and smoke emissions. However, their mission did expand from developing site-specific prescriptions for fire use in southern California chaparral country to studying ecosystems in the Southwestern United States, and to studies in Latin American, European, and Middle Eastern countries. By the close of 1994, the unit had seven permanent employees (five research foresters, a forest technician, and an ecologist). They managed the North Mountain Experimental Area located about 30 miles east of the laboratory, which was designated for research relating to fire suppression, prevention, and control. Project scientists also were involved with the SNEP and a large, stationwide interdisciplinary study, which was located within the Hayfork Adaptive Management Area in northern California (PSW 1995e).

Besides fire science research, another important research facet of forest protection research was insect research. In the late 1980s and early 1990s, basic research in the biochemistry, genetics, and biometry of forest insect populations formed the

⁵⁶ During the 1993 fire season, a series of devastating fires ravaged southern California early in November, burning more than 200,000 acres of land from Ventura County to the Mexican border, destroyed 1,200 homes, caused an estimated \$1 billion in damage, and resulted in three deaths and 200 injuries. Furthermore, control of the fires required the efforts of more than 5,000 firefighters and nearly 800 engine companies. Following the fire season, the issue of fire at the urban-wildland interface was the subject of the "Biswell Symposium" that year, which was named after Harold Biswell of the University of California, Berkeley, a long-time advocate of prescribed fire use to manage fuels both in wildlands and at the interface (PSW 1993j).

mission of the Albany Station's insect population research units, which was broken down into two related research units. The first RWU was Biology and Control of Insects Adversely Affecting Regeneration and Establishment of Western Forests, which was led by project leader Michael I. Haverty. During most of the years between 1988 and 1994, scientists, such as Haverty, Thomas W. Koerber and Patrick Shea, focused their work on basic research in the biology and control of insects affecting flowers, cones, and seeds, and insects affecting nursery stock and trees in young stands, with a few hours given over to research on termites in California and Hawaii. Their work produced sound research in these areas, as well as a steady stream of publications. However, in 1994, the unit was renamed Chemical Ecology and Management of Western Forest Insects. This change resulted from the Forest Service's new emphasis on ecosystem management, which altered the direction of some insect research from evaluation of pest impacts to studying the beneficial roles insects played in maintaining a productive forest environment or ecosystem. For instance, it had long been suspected that when bark beetles altered forest stand structures and species diversity they also produced important bird refuges and wildlife habitats (USDA FS 1992, 1993, 1994).

The second insect research RWU at the Albany Station was called Improved Technology for Integrated Management of Western Forest Insects. Jacqueline L. Robertson was the unit's project leader, and remained so even after 1990 when the RWU was renamed Forest Insect Population Genetics and Biochemistry. The unit was responsible for developing integrated pest management strategies for managing forest defoliators over large and special-use areas, and much of its research emphasized insect pheromones, bark thickness, and tree size as important subjects for understanding why mountain pine beetles attack certain trees and not others. Robertson's staff also analyzed spatial patterns of lodgepole pines to see if spatial distribution might provide a clue for predicting an outbreak. In addition to this research, the RWU defined statistical models to estimate effects upon insect populations exposed to a variety of pesticides, and developed models to forecast changes in insect population status independent of pesticide use (USDA FS 1992, 1993, 1994). In doing so, unit researchers sought to isolate indicators of population changes from endemic to epidemic, and to determine when population increase management strategies could best be used to prevent epidemics from occurring (PSW 1993h). One captivating early project pertained to a novel pesticide delivery method, developed by PSW Research Station scientist Thomas Koerber in cooperation with Pacific Northwest Region forester Roger E. Sandquist. Relying on a recent development in the science of pesticide delivery, they discovered in field tests that genetically valuable Douglas-fir specimens could be protected from the ravages

INSEX provided information on damage type, tree and insect species, infestation location, constraints on insecticide application, and recommendations.

of the western spruce budworm by a dozen or so bullet-sized capsules implanted around the base of each tree. So dramatic were the results from this experiment that local foresters, who had cooperated in the trials, immediately expanded the scientific study to include several thousand Douglas-fir specimens they had selected as parent stock for reforestation efforts. Koerber and Sandquist's decision to let potential users assist in the study showed how researchers and workers in the field could collaborate for useful ends to both parties. Koerber and Sandquist's work was thought to be effective and economical, confounding the assumption that high-tech necessarily meant high cost (Pearce 1988b).

Another interesting project came from 20 years of research by project leader Jackie Robertson. Called INSEX, this software program helped users of insecticides determine under what conditions control treatment was warranted, then helped them select the safest pesticide for that pest and environmental conditions. INSEX provided information on damage type, tree and insect species, infestation location, constraints on insecticide application, and recommendations. With research shifting from pesticides to a biochemical approach, the program served as an example of Forest Service technology transfer (PSW 1989c).

Pest Impact Assessment, later called Disease Pests of California Forests, faced troubling times after 1988. Since 1956, when the station created its own forest disease research division, forest disease research had been an important function of the PSW Research Station. However, in 1991, project leader Robert Scharpf retired after a long career of studying the plant pest western dwarf mistletoe (PSW 1991k). Following Scharpf's retirement, Mike Haverty was named acting project leader, but continued as project leader for Insect and Biological Control Research. Station Director Barbara Weber stated that the PSW Station intended to maintain the Forest Disease Research Unit as a separate RWU whose function would be root disease research, emphasizing annosus root rot.⁵⁷ Furthermore, she added that the RWU would keep its separate identity, with distinct funding and management codes, and a permanent project leader would be recruited and appointed as soon as possible. Meanwhile, current Forest Disease Research Unit pathologists and biological technicians carried on (PSW 1991j). Although a Forest Disease Unit pathology laboratory was included in the new Albany facility, no project leader replacement was hired during Weber's administration (PSW 1992n) because of major cuts in

⁵⁷ Research plant pathologist Bill Otrrosina had been carrying out research in this area since 1985. According to Otrrosina, root diseases were a highly underrated problem because often foresters do not see the dramatic effect on forests that is usually observed with insect attacks (PSW 1993c).

insect and disease research (18 percent) starting in fiscal year 1991 (PSW 1990l). This came about largely because of a freeze on hiring employees from outside the Forest Service, instituted in November 1992, that continued for several years (PSW 1992h, 1993b).

Meanwhile, one other research focus at Riverside—atmospheric deposition—was considered under the rubric of forest protection research. Atmospheric Deposition on Montane Forests of the West was the formal title and mission of the RWU, which had a number of different project leaders during the period 1988 to 1994. They included Paul Dunn, David L. Peterson, Mark A. Poth, and lastly Paul R. Miller (PSW 1988k, 1988l). This research unit sought to answer two basic questions: What changes in forest productivity and biogeochemistry were being caused by increased levels of atmospheric deposition in montane forests? What were the responses of western forest tree species to atmospheric pollutants and environmental stresses that occurred sequentially or in combination? In 1993, in addition to the research carried out by its scientists—several plant physiologists, as well as an ecologist, a soil microbiologist, a chemist, and a statistician—the unit provided support activities for the entire Riverside facility, including a chemistry laboratory, health and safety coordination, and photographic services. The RWU maintained two field facilities. Since 1983, it had operated a wet deposition monitoring station at Tanbark Flats on the SDEF. The Riverside unit also maintained a field fumigation facility in Garner Valley, within the San Jacinto Ranger District of the San Bernardino National Forest, used mainly for long-term ozone fumigations (PSW 1993f).

The unit conducted several important studies. Beginning in the 1970s, one long-term study had aimed at improving an understanding of the long-term ozone exposure effects on individual crowns of conifers and on the successional dynamics of forest stands. Cooperative experimental work in the San Bernardino Mountains with the California Air Resources Board focused on a multidisciplinary approach to understanding changes induced by air pollution and other stresses. Research investigated the possible combined effects of ozone, acidic air pollutants, and climate on annual changes in tree health, stand succession, and nutrient cycling (PSW 1993f; USDA FS 1992, 1993, 1994). By early 1989, PSW Research Station scientists were briefing Congressman George E. Brown and the legislative representative for Senator Pete Wilson on the topic of Global Climate and Forestry. Project leader Dave Peterson proposed a research program in the Western United States to determine the consequences of increasing atmospheric ozone levels and acid deposition. Other project leaders were also present at these legislative briefings, such as Rowan Rowntree (Urban Forestry), who spoke on urban forestry issues and compared cities

What were the responses of western forest tree species to atmospheric pollutants and environmental stresses that occurred sequentially or in combination?

Scientists began to look more closely at global warming to determine whether forest health and forest management practices were a source, or sink, for greenhouse gases.

to greenhouses, stating that urban forests could be used to reduce global warming, and Phil Riggan (Chaparral Ecology), who described his concerns about the effects of wildland and agricultural fires on global warming, and the need to monitor ecosystem changes that threatened forest survival. Congressman Brown thereafter stated that he expected that the station would become a “center of excellence for studying forest and fire-related issues in global climate changes” (PSW 1989m).

In response to this encouragement, scientists began to look more closely at global warming to determine whether forest health and forest management practices (e.g., prescribed burning and timber harvesting) were a source, or sink, for greenhouse gases such as carbon dioxide, methane, nitric oxide, and nitrous oxide. Monitoring studies were soon begun in southern California to better understand the flux of greenhouse gases there, which would be used to develop an overall global assessment for the Forest Service (PSW 1993f). The RWU staff also began attending and presenting papers at global warming workshops and conferences, a topic the Forest Service budgeted for and made a priority program starting in 1990. For instance, in 1992, the Forest Service announced global change program grants. Six PSW Station scientists received \$150,000 for research, and in the same year, PSW Station scientists attended a United Nations conference on global warming held in California (PSW 1989j, 1990l, 1992f, 1992j).

Recreation Research, 1988 to 1994

In 1988, recreation research took place at the Riverside Laboratory and involved a combination of recreation and urban culture research. Known as Wildland Recreation and Urban Culture, RWU 4902 (PSW 1988l, 1989i) had gotten underway at the Riverside Laboratory in 1986 when research forester Art Magill transferred to the laboratory from station headquarters in Berkeley. Shortly afterwards, a number of cooperative studies were completed that addressed communication, land ethics, vandalism, and application of recreation policy in southern California. Then in 1988, Alan Ewert was named project leader, and the WO approved the unit. Research to develop effective visitor management strategies for high-use wildland recreation areas with emphasis on cultural and user groups was its stated mission. Much of the focus of its research was outdoor recreation sites in southern California, which were being impacted by many of the 15 million people living in the Los Angeles basin. Research was aimed at understanding the cultural groups using these recreation areas, and to learning about their activities and the satisfactions they derived from that use. Methods were also developed to reduce conflicts, increase satisfaction, and control vandalism while protecting natural resources (PSW 1993i). Workshops were held on various wildland recreation subjects, papers

were given at leisure research symposia, and articles were written for journals on wildland recreation and contemporary society. Many of the unit's early studies were done under cooperative agreements with universities, such as the University of California, Irvine and University of California, Chico. Some studies identified depreciative behavior regarded as most serious by managers of federal, state, and county recreation areas, such as littering, damage or destruction of facilities, drug and alcohol abuses, off-road vehicles operated in unauthorized areas, and graffiti. For instance, cooperative research projects were undertaken with the California Department of Parks and Recreation and other interested stakeholders in 1989 to develop standards for acceptable off-road vehicle use in southern California. Unfortunately, the best solutions to many problems were also the most expensive. They included visibility of park and recreation personnel, increased patrols, presence of hosts or volunteers at the sites, stricter enforcement of rules, increased user involvement, better communication of reasons behind rules, onsite education or interpretive programs, and incentives to users for proper behavior (PSW 1989f, 1989h, 1989k, 1990d, 1993i).

In 1991, research social scientist Deborah Chavez, who had joined the unit in 1989, became project leader when Ewert was transferred to the WO's Forest Inventory, Economics, and Recreation Staff as a branch chief (PSW 1990o, 1991d). Chavez continued the work of the research unit along much the same path as her predecessor, including research on cultural differences in recreation use, especially Hispanic use. Studies indicated that Hispanic visitors were composed of three subcultures (Hispanics born in the United States, Hispanics born in Mexico, and Hispanics born in Central and South America), and that each subculture differed in perceptions of how the land should be used, rules and regulations, and satisfactions derived. Additional studies by the unit contrasted recreational use by Hispanics and Anglo populations and investigated trends by such users regarding mountain biking, four-wheel driving, hang-gliding, or eco-vacations. Additional studies examined social demographics, communication methods, user conflicts, and visitation history and patterns of visitors not just on Forest Service land, but also on Bureau of Land Management lands in California. Finally, starting in 1992, the unit held symposia on the social aspects of recreation research, which brought managers and scientists together to discuss their common problems and to distribute information about current research. By 1993, the culmination of much of the unit's research came in a collection of 30 essays that explored a variety of interface issues and problems entitled *Culture, Conflict, and Communication in the Wildland-Urban Interface* that was edited by Ewert, Chavez, and Magill (Ewert et al. 1993, PSW 1993i).

End of An Era

On September 25, 1992, A. Everett Wieslander, a member of the first graduating class of the University of California School of Forestry, and the last surviving member of the original four-person staff who had been present at the California Station's founding in 1926, died in Alameda, California, at the ripe age of 102 (PSW 1992p). Wieslander's passing marked the end of an era in forestry science and at the PSW Research Station.

Chapter 9: 1995–2000, Epilogue

According to Vice-President Al Gore's 1994 *National Performance Review*, the task of "reinventing" the Forest Service and therefore the Pacific Southwest (PSW) Research Station¹ fell to Station Directors James C. Space (1994–1997) and Harold R. Salwasser (1997–2000). The reinvention effort included restructuring and reducing the Forest Service from top to bottom, including "changing its culture, reengineering its work, achieving healthy ecosystems and vital communities, and creating an effective, multidisciplinary, multicultural organization" (PSW 1995g). Station Director Space was a member of the Forest Service's Reinvention Team and succeeded Barbara Weber in May, 1994. Space had worked his way up through the Forest Service ranks² but he was not a research scientist, nor did he have a science background. His job was to provide "leadership" and "teamwork" style to the station and to work with personnel toward understanding, accepting, and supporting the mission, vision, guiding principles, and operating guidelines established nationally for the Forest Service and Research during the massive reorganization of the U.S. Department of Agriculture that began that year.³ His personal goal was to carry on, and if possible, to strengthen the tradition of excellence in science for which the PSW Research Station was recognized. In this regard, he focused the station's research efforts on the "vital few" areas where he thought the station could make a significant difference. But he not only strove for incremental additions to

¹ Since 1990, PSW had called itself the "Pacific Southwest Research Station," and not the "Pacific Southwest Forest and Range Experiment Station," which had been its official title since 1959. In 1997, under 36 Code of Federal Regulations 200.2d, all six Forest Service stations were now called "Research Stations" (PSW 1997b).

² Jim Space started his Forest Service career in 1958 as a GS-3 fire lookout, and from that time, he did everything, from making timber sales, to conducting forest inventories, to developing computer applications, to dealing with insect and disease problems. Upon receiving his Master of Forestry degree from Yale University, he joined the Forest Service, holding various positions in the Northern Region before transferring in 1972 to Atlanta, where he worked as a forestry inventory specialist in the Southeastern Area's State and Private Forestry Staff. Upon transferring to the Washington office in 1974, he became Director of the Computer Applications Staff and then in 1980, Assistant Director of Cooperative Forestry. In 1981, Space transferred to the Pacific Northwest Region as Deputy Regional Forester for State and Private Forestry (PSW 1994n, 1997e).

³ At this time, the 43 agencies of the USDA were reduced to 29, and the Agriculture Department was to cut at least 7,500 staff-years by the end of fiscal year 1999. However, the Forest Service continued as a separate agency and remained the largest in the Agriculture Department. Nonetheless, as part of this reorganization effort, the Intermountain Research Station was merged with the Rocky Mountain Station at Fort Collins, Colorado (1997), and the Southern Station was merged with the Southeastern Station at Asheville, North Carolina (PSW 1994l, 1997f). At the field headquarters level, a reduction of 600 full-time equivalent employees was planned servicewide (PSW 1995g). Between March 1995 and May 1998, the Washington office was restructured as well (PSW 1995l, 1997k 1998c).

knowledge, he also confidently encouraged station scientists to seek true scientific breakthroughs or “revolutions” (PSW 1994m, 1994n, 1994o).

Unlike James Space, Station Director Salwasser, who succeeded Space in 2000, was a scientist and the author of dozens of publications and popular articles.⁴ Upon his assignment to the PSW Research Station, Salwasser was struck by the ongoing need for research regarding California and Pacific island natural resources, and concerned about the resources available to meet those needs. The station also needed stronger capabilities, including increases in both budgets and staff, to address research and development demands. In the long run, Salwasser wanted to increase the station’s overall research and development capacity by strengthening the station’s complementary relationships with the PSW Region 5, other federal agencies, universities, states, industries, and conservation groups (PSW 1997a).

The effects of the reorganization plan on the PSW Station were expected to be minimal in comparison to other stations, but in truth, there were important changes and significant hardships during both James Space and Hal Salwasser’s administrations. Declining budgets and staffing presented their greatest challenge. Fiscal year 1996, was remembered as one of the most difficult periods in its history, for in that year, the year of the station’s 70th anniversary, the PSW Research Station faced budget cuts totaling \$2.8 million. These cuts equaled 12 percent of the budget, which translated into 43 positions that could not be filled at facilities at Albany, Placerville, Riverside, and in Hawaii. Reduction in funds by research work units (RWUs) were across the board and led to the disbanding of two RWUs (Forest Insect Population and Watershed/Inland Fisheries), both based at Albany headquarters. Of these positions, two actually underwent a reduction-in-force (RIF). Employees in the other 41 positions retired, resigned, transferred, or found

⁴ By the time the position of PSW Research Station Director came open, Salwasser had been the Boone and Crockett Professor of Wildlife Conservation at the University of Montana (1992–95) and then the Regional Forester of the Northern Region (1995–1997). Apparently, Salwasser was assigned to the Northern Rocky region to repair relationships between the Forest Service and University over the Bitterroot controversy and the Bolle Report of 1970 (PSW 1997l). His reassignment to the PSW Research Station brought him back to an area where he had strong ties, for Hal Salwasser was reared in Fresno, California, had received his biology degree at the University of California, Fresno (1971) and his doctorate in wildland resources science at the University of California, Berkeley (1979). He began his Forest Service career as a wildlife ecologist with Region 5 in Nevada City, California, and thereafter served in succession as wildlife ecologist, Deputy Director of Wildlife and Fishery, and then Director of New Perspectives in the Washington office from 1982 to 1992 (PSW 1997o).

alternative sources of funding. This was the first application of RIF at the PSW Research Station since 1982. By the end of 1996, the station had 63 permanent scientists, from 21 disciplines. In contrast, the scientific staff had peaked in 1980 with 91 scientists⁵ (PSW 1995h, 1995i; 1995j, 1995k; 1996b). Notwithstanding these many adverse changes, station scientists continued to make some major strides in their research.

With thinned ranks, the PSW Research Station tried to retain its ability and capacity to do innovative research, to assist resource managers in solving land management problems, and to help expand the frontiers of science in a positive way. Their accomplishments included work on the Congressionally mandated Sierra Nevada Ecosystem Project (SNEP),⁶ President Clinton's Forest Plan for the Pacific Northwest,⁷ the Blacks Mountain Experimental Forest (BMEF) interdisciplinary

⁵ The station's total workforce in fiscal year 1996 stood at 419 employees, including 205 permanent employees, 48 term appointees, seven postdoctoral appointees, 79 not-to-exceed-1-year appointees, and 80 exempt employees. Nonpermanent employees increasingly made up the workforce, making up 51 percent in fiscal year 1996—an increase from 42 percent 5 years earlier (PSW 1996b).

⁶ During 1992 to 1995, PSW scientists had been studying the social, economic, and ecological conditions in the 400-mile-long Sierra Nevada Range. In August 1996, the station's massive final reports of the SNEP, totaling 2,000 pages, were published. The PSW scientists writing chapters in the final assessment report included Bruce McGurk and Neil Berg (Sediment Production From Forest Management and Residual Development), Bruce McGurk and Maureen Davis (Chronology and Hydrologic Effects of Land Use Change), Kevin McKelvey and Kelly Busse (Evaluation of 20th Century Fire Patterns on Forest Service Lands in the Sierra Nevada), Connie Millar (Diversity Within Species: Significant Natural Areas, Tertiary History), Carl Skinner (Historical and Current Fire Regimes), Phil Weatherspoon (Fire and Fuels Relationship to Silviculture: Landscape-Level Strategies for Fuels Management), and Rowan Rowntree (co-author on the Sierra Nevada report's human population section) (PSW 1995m).

⁷ In April 1993, President Clinton fulfilled a campaign promise to convene a forest conference in Portland, Oregon, to address the gridlock over management of federal forest lands in the Pacific Northwest and the resulting effects on communities and the regional economy. A year later, the Clinton administration formally announced his Forest Plan for the Pacific Northwest, which called for a new approach to land management in that region to resolve the continuing controversy over forest management. From the beginning, PSW's participation in carrying out the plan was highly significant and closely involved with research and other activities directly associated with the plan. Furthermore, for more than a decade, PSW scientists played a significant role in the plan's evolution. They researched and published on the biology and behavior, population status, and habitat needs of the high-profile wildlife species—such as northern spotted owls, marbled murrelets, Pacific salmon, pine martens, and fishers—that drove Pacific Northwest issues. They also reported on the basic functions of hydrologic streams, disturbance factors and their effects, and on stream conditions in forest watersheds, including linkages between physical stream conditions in forested watersheds and aquatic habitat for fish and other stream inhabitants (PSW 1996e).

study,⁸ the Kings River sustainable forest ecosystem study,⁹ conservation of the marbled murrelet¹⁰ (see “Scientific and Common Names” section) and furbearing animals, fire weather predictions, long-term soil productivity, ozone effects on forests, and introduced tree species (1996a, 1996b). To reach a wider audience with its research publications, the Station started full-fledged electronic publishing of station publications (PSW 1996c).¹¹

⁸ At Blacks Mountain, Kathy Harcksen continued to lead an interdisciplinary team of scientists in the study of effects of forest and range management on the diversity of plant and animal communities, including genetic and biological diversity, the ecosystem processes that were sensitive to disturbances and stress, the effects of restoration efforts, and the consequences of disturbance on biological productivity. The overall research goal was to better understand how forest structural complexity affects the health and vigor of east-side pine forest ecosystems, to quantify their resilience to natural and human-induced disturbances, and to determine how such ecosystems could be managed for sustained resource values (PSW 1997g).

⁹ In the early 1990s, it became evident that a new direction was needed for managing forest lands in the western Sierra Nevada for multiple resources and values perspective. Therefore, in 1994, the Kings River Sustainable Forest Ecosystems Project began on two adjacent watersheds (Big Creek and Dinkey Creek) on the Sierra National Forest. On each watershed, a different management option was tested to identify its effect on forest resources and values. The aim on both options was to sustain on each watershed all key resources and functions of the ecosystem, while reducing the risks of catastrophic fire, promoting forest health, allowing significant levels of commodity extraction, and supporting recreational use by the public (PSW 1997m 1997h).

¹⁰ Limits had been placed on Pacific Northwest logging to protect the marbled murrelet, a threatened bird species. Much of what was known about the species was documented in a station General Technical Report, *Ecology and Conservation of the Marbled Murrelet* (Ralph et al. 1995). This 420-page report described the ecology, biology, territory, habitat requirements, and distribution of the species (PSW 1997i).

¹¹ In 1996, under the direction of Sara Garetz, the PSW Research Station library began its move from Albany to Mare Island, Vallejo, where the Forest Service PSW Regional Office would be moved by early 1998 (PSW 1996a). The move was completed in 1998. An estimated 30,000 books and technical reports and 130 journal titles were shipped from Albany to Mare Island. Space was the major consideration in relocating the library. The move was only the second since 1960, when it was founded as the first professional library in the agency, at station headquarters in Berkeley. At that time, Bruce Yerke was hired as the agency's and station's first professional librarian (PSW 1999m).

In January 1997, Michael P. Dombeck¹² was named the new Chief of the Forest Service, succeeding Jack Ward Thomas, who had only served a 3-year term.¹³ Dombeck, the agency's 14th chief, was a career appointee, who had been acting director of the Interior Department's Bureau of Land Management (BLM). Dombeck's first priority was to build on the "tradition of working closely with local communities to restore and maintain productive, healthy, and diverse ecological systems," and his appointment offered "vision, leadership, and professional resource management experience needed to guide the agency at a critical juncture in its history" (PSW 1996d). By March 1998, Chief Dombeck set the agency's course for the 21st century and emphasized four key areas in his Forest Service Natural Resources Agenda: watershed health and restoration, sustainable forest ecosystem management, forest roads, and recreation¹⁴ (PSW 1998a). In a speech entitled "Protecting and Restoring a Nation's Land Health Legacy" given in February 1998 at Missoula, Montana, Dombeck recognized that many people ceased viewing national forests and grasslands as a warehouse of outputs to be brought to market and instead began to assign greater value to the positive outcomes of forest management. Wildlife and fish habitat, recreation, clean water, wilderness, and cultural and spiritual values

Wildlife and fish habitat, recreation, clean water, wilderness, and cultural and spiritual values became more and more important as national goals.

¹² Michael P. Dombeck was reared in Wisconsin's northern lake country. He earned his B.S. and M.S. degrees in biology from the University of Wisconsin, Stevens Point, another M.S. degree in zoology at the University of Minnesota, and a Ph.D. in fisheries biology at Iowa State University. In his Forest Service career, Dombeck was a fisheries biologist in Michigan and Wisconsin (1978–1985), and regional fisheries program manager with the PSW Region in San Francisco (1985–1987). In 1989, he became a science advisor for the BLM, acting assistant secretary and deputy assistant secretary for land and minerals management, chief of staff to the assistant secretary, and then acting BLM director (PSW 1996d).

¹³ After his retirement, Thomas stated that the primary problems during his term were "lack of clear mission; operating under laws that mesh poorly with effects exacerbated by overlapping responsibilities of several agencies; and a wide range of sometimes confusing court decisions, micromanagement—in other words, politicization of agency activities by Congress and political appointees; continued downsizing with inadequate consideration of what is expected of the Forest Service; and demonization of the agency by extremes in the debate over public land management" (PSW 1997n).

¹⁴ Under Dombeck's agenda, maintaining and restoring the health of the ecosystems and watersheds of the national forests were the agency's first priority and an overriding concern to be addressed in all future forest plans. Dombeck's second priority was sustainable forest ecosystem management. He wanted the agency to develop policies that encouraged long-term investments in forests and discouraged their conversion to other uses, and to increase the number of private forest landowners that completed long-term forest stewardship plans. His agenda also emphasized management of the forest road system, which was an essential part of the transportation system in many rural parts of the country. The final element of the agenda was recognition that recreation was the fastest growing use of national forests and grasslands and the need to improve the quality and quantity of information about recreation opportunities on national forests (PSW 1998a).

became more and more important as national goals. He emphasized the fact that forest management had shifted from commodity timber sales to management activities to meet stewardship objectives in response to shifting social values, public demand, and ever-evolving understanding of how to best manage for ecological sustainability¹⁵ (PSW 1999a, 1999b, 1999c).

Recognizing that current budgets had dwindled, Dombeck, on a visit to the PSW Research Station in 1997, predicted that they would rise again in the future (PSW 1997c). Nonetheless, the station faced continuing tight budgets, which resulted in important changes. For instance, to consolidate units and services, over the next 5 years the station relocated most of its scientists in forest genetics, insect chemical ecology, and western forest management at Albany and Redding to the University of California, Davis campus. The space vacated by PSW on the second floor at Albany was returned to the USDA Agricultural Research Service (ARS). The PSW already had a contingent at Davis (Urban Forestry RWU), and the purpose of the move was to get scientists back into a university atmosphere where they could maintain closer contact with colleagues in natural resources research (PSW 1997j). As another example, in 1999 the station's Institute of Pacific Islands Forestry (IPIF) relocated its headquarters from Honolulu to the University of Hawaii at Hilo. There, IPIF continued its research on reforestation, control of nonnative species, and forested wetlands and watersheds (PSW 1999e). Meanwhile, Station Director Salwasser and his staff focused their program and budget to take advantage of administration priority research areas: threatened and endangered species, global change, climate change technology, national forest system planning, nonnative invasive species, forest health monitoring, fire science, recreation research, and ecosystem management (PSW 1999g).

"Research values" became the key phrase at the PSW Research Station and was reflected in the 14 RWUs in California and the western Pacific. Twelve were in California and located at forest science laboratories in Albany, Arcata, Davis, Fresno, Placerville, Redding, and Riverside.¹⁶ The remaining RWUs were in

¹⁵ In early 1999, a committee of USDA scientists appointed by Agriculture Secretary Dan Glickman concluded that sustainability should be the focus of the Forest Service in the next century. This meant less emphasis on production and more on the preservation of plants, animals, and habitats whenever management decisions were made (PSW 1999d).

¹⁶ In 1998, they included Institute of Forest Genetics; Ecology and Management of Western Forests; Wildlife Communities and Key Ecosystem Linkages in Montane Forests; Timber Management/Wildlife Habitats Interactions in Northern California; Forest Management Effects on Hillslope Processes and Fisheries; Meteorology for Forest and Brushland Management; Wildland Fire Management Research, Development, and Application Program; Prescribed Fire and Fire Effects; Air Pollution and Global Change Impacts; Chemical Ecology and Management of Forest Insects; Wildland Recreation and Urban Culture; and Effects of Urbanization on Forest Ecosystems (USDA FS 1998).

Honolulu, Hawaii (IPIF) with small field offices in Hilo and Volcano (Island of Hawaii), and Yap (Federated States of Micronesia). To understand the relationships of the many components of forest ecosystems and to further the influences of proposed land production, long-term productivity, and ecosystem sustainability, Station Director Salwasser believed that science must inform these choices, driven by needs, values, financial capabilities, and aspirations. The station's role was to provide basic data, knowledge of how things work and are related to one another, information syntheses, decision-support systems, analyses of the potential consequences of options, and new technologies (Gill and Hildreth 1998).

Accomplishments during the Salwasser administration were many. For instance, they included active work in the Sierra Nevada, as station scientists worked closely with their colleagues in the National Forest System and State and Private Forestry, as well as other agencies and institutions, to craft an interagency conservation strategy that built upon the superb work done on SNEP. Together, they developed the Sierra Nevada Conservation Framework (SNCF), based upon the work that was done on SNEP and Region 5's revised draft environmental impact statement (RDEIS). The SNCF addressed the management of the California spotted owl habitat and associated resources in forests of the Sierra Nevada as well as the overall goal of sustaining the health, productivity, and resilience of Sierra Nevada ecosystems. Furthermore, it did this while meeting the needs of people and communities whose well-being depended in various ways on the Sierra Nevada, including water and riparian areas, forest fuels management and forest health, late-succession forests, wildlife associated with old forests, native biodiversity, sustainable production of natural resources, roads and roadless area management,¹⁷ and community vitality. In the future, PSW, the University of California, and other institutions used these research, educational, and monitoring objectives to identify priority projects (PSW 1998b). The station also worked well with its colleagues in Hawaii and the Pacific Islands in continuing to increase the relevance and value of Forest Service programs in those places (PSW 1997d).

Just as Station Director Salwasser had started to make progress in leading a revitalized PSW Research Station, he announced that in July 2000 he would be moving on to become Dean of the College of Forestry at Oregon State University

**The Sierra Nevada
Conservation
Framework addressed
the management of the
California spotted owl
habitat and associated
resources in forests of
the Sierra Nevada.**

¹⁷ In October 1999, President Clinton directed the Forest Service to develop a proposal to protect more than 40 million acres of inventoried roadless areas on its 155 national forests and 20 grasslands. Logging and mining would be prohibited in these areas, including 4 million acres in California. Road building was also severely restricted on these areas as well (PSW 1999i).

(PSW 1999h). Salwasser's announcement came at the same time as the news of the deaths of key "old guard" scientists, such as August L. "Gus" Hormay, who pioneered the concept of rest-rotation for managing rangelands, and Robert V. Bega,¹⁸ who was widely known for his research on root diseases, mainly those in tree nurseries (PSW 1999j, 1999k). Retirements of long-term key scientists and staff happened as well, including entomologist Patrick Shea,¹⁹ whose career was devoted to the study of western bark beetles and research on developing pheromone-based management systems; geneticist M. Thompson Conkle,²⁰ who focused his research on developing molecular markers for forest trees; Philip S. Aune,²¹ who managed the station's vegetation management alternatives for regeneration of California's conifer research and development program at Redding; wildlife biologist Jared Verner,²² who oversaw sensitive species research and wildlife population monitoring research at the station's Fresno Laboratory; and research forester Philip M. McDonald,²³ whose work centered on California hardwoods and on vegetation

¹⁸ Robert V. Bega had served as project leader for forest disease research at PSW for more than 20 years. Bega earned his B.S. (1955) and Ph.D. (1957) degrees at the University of California at Berkeley. In 1955, he worked for the station on a grant before formally joining the research staff in 1955. He was appointed project leader in 1962 and retired in 1984 after more than 30 years of federal service (PSW 1999k).

¹⁹ Patrick Shea received his B.S. (1966) and M.S. (1967) degrees in entomology from the University of California at Berkeley and his Ph.D. (1988) from the University of California at Davis. He joined the Forest Service and the station in 1967 as a biological technician working in the Insecticide Evaluation Research Unit (PSW 1999l).

²⁰ M. Thompson "Tom" Conkle earned his B.S. degree in forestry at Michigan State University, his M.S. degree in forest genetics at North Carolina State University, and his Ph.D. degree in forest genetics at the University of California, Berkeley. In 1962, when he arrived at the Institute of Forest Genetics, he was the first summer student at the Placerville facility. In 1966, he joined the PSW staff as a research geneticist, working at the Berkeley laboratory, and in 1990 became project leader for forest genetics research at Berkeley and later at Albany (PSW 1999l).

²¹ Philip S. Aune started his Forest Service career in 1962 as a temporary employee, earning a forestry degree from Humboldt State University 3 years later. Aune joined the station staff in 1987 after having served the previous 23 years on four California national forests (Shasta-Trinity, Sequoia, Six Rivers, and Tahoe) as a forestry technician, forester, and district and forest silviculturalist (PSW 1999n).

²² Jared "Jerry" Verner left academia in 1976 to join the Forest Service, where he was assigned to the Fresno Laboratory as project leader. There, he became involved in most of the controversial issues of the day, including research on California condors, mountain lions, and finally the spotted owl. He earned his B.S. degree (1957) in wildlife management at Washington State University, an M.S. degree (1959) in zoology at Louisiana State University, and a doctorate in zoology (1963) at the University of California at Berkeley (PSW 1999n).

²³ Long-time PSW scientist Philip M. McDonald joined the Forest Service in 1961 as a snow researcher at the station's Central Sierra Snow Laboratory (CSSL). His research was reported in more than 135 publications, largely as serials aimed at providing information that was interesting and worthwhile for scientists and practitioners. McDonald earned his forestry degree at Washington State University (1960), his master of forestry degree at Duke University (1961), and his doctorate in forest science at Oregon State University (1978) (PSW 2000).

management at the Challenge Experimental Forest (CEF) and later at the station's Redding facility. Key staff retirements included Cynthia K. Jacobs, who during her 37-year career with PSW watched the station's fortunes as the secretary for five directors, and Roxanne Orly, who occupied many positions in management at PSW for 30 years. Because of her personal interest in seeing that all station historical documents were preserved, she became the station's ex-officio historian (PSW 1999l, 1999n, 2000a).

One year after Station Director Salwasser left, the station celebrated its 75th anniversary, but was leaderless. Pending selection of a permanent director, Assistant Station Director Garland N. Mason had served as Acting Station Director since July 2, 2001. From its modest beginnings in 1926 in four rooms in Hilgard Hall on the campus of the University of California at Berkeley, and from its six-person staff headed by its first Station Director, Edward I. Kotok, the station had gone through four name changes, enlarged its area of responsibility from California to include Hawaii and the United States-affiliated Pacific islands, seen a dramatic growth in the scope and complexity of its research programs, and now entered the 21st century with advances in cutting-edge research and technology. With budgets less than \$33,000 a year during its founding period, the station peaked in the late 1970s with \$20 million in funding and a staff of more than 350 full- and part-time employees. This growth was reflected in the changes in station headquarters and growing research opportunities at the station's field facilities (Arcata, Davis, Fresno, Placer-ville, Redding, and Riverside in California and Honolulu and Hilo in Hawaii) and experimental forests and ranges that served as outdoor research laboratories.

Research staff specialties were once largely in forestry, entomology, genetics, and pathology. That pattern evolved and expanded to such fields as wildlife biology, hydrology, sociology, fire ecology, fish biology, and others to allow a more balanced perspective in resource management. In its 75-year history, according to Acting Station Director Mason, "Station scientists mapped California's vegetation types and soils and provided the foundation for timber-related research, including studies of tree and site quality classification and built upon the mosaic pattern of plant growth in forests. They pioneered work on the biochemistry of the turpentines of pines and helped clarify the genetic relationships among the genus *Pinus*. They developed methods for species hybridization and techniques for rating tree hazards. They surveyed the forest resources of Hawaii and other western Pacific islands. They studied factors influencing soil erosion and water runoff and yield, and developed procedures for conducting watershed assessments. In their work, they evaluated insecticides, and investigated alternatives to DDT. In fire research, they pioneered studies

From its modest beginnings in 1926 the station had gone through four name changes, enlarged its area of responsibility from California to include Hawaii and the United States-affiliated Pacific islands, seen a dramatic growth in the scope and complexity of its research programs, and now entered the 21st century.

on fire behavior and helped develop new fire management techniques, including air attack, fire retardants, fuelbreaks, fire safety, escaped wildfires, and especially the incident command system, now used worldwide. Station scientists also explored the relationships among timber, harvest, livestock grazing, and wildlife. They developed a rest-rotation system for cattle grazing on California's national forests, and developed guides to the viability and habitat requirements of the California spotted owl. Their recreation research enabled resource managers to apply the principles of landscape architecture to land-use planning, such as at Nacio, and they developed models to evaluate the benefits and costs of urban forests. Further, they completed the first comprehensive evaluation of the natural resources of the Sierra Nevada. All of the above work and other important studies and investigations were documented by station scientists in more than 7,000 publications, whose spectrum ranged from the mapping of forest ecoregions to the mapping of the forest vegetation genes (PSW 2001a).

The PSW Research Station's accomplishments over three-quarters of a century helped bring status and credibility to the whole Forest Service research organization, and earned for the station an outstanding reputation in research and technological development. Some of the best scientists, technicians, administrators, and support staff made their way through the station. A few station directors, such as Edward Kotok, George Jemison, and Keith Arnold, went on to serve in higher positions in the research organization of the Washington office of the Forest Service, and one former director, John R. McGuire, became Chief of the Forest Service. But the station's history is best demonstrated by its service to the people of California, Hawaii, and the western Pacific islands, making a difference in the quality of their lives, and in conservation, use, and protection of their natural resources. No doubt, this tradition will grow and progress as the station moves forward to the next 25 years of accomplishments and toward its 100th anniversary.

Scientific and Common Names

Common names	Scientific names
Plants:	
Acacia	<i>Acacia</i> Mill.
Ash	<i>Fraxinus</i> spp.
Asian raspberry	<i>Rubus ellipticus</i> Sm.
Australian saltbush	<i>Atriplex semibaccata</i> R. Br.
Austrian pine	<i>Pinus nigra</i> Arnold
Banana poka	<i>Passiflora mollissima</i> (Kunth) L.H. Bailey
Bear clover	<i>Chamaebatia foliolosa</i> Benth.
Bishop pine	<i>Pinus muricata</i> D. Don
Bitterbrush	<i>Purshia tridentata</i> (Pursh) DC.
Blue gum	<i>Eucalyptus globulus</i> Labill.
Bristlecone pine	<i>Pinus aristata</i> Engelm.
California black oak	<i>Quercus kelloggii</i> Newberry
California poppy	<i>Eschscholzia californica</i> Cham.
California red fir	<i>Abies magnifica</i> A. Murray
Catalpa	<i>Catalpa</i> spp.
Chamise	<i>Adenostoma fasciculatum</i> Hook. & Arn.
Cinchona	<i>Cinchona</i> spp.
Common iceplant	<i>Mesembryanthemum crystallinum</i> L.
Cork oak	<i>Quercus suber</i> L.
Coulter pine	<i>Pinus coulteri</i> D. Don
Currant	<i>Ribes</i> spp.
Desert false indigo	<i>Amorpha fruticosa</i> L.
Digger pine (gray pine)	<i>Pinus sabiniana</i> Douglas ex Douglas
Douglas-fir	<i>Pseudotsuga menziesii</i> (Mirb.) Franco
Faya-tree	<i>Myrica faya</i> Aiton
Four-leaf pine	<i>Pinus quadrifolia</i> Parl.
Gorse	<i>Ulex europaeus</i> L.
Gray pine	<i>Pinus sabiniana</i> Douglas ex Douglas
Guayule	<i>Parthenium argentatum</i> A. Gray
Hemlock	<i>Tsuga</i> spp.
Hemp	<i>Cannabis</i> spp.
Hickory	<i>Carya</i> spp.
Incense-cedar	<i>Calocedrus decurrens</i> (Torr.) Florin
Indian hemp	<i>Apocynum cannabinum</i> L.
Indigo bush	<i>Amorpha californica</i> Nutt.
Interior live oak	<i>Quercus wislizeni</i> A. DC.
Jeffrey pine	<i>Pinus jeffreyi</i> Balf.
Knobcone pine	<i>Pinus attenuata</i> Lemmon
Koa	<i>Acacia koa</i> A. Gray
Koster's curse	<i>Clidemia hirta</i> (L.) D. Don
Larkspur	<i>Delphinium</i> spp.
Loblolly pine	<i>Pinus taeda</i> L.
Locust	<i>Robinia</i> spp.

Longleaf pine	<i>Pinus palustris</i> Mill.
Madrone	<i>Arbutus</i> spp.
Mamane (mamani)	<i>Sophora chrysophylla</i> (Salisb.) Seem.
Monterey cypress	<i>Cupressus macrocarpa</i> Hartw. ex Gord.
Monterey pine	<i>Pinus radiata</i> D. Don
Ohia lehua	<i>Metrosideros collina</i> J.R. Forst. & G. Forst. (<i>Metrosideros polymorpha</i> Gaudich.)
Ponderosa pine	<i>Pinus ponderosa</i> C. Lawson
Pyrethrum	<i>Chrysanthemum cinerariifolium</i> (Trevir.) Vis.
Rabbitbrush	<i>Chrysothamnus</i> spp.
Redcedar	<i>Thuja plicata</i> Donn ex D. Don
Red fir	<i>Abies magnifica</i> A. Murray
Red gum	<i>Eucalyptus</i> spp.
Redwood	<i>Sequoia sempervirens</i> (Lamb. ex D. Don) Endl.
Sandalwood	<i>Santalum album</i> L.
Scotch pine	<i>Pinus sylvestris</i> L.
Sequoia	<i>Sequoiadendron giganteum</i> (Lindl.) J. Buchholz
Shasta red fir	<i>Abies</i> × <i>shatensis</i> (Lemmon) Lemmon
Silktassel	<i>Garrya</i> spp.
Slash pine	<i>Pinus elliotii</i> Engelm.
Strawberry guava	<i>Psidium cattleianum</i> Sabine
Sugar pine	<i>Pinus lambertiana</i> Dougl.
Swampmahogany	<i>Eucalyptus robusta</i> Sm.
Swiss stone pine	<i>Pinus cembra</i> L.
Tanbark oak (tanoak)	<i>Lithocarpus densiflorus</i> (Hook. & Arn.) Rehder
Torrey pine	<i>Pinus torreyana</i> Parry ex Carrière
True fir	<i>Abies</i> spp.
Walnut	<i>Juglans</i> spp.
Western hemlock	<i>Tsuga heterophylla</i> (Raf.) Sarg.
Western yellow pine (ponderosa pine)	<i>Pinus ponderosa</i> C. Lawson
White fir	<i>Abies concolor</i> (Gord. & Glend.) Lindl. ex Hildebr.
White pine	<i>Pinus monticola</i> Douglas ex D. Don
Willow	<i>Salix</i> spp.
Yucca	<i>Yucca</i> spp.
Diseases	
Annosus root rot	<i>Heterobasidion annosum</i>
Western dwarf mistletoe	<i>Arceuthobium campylopodum</i>
Western gall rust	<i>Endocronartium harknessii</i>
White pine blister rust	<i>Cronartium ribicola</i>
Insects	
California five-spined engraver	<i>Ips paraconfusus</i> Lanier
California flatheaded borer	<i>Melanophila californica</i> Van Dyke
Douglas-fir bark beetle	<i>Dendroctonus pseudotsugae</i> Hopk.
Douglas-fir tussock moth	<i>Orgyia pseudotsuga</i> McDunnough
Gypsy moth	<i>Lymantria dispar</i> Linnaeus

Ips beetle	<i>Ips</i> spp.
Jeffrey pine beetle	<i>Dendroctonus jeffreyi</i> Hopk.
Lodgepole needle-miner	<i>Coleotechnites milleri</i> Busck
Mountain pine beetle	<i>Dendroctonus ponderosae</i> Hopk.
Southern pine beetle	<i>Dendroctonus frontalis</i> Zimmerman
Spider mite	Tetranychidae family
Spruce budworm	<i>Choristoneura occidentalis</i> Freeman
Termite	Isoptera order
Western pine beetle	<i>Dendroctonus brevicomis</i> Le Conte
Birds	
Bald eagle (see southern bald eagle)	<i>Haliaeetus leucocephalus</i>
California condor	<i>Gymnogyps californianus</i>
California spotted owl	<i>Strix occidentalis occidentalis</i>
Horned owl	<i>Bubo virginianus</i>
Marbled murrelet	<i>Brachyramphus marmoratus</i>
Northern spotted owl	<i>Strix occidentalis caurina</i>
Palila	<i>Loxioides bailleui</i>
Peregrine falcon	<i>Falco peregrinus</i>
Southern bald eagle	<i>Haliaeetus leucocephalus leucocephalus</i>
Yellow-headed blackbird	<i>Xanthocephalus xanthocephalus</i>
Mammals	
Alpine chipmunk	<i>Tamias alpinus</i>
Fisher	<i>Martes pennanti</i>
Meadow vole	<i>Microtus pennsylvanicus</i>
Mountain lion	<i>Puma concolor</i>
Mule deer	<i>Odocoileus hemionus</i>
Pine marten	<i>Martes americana</i>

References

- Adams, M.B.; Loughry, L.; Plaughter, L., comps. 2004.** Experimental forests and ranges of the USDA Forest Service. Gen. Tech. Rep. NE-321. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Research Station.
- Ahuja, L.R.; El-Swaify, S.A. 1975.** Forest conservation research plan for the seventies. City, HI: University of Hawaii, Department of Agronomy; U.S. Department of Agriculture, Forest Service. 255 p.
- Aitro, V.P., comp. 1977.** Fifty years of forestry research: annotated bibliography of the Pacific Southwest Forest and Range Experiment Station, 1926–1975. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. 250 p.
- American Forestry Association. 1919.** Why we need more forest research. *American Forestry*. 25(July): 1237.
- American Forestry Association. 1920.** Increase in forest research necessary. *American Forestry*. 26(February): 69–70.
- American Forestry Association. 1921a.** Forest experiment stations. *American Forestry*. 27(February): 86.
- American Forestry Association. 1921b.** More forest experiment stations. *American Forestry*. 27(December): 796–797.
- American Forests. 1968.** A piece of cake for research. 74(July): 33.
- American Forests and Forest Life. 1925.** California experiment station authorized. 31(April): 242.
- American Forests and Forest Life. 1926.** Edward I. Kotok, Director of California Forest Experiment Station. 32(October): 632.
- American Forests and Forest Life. 1927a.** The California Forest Experiment Station Opens. 33(February): 112.
- American Forests and Forest Life. 1927b.** A national program of forest research. 33(February): 94–95.
- American Forests and Forest Life. 1928a.** Annual conference at Madison. 34(July): 444.
- American Forests and Forest Life. 1928b.** Forest research marks time. 34(February): 100.

American Forests and Forest Life. 1929. The plague of insects. 35(February): 100.

American Forests and Forest Life. 1932. Institute of Forest Genetics. 30(May): 623–624.

American Forests and Forest Life. 1938. A look back and a glance ahead. 36(September): 829–830.

Anderson, H.W. 1958. Progress in snow management research in California. On file with: Alphabetical Author's Publications: Boxes 1232521-1232526, Accession No. 95-63-0532, Federal Records Center, San Bruno, CA.

Anderson, M. 1927. Politics and science affecting public land management. *Journal of Forestry*. 25(November): 889–892.

Anonymous. 1941. Cary Leroy Hill, U.S. Forester, passes away. File: C.L. Hill, Boxes 761147-761158, Accession No. 95-59-0744, Federal Records Center, San Bruno, CA.

Arnold, K.R. 1949. Development of forest fire protection in the United States. Unpublished manuscript. On file with: Box 3. Pacific Southwest Research Station Archives, Pacific Southwest Research Station, Albany, CA.

Austin, L. 1927. A new enterprise in forest tree planting. *Journal of Forestry*. 25(8): 928–953.

Austin, L. 1928a. Breeding pines for more rapid growth. *Journal of Heredity*. 19(7): 289–301.

Austin, L. 1928b. The Institute of Forest Genetics: a new science utilized to advance American forestry. *American Forests*. 43(9): 444–446, 466–467.

Austin, L. 1929. The Eddy Tree Breeding Station. *Madrono*. 1(August): 203–207.

Austin, L. 1932. Eddy Tree Breeding Station carries on under new name. *Forest Worker*. 8(2): 10.

Austin, L. 1937. Forest genetics. *American Forests*. 43(September): 444–446, 446–468.

Austin, G.; Righter, F.I.; Cumming, W.G.; Liddicoet, A.R.; Carpenter, J.; Mirov, N.T. 1974. The Eddy Tree Breeding Station, Institute of Forest Genetics. Transcript. Stone, Lois C., interviewer. Bancroft Library, Regional Oral History Office for the Forest History Society, University of California, Berkeley, CA.

- Ayres, R.W. 1941.** History of the Forest Service in California. On file with: Box 4: Selected alphabetical subject file, 1909–1974, Record Group 95. National Archive Record Center, San Bruno, CA.
- Ayres, R.W. 1958.** History of timber management in the California national forests, 1850 to 1937. On file with: USDA Forest Service, Pacific Southwest Region Archives, Vallejo, CA.
- Bates, C.G.; Henry, A.J. 1921.** Streamflow at Wagon Wheel Gap, Colo. Monthly Weather Review. 49(12): 637–650.
- Bell, E. 2007.** Personal communication. Former Assistant Director, Pacific Southwest Research Station.
- Berg, N.H. 1990.** Experimental forests and ranges of the Pacific Southwest Research Station. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station.
- Boe, K.N. 1983.** Yurok Redwood Experimental Forest. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. <http://www.fs.fed.us/psw/publications/4351/boe.pdf>. (September 2009).
- Boerker, R.H. 1912.** Light burning versus forest management in northern California. Forestry Quarterly. 10(June): 184–194.
- Boerker, R.H. 1918.** Our national forests: a short popular account of the work of the United States Forest Service on the national forests. New York: Macmillan Company.
- Boyce, S.G.; Oliver, C.D. 1999.** The history of research in forest ecology and silviculture. In: Steen, H.K., ed. Forest and wildlife science in America: a history. Durham, NC: Forest History Society: 414–453.
- Bradshaw, K.E.; Jensen, H.A. 1992.** A. Everett “Wies” Wieslander. On file with: Marilyn Hartley, office files (loose). Pacific Southwest Research Station Archives, Albany, CA.
- Brewer, W.H. 1883.** Pasture and forage plants. Report on the productions of agriculture as returned at the tenth census, 1880. Washington, DC: U.S. Census Bureau. In: III: 959–964.
- Brown, J.D. 1832.** The sylvia Americana, or description of the forest trees indigenous to the United States. Boston, MA: William Hyde & Co.
- Brown, W.S., comp. 1945a.** History of the Angeles National Forest. On file with: USDA Forest Service, Pacific Southwest Region, Vallejo, CA.

- Brown, W.S., comp. 1945b.** History of the Los Padres National Forest. On file with: USDA Forest Service, Pacific Southwest Region Archives, Vallejo, CA.
- Brown, W.S., comp. 1945c.** History of the Modoc National Forest. On file with: USDA Forest Service, Pacific Southwest Region Archives, Vallejo, CA.
- Bruce, D. 1999.** Statistical methods in forestry research. In: Steen, H.K., ed. Forest and wildlife science in America: A history. Durham, NC: Forest History Society: 181–208.
- Bruce, D.; Schumacher, F.X. 1935.** Forest mensuration. New York: McGraw-Hill. 360 p.
- Bruce, R.V. 1987.** The launching of modern American science, 1846–1876. Ithaca, NY: Cornell University Press.
- Brundage, M.R.; Krueger, M.E.; Dunning, D. 1933.** The economic significance of tree size in western Sierra Nevada lumbering. Bull. 549. Berkeley, CA: California Agricultural Experiment Station: 1–61.
- Buck, J.M. 1974.** History of the Division of Timber Management. San Francisco, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Region. p.
- Buck, C.C.; Bruce, H.D.; Abell, C.A.; Fons, W.L. 1941.** A forest fire protection analysis for California. On file with: California Forest and Range Experiment Station Articles, Boxes 761147-761158, Accession No. 95-59-0744, Federal Records Center, San Bruno, CA
- Burke, H.E. 1946.** My recollections of the first years in Forest Entomology. On file with: Pacific Southwest Research Library, Ogden, Utah.
- California State Board of Forestry [CBF]. 1886.** First biennial report, for the years 1885–86, to Governor George Stoneman. Sacramento, CA: State Printer. 238 p.
- California State Board of Forestry [CBF]. 1892.** Fourth biennial report, for the years 1891–92, to Governor H. H. Markham. Sacramento, CA: State Printer. 81 p.
- Camp, H.W. [N.d.].** An historical sketch of recreation research in the USDA Forest Service. PSW-H-1. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station.
- Camp, H. 2006.** Harry Camp oral history. E. Bell and L. Schmidt, interviewers. Region Five History Project. Transcript. On file with: USDA Forest Service, Pacific Southwest Region Archives, Vallejo, CA.

- Carson, R. 1962.** Silent spring. Boston, MA: Houghton, Mifflin Co.
- Casamajor, P., ed. 1965.** Forestry education at the University of California: the first fifty years. Berkeley, CA: California Alumni Foresters.
- Casamajor, P., ed. [N.d.].** PSW history: the California Forest Experiment Station. 4 p. On file: Box 8, Pacific Southwest Research Station Archives, Albany, CA.
- Cermak, R. 2005.** Fire in the forest: a history of forest fire control on the national forests in California, 1898–1956. R5-FR-003. Washington, DC: U.S. Department of Agriculture, Forest Service, Pacific Southwest Region. 452 p.
- Chandler, C.C. 1982.** Operation FIRESTOP—a history. Unpublished manuscript. On file with: Box 6, Pacific Southwest Research Station Archives, Albany, CA.
- Cheng, S. 2004.** Forest Service research natural areas in California. Gen. Tech. Rep. PSW-GTR-188. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station.
- Clapp, E.H. 1917.** The correlation of American forest research. *Journal of Forestry*. 15(February): 165–175.
- Clapp, E.H. 1918.** Forest research and the war. *American Forestry*. 24(July): 439.
- Clapp, E.H. 1919a.** Forest research and the war. *Journal of Forestry*. 17(March): 260–272.
- Clapp, E.H. 1919b.** Forest research: in the war and after. *American Forestry*. 25(March): 947–950.
- Clapp, E.H. 1921.** Forest experiment stations. Circular 183. Washington, DC: U.S. Department of Agriculture.
- Clapp, E.H. 1926.** A national program of forest research. Washington, DC: The American Tree Association for the Society of American Foresters.
- Clapp, E.H. 1934.** Major proposals of the Copeland report. *Journal of Forestry*. 32(February): 174–179, 179–195.
- Clapp, E.H. 1938.** The decennial of the McSweeney-McNary Act. *Journal of Forestry*. 36(September): 832–836.
- Clapp, E.H. 1940 (31 May).** Letter to Regional Forester. On file with: Public Affairs and Communication Office, USDA Forest Service, Pacific Southwest Region, Vallejo, CA.

- Clapp, E.H. 1956.** Zon. American Forests. 62(December): 6, 44, 46.
- Clar, C.R. 1959.** California government and forestry from Spanish days until the creation of the Department of Natural Resources in 1927. Sacramento, CA: California Department of Natural Resources, Division of Forestry.
- Clar, C.R. 1969.** California government and forestry—II. Sacramento, CA: California Conservation Department, Division of Forestry. 319 p.
- Clepper, H., ed. 1971.** Leaders of American conservation. New York: The Ronald Press Company.
- Colman, E.A. 1955.** Operation wet blanket: proposed research in snowpack management in California. On file with: Alphabetical Author's Publications: Boxes 1232521-1232526, Accession No. 95-63-0532, Federal Records Center, San Bruno, CA.
- Connaughton, C.A. 1971.** What's ahead in forestry—a challenge to research. Journal of Forestry. 69(September): 556–559.
- Connors, P.A. 1995.** Headquarters for the Yurok Redwood Experimental Forest—a symbol of shifting paradigms. History Line: A Newsletter of the Forest Service History Program. 1995(Fall): 15–18.
- Connors, P.A. 2006.** Stanislaus Branch, California Forest and Range Experiment Station (CF&RES). National Register Nomination (Draft). CA-Tuo-2351H. On file with: Public Affairs and Communication Office, USDA Forest Service, Pacific Southwest Region, Vallejo, CA.
- Conrad, C.E. 1987.** Common shrubs of chaparral and related ecosystems of southern California. Gen. Tech. Rep. PSW-99. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. 86 p.
- Conrad, E.; Gill, C.R. 1996.** Forest restoration research in the Hawaiian Islands. Forestry Research West. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 1996(August): 6–9.
- Cooper, A. 1906.** Sugar pine and western yellow pine in California. Bull. 69. Washington, DC: U.S. Department of Agriculture, Forest Service. 42 p.
- Cooper, A.W.; Kelleter, P.D. 1907.** The control of forest fires at McCloud, California. Circ. 79. Washington, DC: U.S. Department of Agriculture, Forest Service.

- Corson, C.W.; Fowells, H.A. 1952.** Here's how—a guide to tree planting in the California pine region. Misc. Pap. 8. Berkeley, CA: U.S. Department of Agriculture, Forest Service, California Forest and Range Experiment Station. 26 p.
- Cossitt, F. 1960.** Plan for a centralized nursery for the state of Hawaii. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. 40 p.
- Cox, T.R. 1991.** The birth of Hawaiian forestry: the web of influences. Presentation at 17th Pacific Science Congress. <http://www.state.hi.us/dhr/dofaw/pubs/history.html>. (October 2009).
- Crafts, E.C.; McKennan, R.B. 1957.** General integrating inspection report: California Region and California Forest and Experiment Station. On file with: USDA Forest Service, Pacific Southwest Region Archives, Vallejo, CA.
- Curtis, R.O.; Marshall, D.D. 2004.** Douglas-fir growth and yield: research 1909–1960. *Western Journal of Applied Forestry*. 19(1): 66–68.
- Dana, S.T. 1909.** Experiment stations on the national forests. *Society of American Foresters Proceedings*. 1(1): 22–29.
- Dana, S.T. 1924.** Functions of forest experiment stations. On file with: Box 2, Pacific Southwest Research Station Archives, Albany, CA.
- Dana, S.T. 1956.** Forest and range policy: its development in the United States. New York: McGraw-Hill Book Company, Inc.
- Dassman, R.F. 1973.** The destruction of California. New York: Collier MacMillan. 223 p.
- Davis, K.P. 1963.** Requirements for a successful forest research program. *Journal of Forestry*. 61(November): 861–864.
- Dayton, W.A. 1955.** Historical sketch of U.S. Forest Service botanical activity, 1905–1954. *Journal of Forestry*. 53(July): 505–507.
- Doolittle, W.T. 1969.** Research in urban forestry. *Journal of Forestry*. 67(September): 650, 652, 656.
- Dravnieks, D. 2007.** Personal communication. Former natural resources economist, Pacific Southwest Research Station.
- DuBois, C. 1914.** Systematic fire protection in the California forests. Washington, DC: U.S. Department of Agriculture, Forest Service. 99 p.

Duffield, J.W. 1979. Recollections of the Institute of Forest Genetics. On file with:
Box 8, Pacific Southwest Research Station Archives, Albany, California.

Dunn, P.H.; Barro, S.C.; Wells, W.G., II; Poth, M.A.; Wohlgemuth, P.M.; Colver, C.G. 1988. The San Dimas Experimental Forest: 50 years of research. Gen. Tech. Rep. PSW-104. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. p.

Dunning, D. 1925. An instrument for measuring increment cores. *Journal of Forestry*. 27(2): 183–184.

Dunning, D. 1929. Fire in the foothills: the problem of controlling fires in the marginal brush lands of California. *California Countryman*. 15(March): 6, 16.

Dunning, D. 1938. Logging to start at Halls Flat. *California Ranger: Region 5*. 9(29): 1.

Dunning, D. 1941. Logging at Blacks Mountain. *California Ranger: Region 5*. 12(36): 1.

Dupree, A.H. 1957. Science in the federal government: a history of policies and activities to 1940. Cambridge, MA: Harvard University Press.

Egleston, N.H. 1884. Report upon forestry. Washington, DC: U.S. Department of Agriculture, Division of Forestry. 421 p.

Ellison, L. 1942. Trends of forest recreation in the United States. *Journal of Forestry*. 40: 630–638.

Ewert, A.W.; Chavez, D.J.; Magill, A.W. 1993. Culture, conflict, and communication in the wildland-urban interface. Boulder, CO: Westview Press. 410 p.

Fernald, M.L., ed. 1950. Gray's manual of botany: a handbook of the flowering plants and ferns of the Central and Northeastern United States. 8th ed.

Fernow, B.E. 1887. Report upon forestry. Place of Publication Washington, DC: U.S. Department of Agriculture, Division of Forestry.

Fernow, B.E. 1892. Report of the Chief of the Division of Forestry. Washington, DC: U.S. Department of Agriculture, Division of Forestry.

Fernow, B.E. 1897. Report of the Chief of the Division of Forestry. Washington, DC: U.S. Department of Agriculture, Division of Forestry.

Fernow, B.E. 1899. Report upon the forestry investigations of the U.S. Department of Agriculture, 1877–1898. 55th Congress, 3rd session. House Doc. 181. Washington, DC.

- Fernow, B.E. 1909.** A brief history of forestry in Europe, the United States and other countries. Toronto, ON: Toronto University Press. 438 p.
- Forsling, C.L. 1978.** Harper, Verne Lester, George M. Jemison, Clarence L. Forsling: early Forest Service research administrators. Transcript. Maunder, E.R., interviewer. Santa Cruz, CA: Forest History Society.
- Fowells, H.A. 1940.** Cutworm damage to seedlings in California pine stands. *Journal of Forestry*. 38(7): 590–591.
- Fowells, H.A. 1978.** History of the Stanislaus-Tuolumne Experimental Forest (The Stanislaus Branch). On file with: Box 8, Pacific Southwest Research Station Archives, Albany, CA.
- Fowells, H.A. 1983.** The Feather River Branch Station (Originally Feather River Experiment Station). On file with: Box 8, Pacific Southwest Research Station Archives, Albany, CA.
- Fowells, H.A.; Schubert, G.H. 1951.** Recent direct seeding trials in the pine region. Res. Note 78. Berkeley, CA: U.S. Department of Agriculture, Forest Service, California Forest and Range Experiment Station. 9 p.
- Fowells, H.A.; Schubert, G.H. 1956.** Seed crops of forest trees in the pine region of California. Tech. Bull. 1150. Washington, DC: U.S. Department of Agriculture.
- Fullaway, S.V.; Johnson, H.M.; Hill, C.L. 1928.** The air seasoning of western softwood lumber. Bulletin 1425. Washington, DC: U.S. Department of Agriculture.
- Gaines, E.M.; Shaw, E.W. 1958.** Half a century of research—Fort Valley Experiment Station, 1908–1958. Station Paper 38. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station.
- Gessel, S.P.; Harrison, R.B. 1999.** A short history of forest soils research and development in the United States. In: Steen, H.K., ed. *Forest and wildlife science in America: a history*. Durham, NC: Forest History Society: 389–413.
- Gill, C.; Hildreth, J. 1998.** Research brings natural resource science to life. *Forestry Research West*. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. 1998(April): 1–12.
- Gisborne, H.T. 1942.** Mileposts of progress in fire control and fire research. *Journal of Forestry*. 40(August): 597–608.

- Godfrey, A. 1985.** Congressional-Indian politics: Senate survey of conditions among the Indians of the United States. Salt Lake City, UT: University of Utah. Ph.D. dissertation.
- Godfrey, A. 1990.** Progress through wood research: a history of the U.S. Forest Products Laboratory—Madison, Wisconsin, 1960–1990. Final report from contract 53-3187-8-29. Salt Lake City, UT: U.S. West Research, Inc.
- Godfrey, A. 2005.** The ever-changing view: a history of the national forests of California. R5-FR-004. Washington, DC: U.S. Department of Agriculture, Forest Service, Pacific Southwest Region.
- Gordon, D.T. 1978.** History of the Swain Mountain Experimental Forest, 1932 through 1977, with some history of the adjacent area of Lassen and Plumas Counties, California. Unpublished manuscript. On file with: Box 6, Pacific Southwest Research Station Archives, Albany, CA.
- Gordon, D.T. 1982.** History of the Blacks Mountain Experimental Forest, 1933 through 1981, with some history of the adjacent area of Lassen County, California. Unpublished manuscript. On file with: Box 6, Pacific Southwest Research Station Archives, Albany, CA.
- Gordon, A.; Sampson, A.W. 1939.** Composition of common California foothill plants as a factor in range management. Bull. 627. Berkeley, CA: University of California, Agricultural Experiment Station. 95 p.
- Gore, A. 1993.** National performance review. <http://www.iberlibio.org/npr/nptoc.html>. (October 2009).
- Graham, K.L. 2004.** History of the Priest River Experiment Station. Gen. Tech. Rep. RMRS-GTR-129. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.
- Graves, H.S. 1910.** Report of the Forester for 1910. Washington, DC: U.S. Department of Agriculture, Forest Service.
- Graves, H.S. 1912.** Report of the Forester. Washington, DC: U.S. Department of Agriculture, Forest Service.
- Graves, H.S. 1913.** Report of the Forester. Washington, DC: U.S. Department of Agriculture, Forest Service.
- Graves, H.S. 1914.** Report of the Forester. Washington, DC: U.S. Department of Agriculture, Forest Service.

Graves, H.S. 1915. Report of the Forester. Washington, DC: U.S. Department of Agriculture, Forest Service.

Graves, H.S. 1916. Report of the Forester. Washington, DC: U.S. Department of Agriculture, Forest Service.

Graves, H.S. 1917. Report of the Forester. Washington, DC: U.S. Department of Agriculture, Forest Service.

Graves, H.S.; Guise, C.H. 1932. Forest education. New Haven, CT: Yale University Press.

Greeley, W.B. 1921. Report of the Forester. Washington, DC: U.S. Department of Agriculture, Forest Service.

Greeley, W.B. 1923. Report of the Forester. Washington, DC: U.S. Department of Agriculture, Forest Service.

Greeley, W.B. 1925. Report of the Forester. Washington, DC: U.S. Department of Agriculture, Forest Service.

Greeley, W.B. 1926. Report of the Forester. Washington, DC: U.S. Department of Agriculture, Forest Service.

Greeley, W.B. 1927. Report of the Forester. Washington, DC: U.S. Department of Agriculture, Forest Service.

Grosenbaugh, L.R. 1967. STX-Fortran 4 program—for estimates of tree populations from 3P sample—tree measurements. Res. Pap. PSW-13. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. 49 p.

Guthrie, J.P. 1904a. Coniferous woodlands in the eastern division of the Santa Barbara Reserve—their natural reproduction. On file with: Box 761332, 63-A-390, Record Group 95, San Bruno Federal Records Center, National Archives and Records Administration. San Bruno, CA.

Guthrie, J.P. 1904b. Coniferous woodlands in the western division of the Santa Barbara Reserve—their natural reproduction and extension. On file with: Box 761332, 63-A-390, Record Group 95, San Bruno Federal Records Center, National Archives and Records Administration. San Bruno, CA.

Hall, M. 2004. The provincial nature of George Perkins Marsh. *Environment and History*. 10(May): 191–204.

- Hall, R.C.; Dowing, G.; Wickman, B.E.; Ferrell, G.T. [N.d.]**. A history of the Hat Creek Field Laboratory. Unpublished manuscript. On file with: Box 6, Pacific Southwest Research Station Archives, Albany, CA.
- Hallin, W.E. 1959**. The application of unit area control in the management of ponderosa-Jeffrey pine at Blacks Mountain Experimental Forest. Tech. Bull. 1191. Washington, DC: U.S. Department of Agriculture.
- Hanson, D.G. 1983**. Monitoring wildlife by whole-guild inventories. Forestry Research West. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 1983(September): 1–4.
- Hardy, C.E. 1983**. The Gisborne era of forest fire research—a legacy of a pioneer. FS-367. Washington, DC: U.S. Department of Agriculture, Forest Service.
- Harper, V.L. 1959 (6 October)**. Letter to Pacific Southwest Station. On file with: Box 9, Pacific Southwest Research Station Archives, Albany, CA.
- Harper, V.L. 1978**. Harper, Verne Lester, George M. Jemison, Clarence L. Forsling: early Forest Service research administrators. Transcript. Maunder, E.R., interviewer. Santa Cruz, CA: Forest History Society.
- Harper, V.L.; McGuire, J.R. 1963**. Report of general research inspection. Washington, DC: U.S. Forest Service. On file with: Box 7, Pacific Southwest Research Station Archives, Albany, CA.
- Harris, R.W. [N.d.]**. Resume of academic training and professional career of Robert W. Harris. On file: Station Directors' resumes, Box 7, Pacific Southwest Research Station Archives, Albany, CA.
- Harrison, A. 1989**. Predators and prey—a case of imbalance. Forestry Research West. U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. 1989(June): 1–5.
- Hastings, J.H. 1976**. Chronological history of the California Division of Forestry. On file with: Box 4, Pacific Southwest Station Research Archives, Albany, CA.
- Helms, D. 1984**. Walter Lowdermilk's journey: forester to land conservationist. Environmental Review. 8: 132–145.
- Hill, C.L. 1931**. The development of forest research in California. Journal of Forestry. 29(April): 484–496.
- Hill, C.L. 1939 (9 October)**. Memorandum to Director Kotok. On file with: Research program general, 1939 to 1952, Box 25986, Accession No. 95-59-B0496, Federal Records Center, San Bruno, CA.

- Hill, C.L.; Kofold, C.A., eds. 1927.** Marine borers and their relation to marine construction on the Pacific coast. Final report of the San Francisco Bay Marine Piling Committee. San Francisco, CA: San Francisco Bay Marine Piling Committee; National Research Council (U.S.); American Wood Preservers Association. 357 p.
- Hill, L.W. 1963.** The San Dimas Experimental Forest. On file with: Box 6, Pacific Southwest Research Station Archives, Albany, CA.
- Hodge, W.C. 1959.** A report on the forest policy for the state of California. In: Clar, C.R. California government and forestry from Spanish days until the creation of the Department of Natural Resources in 1927. Sacramento, CA: California Department of Natural Resources, Division of Forestry: 224.
- Hopkins, A.D. 1899.** A preliminary report on the insect enemies of forests in the Northwest. Bull. 21 (new series). Washington, DC: U.S. Department of Agriculture, Division of Entomology. 48 p. plus photos.
- Horton, J.S.; Kraebel, C. 1955.** Development of vegetation after fire in chamise chaparral in southern California. *Ecology*. 36(April): 244–262.
- Hostetter, A. 1966.** Annotated bibliography of publications by USDA Forest Service fire research staff, their colleagues, and cooperators in California, 1962–1975. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. 24 p.
- Hough, F.B. 1882.** The elements of forestry. Cincinnati, OH: Robert B. Clark & Co.
- Hough, F.B. 1878.** Report upon forestry, Volume 1. Washington: Government Printing Office. 650 p.
- Hough, F.B. 1880.** Report upon forestry, Volume 2. Washington: Government Printing Office. 618 p.
- Hough, F.B. 1882.** Report upon forestry, Volume 3. Washington: Government Printing Office. 318 p.
- Hoyt, W.G.; Troxell, H.C. 1934.** Forests and streamflows. *Transactions of the American Society of Civil Engineers*. 99: 1–111.
- Hubbard, R.L.; Hiehle, J. 1965.** Deer habitat research needs in California. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station.

- Hughes, B.L.; Dunning, D. 1948.** Timber management in the national forests of California. On file with: California Forest and Range Experiment Station Articles, Boxes 761147-761158, Accession No. 95-59-0744, Federal Records Center, San Bruno, CA.
- Hutchinson, C.B.; Kotok, E.I., eds. 1942.** The San Joaquin Experimental Range. Bull. 663. Berkeley, CA: U.S. Department of Agriculture, Forest Service, California Forest and Range Experiment Station.
- Jemison, G.M. 1978.** Harper, Verne Lester, George M. Jemison, Clarence L. Forsling: Early Forest Service research administrators. Transcription. Maunder, E.R., interviewer. Santa Cruz, CA: Forest History Society.
- Journal of Forestry. 1932.** Institute of Forest Genetics. 30(May): 623–624.
- Journal of Forestry. 1938.** A look back and a glance ahead. 36(September): 829–830.
- Journal of Forestry. 1940.** Forest research and next thirty years. 38(February): 79, 164–188.
- Journal of Forestry. 1941.** Edward I. Kotok named Assistant Chief of U.S. Forest Service Divisions. 39(January): 66.
- Journal of Forestry. 1945.** Changes in experiment station directorships. 43(February): 140.
- Journal of Forestry. 1957.** Ralph Sheldon Hosmer. 55(May): [N.p.] Reprint.
- Judd, R.W. 2004.** George Perkins Marsh: the times and their man. *Environment and History*. 10(May): 169–190.
- Keen, F.P.; Hall, R.C. 1977.** Oral history volume of forest entomology in the West. Transcription. Maunder, E.R., interviewer. Santa Cruz, CA: Forest History Society.
- Klade, R.J.; Lassen, L.E. 2005.** Building a research legacy: the Intermountain Station, 1911–1997. On file with: U.S. West Research, Inc., 2395 Fisher Lane, Salt Lake City, UT 84109.
- Kotok, E.I. 1925.** Forests and agriculture...a public fire conscience must be developed. *California Countryman*. 12(December): 7, 25.

- Kotok, E.I. 1930.** Research work in forestry by the United States Forest Service. Talk given at University of California, Berkeley. 7 January 1930. On file with: Edward I. Kotok, Box 22451, Accession No. 95-51-D0151, Federal Records Center, San Bruno, CA.
- Kotok, E.I. 1932.** Solving the forest and water riddle: recent results of widely conducted experiments are providing abundant facts to show the beneficial effects of forest and other plant cover upon streamflow and water conservation. *American Forests*. 38(September): 488–491.
- Kotok, E.I. 1938.** Some economic problems in Pacific coast forestry. *Proceedings, 17th annual conference of Pacific Coast Economic Association*. Santa Clara, CA: Pacific Coast Economic Association: 90–95.
- Kotok, E.I. 1948.** Organization of research in the U.S. Forest Service. *Unasylva*. 2(March-April): 69–76.
- Kraebel, C.J. 1932.** The denudation of mountains and the water supply. Talk given at Forestry and Wild Life Committee of the Commonwealth Club of San Francisco. 26 April 1932. On file with: Edward I. Kotok, Box 22451, Accession No. 95-51-D0151, Federal Records Center, San Bruno, CA.
- Kraebel, C.J.; Kellogg, L.F. 1938.** The forest guardians of our watersheds. *Journal of Forestry*. 36(September): 858–860.
- LeMaster, D.C. 1984.** Decade of change: the remaking of Forest Service statutory authority during the 1970s. Westport, CT: Greenwood Press.
- Lemmon, J.G.; Lemmon, S.A.P. 1902.** How to tell the trees and forest endowment of Pacific slope. Oakland, CA: [Publisher unknown]. <http://www.archive.org/stream/howtotelltreesof00lemmrch#page/n9/mode/2up>. (August 2010).
- Leopold, A. 1949.** A Sand County almanac. New York: Oxford University Press.
- Lewis, J.G. 2005.** The Forest Service and the greatest good: a centennial history. Durham, NC: Forest History Society.
- Loveridge, E.W. 1944.** The fire suppression policy of the U.S. Forest Service. *Journal of Forestry*. 42(August): 549–604.
- Loveridge, E.W.; Dutton, W.L. 1946.** Report to the Chief on general integrating inspection including follow-up of previous G.I. inspections: California Region. On file with: USDA Forest Service, Pacific Southwest Region Archives, Vallejo, CA.

- Lowdermilk, W.C. 1929.** Function of the California Forest Experiment Station: water supply problems. On file with: W.C. Lowdermilk, Box 22451, Accession No. 95-51-D0151, Federal Records Center, San Bruno, CA.
- Lowdermilk, W.C. 1933.** Forests and streamflow: discussion of the Hoyt-Troxell Report. *Journal of Forestry*. 3(3): 296–307.
- Lowdermilk, W.C.; Hamilton, E.L. 1933.** Large lysimeter installation to measure transpiration loss of chaparral forest. On file with: W.C. Lowdermilk, Boxes 7611-47-761158, Accession No. 95-59-0744, Federal Records Center, San Bruno, CA.
- MacCleery, D.W. 1993.** American forests: a history of resiliency and recovery. Durham, NC: Forest History Society.
- Magill, A.W.; Leiser, A.T. 1967.** New help for worn out campgrounds. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station.
- Marsh, G.P. 1864.** Man and nature: or, physical geography as modified by human action. New York: Charles Scribner. 560 p.
- Mastrantonio, J.L. 1989.** Saving Hawaii's native forests. *Forestry Research West*. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. 1989(October): 13–16.
- Mastrantonio, J.L. 1990.** Lessons from the lysimeters. *Forestry Research West*. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. 1990(December): 7–9.
- May, R.H. 1953a.** A century of lumber production in California and Nevada. Forest Survey Release No. 20. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. 33 p.
- May, R.H. 1953b.** Early history of the redwood lumber industry. *Bulletin*, 15th annual redwood regional logging conference and equipment show: 8–9. On file with: Pacific Southwest Research Station archives, Albany, CA.
- McArdle, R.E. 1955.** The Forest Service's first fifty years. *Journal of Forestry*. 53(February): 99–106.
- McCulley, R.D. [N.d.].** Biographical sketch of Robert D. McCulley. On file with: Station Directors' resumes, Box 7, Pacific Southwest Research Station Archives, Albany, CA.

- McDonald, J.K. 1979.** Searching for safe insecticides. Forestry Research West. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. 1979(May): 1–4.
- McDonald, J.K. 1983.** Chaparral R&D Program...catalyst for action. Forestry Research West. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. 1983(March): 11–16.
- McDonald, J.K. 1985.** A brief overview of the Pacific Southwest Station. Forestry Research West. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. 1985(October): 16–21.
- McDonald, P.M.; Huber, D.W. 1995.** California's hardwood resource: managing for wildlife, water, pleasing scenery, and wood products. Gen. Tech. Rep. PSW-GTR-154. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 23 p.
- McGuire, J.R. 1976.** Memo to Director, PSW with enclosure, Revision number two to establishment report on Swain Mountain Experimental Forest. On file with: Box 1, Pacific Southwest Research Station Archives, Albany, CA.
- Meinecke, E.P. 1914.** Forest tree diseases common in California and Nevada. Bull. 799. Washington, DC: U.S. Department of Agriculture, Forest Service. 67 p.
- Meinecke, E.P. 1916.** Forest pathology in forest regulation. Bull. 275. Washington, DC: U.S. Department of Agriculture. 63 p.
- Meinecke, E.P. 1929.** Effect of excessive tourist travel on the California Redwood Parks. Sacramento, CA: California State Printing Office.
- Meinecke, E.P. 1935 (5 April).** Letter to Dr. Haven Metcalf. The trailer menace. On file: Forest History Society, Durham, NC.
- Michaux, A. 1803.** *Flora boreali-americana sistens caracteres plantarum quas in America septentrionali collegit et detexit Andreas Michaux.* 2 vol. Parisiis et Argentorati: apud fratres Levrault. On file with: Library, New York Botanical Garden.
- Michaux, F.A. 1819.** *The North American sylvia, or, a description of the forest trees of the United States, Canada and Nova Scotia.* Translated from the French. Paris: C. d'Hautel.
- Miller, D.C. 1963.** Persistence and the pine. *American Forests*. 69(January): 16–19.

- Miller, D.R.; Kimmey, J.W. 1958.** White pine blister rust in the Western United States. On file with: Alphabetical author's publications: Boxes 1232521-1232526, Accession No. 95-63-0532, Federal Records Center, San Bruno, CA.
- Miller, J.M. 1912.** How the insect control problem compares with the fire problem on national forests in District 5. *Forestry Quarterly*. 10(June): 208–214.
- Miller, J.M.; Keen, F.P. 1960.** Biology and control of the western pine beetle, a summary of the first fifty years of research. Misc. Publ. 800. Washington, DC: U.S. Department of Agriculture, Forest Service. 381 p.
- Miller, P. 1985.** The impacts of air pollution on forest resources. *Forestry Research West*. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. 1985(August): 1–5.
- Mirov, N.T. 1934.** California botany covers more than a century. *California Ranger*. 5(51): 1.
- Mirov, N.T. 1939.** Forest genetics: present status and outlook for the future. Proceedings, sixth Pacific science congress. Berkeley, CA. 4: 727–730.
- Mirov, N.T. 1961.** Composition of gum turpentine of pines. Tech. Bull. 1239. Washington, DC: U.S. Department of Agriculture.
- Mirov, N.T.; Kraebel, C.J. 1937.** Collecting and propagating the seeds of California wild plants. Res. Note 18. Berkeley, CA: U.S. Department of Agriculture, Forest Service, California Forest and Range Experiment Station. 27 p.
- Munns, E.N. 1913.** Reforestation in southern California. On file with: Box 1: Historical Manuscripts, 1902–1913, Record Group 95, National Archive Record Center, San Bruno, CA.
- Munns, E.N. 1923.** Erosion and flood problems in California. Sacramento, CA: California State Board of Forestry.
- Murphy, E.W. 1928.** What passage of the McNary-McSweeney Bill means to California. *California Journal of Development*. 18(1): 26–27.
- Nelson, R.E. 1989.** The USDA Forest Service in Hawaii: the first 20 years (1957–1977). Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station.
- Nelson, R.H. 2000.** Rethinking scientific management: brand-new alternatives for century-old agency. In: Sedjo, R.A., ed. *A vision for the U.S. Forest Service: goals for its next century*. Washington, DC: Resources for the Future: 57–74.

- Nuttall, T. 1865.** North American Sylva, or, a description of the forest trees of the United States, Canada, and Nova Scotia not described in the work of F. Andrew Michaux, and containing all the forest trees discovered in the Rocky Mountains, the territory of Oregon, down to the shores of the Pacific, etc. Philadelphia, PA: Smith & Wister. 3 vols.
- Oakland Tribune. 1940.** Expert added to forestry faculty. 26 July.
- Olberding, S.D. 2000.** Fort Valley: the beginnings of forest research. Forest History Today. (Spring 2000): 9–15.
- Olmsted, F.E. 1902.** Tests on the physical properties of timber. In: Agriculture yearbook. Washington, DC: U.S. Department of Agriculture: 533–538.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1966a.** A night test of helicopters. What's New in Research? 1966(November): 1–2.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1966b.** A talk with Julius Hyman. What's New in Research? 1966(August): 1–2.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1967a.** Astronauts to help. What's New in Research? 1967(March): 8.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1967b.** Sensing by satellite. What's New in Research? 1967(March): 4.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1967c.** Soils that won't "wet up." What's New in Research? 1967(August): 1–2.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1967d.** The trouble with tree fern. What's New in Research? 1967(March): 3.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1968a.** Bark beetles "turn." What's New in Research? 1968(November): 1–2.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1968b.** Blister rust found in central Sierra Nevada. What's New in Research? 1968(November): 5.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1968c.** Designing a super molecule: a symplastic systemic insecticide. What's New in Research? 1968(November): 1–2.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1968d.** Fire dispatching by computer. What's New in Research? 1968(November): 7.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1968e. Nicasio, U.S.A. What's New in Research? 1968(November): 1–2.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1968f. Smog disease...no cure in sight. What's New in Research? 1968(February): 6–8.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1968g. Smog disease in ponderosa pine. What's New in Research? 1968(November): 5.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1969a. Cattle grazing: Can it improve winter deer range? What's New in Research? 1969(December): 9–10

Pacific Southwest Forest and Range Experiment Station [PSW]. 1969b. Forestry research in the 50th state." What's New in Research? 1969(December): 1–4.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1969c. Growing redwoods... What's New in Research? 1969(July): 2–4.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1969d. Soils that won't "wet up." What's New in Research? 1969(July): 6–8.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1970a. Nationwide forest survey from space. What's New in Research? 1970(March): 1–3.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1970b. The Santa Ana: it's an ill wind. What's New in Research? 1970(August): 7–8.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1971. Worst fires in history. What's New in Research? 1971(March): 1–2.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1972a. Forest trees: decoding their genetic structure. What's New in Research? 1972(July): 6–7.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1972b. One of the oldest insecticides known to man. What's New in Research? 1972(July): 1–5.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1972c. Profiling the snowpack. What's New in Research? 1972(April): 2–3.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1973. Limonene...Is it important? Forestry Research: What's New in the West. 1973(Fall): 6–7.

- Pacific Southwest Forest and Range Experiment Station [PSW]. 1974a.** Library network aids California foresters. Forestry Research: What's New in the West. 1974(August): 1–3, 12.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1974b.** Night helicopter operations for fighting wildfires. Forestry Research: What's New in the West. 1974(August): [N.p.].
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1974c.** A virus that kills tussock moths. Forestry Research: What's New in the West. 1974(August): 4–5, 12–13.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1975a.** Pilots try night helitack. Forestry Research: What's New in the West 1975(July): 1–2.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1975b.** Planners look ahead with VIEWIT. Forestry Research: What's New in the West. 1975(February): 6–7, 15.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1976.** Robert Z. Callaham is PSW's new Director. For Your Information. 1976(8 November): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1978.** Ponderosa pine studied. Forestry Research: What's New in the West. 1978(July): 20.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1979a.** Helping the California condor. Forestry Research West. 1979(January): 11.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1979b.** Measuring snow water content in restricted areas. Forestry Research West. 1979(November): 15.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1980a.** Fire and chaparral soils. Forestry Research West. 1980(August): 20.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1980b.** Landscape inventory system developed. Forestry Research West. 1980(May): 14.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1980c.** Measuring chaparral moisture content. Forestry Research West. 1980(August): 18.
- Pacific Southwest Forest and Range Experiment Station. 1981a.** Federal judge approves consent decree. For Your Information. 1981(11 May): 1.

Pacific Southwest Forest and Range Experiment Station. 1981b. Federal judge approves consent decree. For Your Information. 1981(13 July): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1981c. Oak woodlands summary issued. Forestry Research West. 1981(June): 19.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1981d. Plantation success—timing is the key. Forestry Research West. 1981(June): 20.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1981e. Prescribed burning reviewed in report. Forestry Research West. 1981(September): 20.

Pacific Southwest Forest and Range Experiment Station. 1982a. Changes underway in Hawaii program. For Your Information. 1982(10 May): 1.

Pacific Southwest Forest and Range Experiment Station. 1982b. Fiscal year 1982 budget update. For Your Information. 1982(18 January): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1982c. Forest fuels—gauging how much is on the ground. Forestry Research West. 1982(June): 18.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1982d. Genetics research technique reviewed. Forestry Research West. 1982(February): 17.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1982e. POLO2 expands options of insecticide tests. Forestry Research West. 1982(September): 19.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1982f. UC professor to study young spotted owls. For Your Information. 1982(18 July): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1982g. Urban forestry unit receives new charter. For Your Information. 1982(28 June): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1983a. Classifying mountain meadow sites. Forestry Research West. 1983(June): 14.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1983b. Director and Deputy Director to retire April 29. For Your Information. 1983(11 April): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1983c. Dwarf mistletoe in California firs. Forestry Research West. 1983(June): 16.

- Pacific Southwest Forest and Range Experiment Station [PSW]. 1983d.** Goats for brush control. Forestry Research West. 1983(January): 16.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1983e.** Identifying bald eagles through voice prints. Forestry Research West. 1983(June): 12.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1983f.** Roger Bay named Director of PSW. For Your Information. 1983(20 June): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1984a.** Acid rain in California. For Your Information. 1984(25 June): 2.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1984b.** Administrative studies being reviewed. For Your Information. 1984(24 September): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1984c.** Bega, Botsko to retire on December 21. For Your Information. 1984(17 December): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1984d.** Changes in research units announced. For Your Information. 1984(26 November): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1984e.** Clearcutting and natural regeneration...northern Sierra Nevada. Forestry Research West. 1984(June): 11.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1984f.** Consent action plan accepted by WO. For Your Information. 1984(18 June): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1984g.** Consent decree training for supervisors. For Your Information. 1984(20 August): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1984h.** Crowell testifies on 1985 budget. For Your Information. 1984(27 February): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1984i.** Director on consent decree. For Your Information. 1984(11 June): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1984j.** FS announces research accomplishments. For Your Information. 1984(27 August): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1984k.** Funding for acid rain research. For Your Information. 1984(30 January): 2.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1984l.

Growth classification systems for red fir and white fir. Forestry Research West. 1984(June): 12.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1984m. Guide to identification and post-fire management of five California oaks. Forestry Research West. 1984(June): 12.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1984n.

Highlights of Chief's remarks. For Your Information. 1984(13 February): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1984o. More on acid rain. For Your Information. 1984(7 May): 2.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1984p.

President's Forest Service budget. For Your Information. 1984(20 February): 1.

Pacific Southwest Forest and Range Experiment Station [PSW].

1984q. Prescribed burn set for San Dimas Forest. For Your Information. 1984(29 October): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1984r. PSW scientists at acid rain workshop. For Your Information. 1984(16 January): 1.

Pacific Southwest Forest and Range Experiment Station [PSW].

1984s. PSW/R-5 consent decree liaisons selected. For Your Information. 1984(25 June): 1.

Pacific Southwest Forest and Range Experiment Station [PSW].

1984t. Riverside holds acid precipitation meeting. For Your Information. 1984(17 December): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1984u. Roy retires after 41 years' service. For Your Information. 1984(1 October): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1984v. Shared services: PSW Operations Group/R-5. For Your Information. 1984(18 June): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1985a.

"Accomplishments" reports on station research. For Your Information. 1985(23 September): 1

Pacific Southwest Forest and Range Experiment Station [PSW]. 1985b. Awards presented at San Dimas anniversary. For Your Information. 1985(8 July): 1

- Pacific Southwest Forest and Range Experiment Station [PSW]. 1985c.** Brush reduces growth of ponderosa pine. Forestry Research West. 1985(January): 16.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1985d.** Classifying vegetation in Hawaii. Forestry Research West. 1985(January): 22.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1985e.** Computing costs of fire suppression. Forestry Research West. 1985(January): 18.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1985f.** Conard appointed project leader of new unit. For Your Information. 1985(21 October): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1985g.** Dunn appointed project leader of new unit. For Your Information. 1985(12 November): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1985h.** Fire management planning. Forestry Research West. 1985(October): 24.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1985i.** Genetics Institute marks 60th anniversary. For Your Information. 1985(23 December): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1985j.** Larson named first woman forest supervisor. For Your Information. 1985(21 January): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1985k.** Lux launches off on career pathing program. For Your Information. 1985(29 July): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1985l.** New career pathing program launched. For Your Information. 1985(4 March): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1985m.** Prescribed burns completed by fire scientists. For Your Information. 1985(2 December): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1985n.** PSW queries employees on “early retirement.” For Your Information. 1985(10 June): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1985o.** Regeneration of Douglas-fir. Forestry Research West. 1985(October): 25.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1985p.** Robert L. Neal retires at Redding. For Your Information. 1985(18 February): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1985q.** San Dimas Forest to celebrate 50th anniversary. For Your Information. 1985(17 June): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1985r. San Joaquin Range marks 50th anniversary. For Your Information. 1985(22 April): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1985s. Spada, McDonald, Ryan, Skolmen to retire. For Your Information. 1985(30 December): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1985t. Station issues early retirement notices. For Your Information. 1985(25 November): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1985u. Station launches career pathing program. For Your Information. 1985(1 April): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1985v. Two researchers awarded competitive grants. For Your Information. 1985(15 October): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1985w. Two selected for career pathing program. For Your Information. 1985(10 June): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1986a. Bergen, Schaefer, Schelton, Sundahl retire. For Your Information. 1986(3 February): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1986b. Buckman pays farewell visit to station. For Your Information. 1986(21 January): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1986c. Career pathing program directive issued. For Your Information. 1986(21 January): 2.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1986d. Clarke, Maxwell, Roederer to retire. For Your Information. 1986(27 January): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1986e. Consent decree training report issued. For Your Information. 1986(6 October): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1986f. Everett Wieslander—the person. For Your Information. 1986(18 August): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1986g. Finding the optimum fire management program level. Forestry Research West. 1986(November): 21.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1986h. FIRECAST handbook available for estimating fire behavior. Forestry Research West. 1986(November): 25.

- Pacific Southwest Forest and Range Experiment Station [PSW]. 1986i.** Fire lab scheduled to gain 12 new employees. For Your Information. 1986(21 July): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1986j.** First awards in internal competitive grants. For Your Information. 1986(15 September): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1986k.** Guidelines available for testing insecticides on coniferous forest defoliators. Forestry Research West. 1986(November): 24. (Anon 1986c dup of Anon 1986f)
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1986l.** Major changes in fire research announced. For Your Information. 1986(14 July): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1986m.** New to PSW. For Your Information. 1986(29 December): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1986n.** “Outstanding scientist” awardee: Ray Rice. For Your Information. 1986(8 December): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1986o.** Pilot test...progress report. For Your Information. 1986(12 May): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1986p.** PSW among winners of competitive grants. For Your Information. 1986(24 October): 2.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1986q.** “Research Accomplishments” cites work at PSW. For Your Information. 1986(8 December): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1986r.** Robertson: a woman scientist’s rise to the top. For Your Information. 1986(23 June): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1986s.** Station is 60 years old this Wednesday. For Your Information. 1986(30 June): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1986t.** Study shows how to predict effects of thinning and overstory removal on red fir advance regeneration. Forestry Research West. 1986(November): 22.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1986u.** Wieslander hails 60th anniversary of station. For Your Information. 1986(28 July): 1.

Pacific Southwest Forest and Range Experiment Station [PSW].

1986v. Weislander: working with station directors. For Your Information. 1986(4 August): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1986w.

Logo Adopted to Mark Station's Anniversary. For Your Information. 1986(31 March): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1987a. Chief approves PSW/R-5 location study. For Your Information. 1987(12 January): 1–2.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1987b. Chief's watchword: "continuity." For Your Information. 1987(2 March): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1987c.

Competitive grants program renewed. For Your Information. 1987(23 March): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1987d. Consent decree hearing set for January 16. For Your Information. 1987(5 January): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1987e.

De La Toree heads ARS study. For Your Information. 1987(19 January): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1987f. Director Bay reviews FY87's progress. For Your Information. 1987(2 November): 1–2.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1987g.

Landscape research unit relocated. For Your Information. 1987(1 June): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1987h. Mays spotted owl program manager. For Your Information. 1987(16 March): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1987i. Moore assumes assistant director duties. For Your Information. 1987(16 March): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1987j. Pacific Islands Research Unit renamed. For Your Information. 1987(26 May): 1.

Pacific Southwest Forest and Range Experiment Station [PSW].

1987k. Robertson succeeds Peterson as Chief. For Your Information. 1987(26 January): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1987l.

Temporary employees: part of PSW. For Your Information. 1987(15 June): 1.

Pacific Southwest Forest and Range Experiment Station [PSW].

1988a. Congress approves funds for PSW move. For Your Information. 1988(11 January): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1988b.

Director Bay's farewell to employees. For Your Information. 1988(21 March): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1988c.

Director Stewart reviews progress in FY 1988. For Your Information. 1988(14 November): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1988d.

Effects of ryegrass seeding on post-fire erosion and succession. Forestry Research West. 1988(June): 27.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1988e.

Emergency ryegrass seeding to revegetate chaparral burns. Forestry Research West. 1988(June): 26.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1988f.

Federal judge extends consent decree. For Your Information. 1988(16 May): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1988g.

IFG honored as national historic site. For Your Information. 1988(8 August): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1988h.

IFG hosts national genetics workshop. For Your Information. 1988(22 August): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1988i.

Lux is career pathing's first "graduate." For Your Information. 1988(17 October): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1988j.

MaSS exodus after 26 years. For Your Information. 1988(19 September): 1.

Pacific Southwest Forest and Range Experiment Station. 1988k.

Peterson named project leader. For Your Information. 1988(28 November): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1988l.

Research work units listed. For Your Information. 1988(6 September): 1–2.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1988m.

Riverside Fire Lab celebrates 25 years. For Your Information. 1988(31 May): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1988n.

Special publications mark anniversary. For Your Information. 1988(7 June): 1.

- Pacific Southwest Forest and Range Experiment Station [PSW]. 1988o.** Station Director Bay to retire March 31. For Your Information. 1987(7 March): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1988p.** Station priorities set at managers meeting. For Your Information. 1988(2 May): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1988q.** Stewart appointed Station Director. For Your Information. 1988(4 April): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1988r.** Stewart: “We can surmount any obstacles.” For Your Information. 1988(4 April): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1989a.** Chase selected as fire project leader. For Your Information. 1989(6 February): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1989b.** CR/consent decree group reorganized. For Your Information. 1989(24 July): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1989c.** INSEX: a new way to select insecticides. For Your Information. 1989(26 June): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1989d.** Jenkinson receives state’s Raymond award. For Your Information. 1989(6 March): 1–2.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1989e.** Jenkinson wins USDA award. For Your Information. 1989(12 June): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1989f.** Meetings/conferences/seminars attended. For Your Information. 1989(11 December): 2.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1989g.** New to PSW. For Your Information. 1989(17 April): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1989h.** Recreation unit holds workshops. For Your Information. 1989(1 May): 2.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1989i.** Recreation workshop held at Riverside. For Your Information. 1989(9 January): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1989j.** Rice receives state’s Raymond award. For Your Information. 1989(26 December): 1.
- Pacific Southwest Forest and Range Experiment Station [PSW]. 1989k.** Rice to retire on May 3. For Your Information. 1989(1 May): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1989l.

Riverside hosts acid deposition review. For Your Information. 1989(30 May): 1.

Pacific Southwest Forest and Range Experiment Station [PSW]. 1989m.

Scientists brief Congressman Brown. For Your Information. 1989(3 April): 1

Pacific Southwest Research Station [PSW]. 1990a. 50th anniversary celebration.

For Your Information. 1990(19 November): 1.

Pacific Southwest Research Station [PSW]. 1990b. Aune to coordinate PSW

“New Perspectives.” For Your Information. 1990(20 August): 1.

Pacific Southwest Research Station [PSW]. 1990c. The Bedford Canyon Burn:

first-hand report. For Your Information. 1990(20 August): 1.

Pacific Southwest Research Station [PSW]. 1990d. Ewert guest-edits Trends

journal. For Your Information. 1990(5 February): 1.

Pacific Southwest Research Station [PSW]. 1990e. Former Directors: Where are

they? R. Keith Arnold. For Your Information. 1990(6 August): 1–2

Pacific Southwest Research Station [PSW]. 1990f. Former Directors: Where are

they? Roger R. Bay. For Your Information. 1990(11 June): 1–2.

Pacific Southwest Research Station [PSW]. 1990g. Former Directors: Where are

they? Robert Z. Callaham. For Your Information. 1990(4 September): 1–2.

Pacific Southwest Research Station [PSW]. 1990h. Former Directors: Where are

they? Harry W. Camp. For Your Information. 1990(25 June): 1–2.

Pacific Southwest Research Station [PSW]. 1990i. Former Directors: Where are

they? Robert W. Harris. For Your Information. 1990(24 July): 1–2.

Pacific Southwest Research Station [PSW]. 1990j. Former Directors: Where are

they now? John R. McGuire. For Your Information. 1990(9 July): 1–2.

Pacific Southwest Research Station [PSW]. 1990k. Former PSW Directors:

Where are they? George Jemison. For Your Information. 1990(29 May): 1–2.

Pacific Southwest Research Station [PSW]. 1990l. FY91 budget addresses

pressing issues. For Your Information. 1990(20 February): 1–2.

Pacific Southwest Research Station [PSW]. 1990m. Management team/staff. For

Your Information. 1990(8 January): 1.

Pacific Southwest Research Station [PSW]. 1990n. National Hispanic Heritage

Month. For Your Information. 1990(1 October): 1–2.

- Pacific Southwest Research Station [PSW]. 1990o.** New to PSW. For Your Information. 1990(8 January): 2.
- Pacific Southwest Research Station [PSW]. 1990p.** Riverside laboratory spotlighted. For Your Information. 1990(22 January): 1.
- Pacific Southwest Research Station [PSW]. 1990q.** Stewart leaves PSW for regional forester position. For Your Information. 1990(17 December): 1.
- Pacific Southwest Research Station [PSW]. 1990r.** Update: consent decree training. For Your Information. 1990(22 January): 2.
- Pacific Southwest Research Station [PSW]. 1990s.** Women in FS—Have they progressed? For Your Information. 1990(2 April).
- Pacific Southwest Research Station [PSW]. 1991a.** Albany move: an update. For Your Information. 1991(29 July): 1.
- Pacific Southwest Research Station [PSW]. 1991b.** Albany move: update. For Your Information. 1991(21 October): 1.
- Pacific Southwest Research Station [PSW]. 1991c.** Albany move: update. For Your Information. 1991(4 November): 1.
- Pacific Southwest Research Station [PSW]. 1991d.** Chavez named recreation project leader. For Your Information. 1991(15 July): 1.
- Pacific Southwest Research Station [PSW]. 1991e.** Consent decree: from “denial” to “adoption.” For Your Information. 1991(25 March): 1.
- Pacific Southwest Research Station [PSW]. 1991f.** Consent decree hearing set for June 28. For Your Information. 1991(10 June): 2.
- Pacific Southwest Research Station [PSW]. 1991g.** Consent decree reaches milestone. For Your Information. 1991(20 May): 1.
- Pacific Southwest Research Station [PSW]. 1991h.** Court extends CD for FS Region 5. For Your Information. 1991(15 July): 2.
- Pacific Southwest Research Station [PSW]. 1991i.** Decade does make difference at PSW. For Your Information. 1991(9 September): 1.
- Pacific Southwest Research Station [PSW]. 1991j.** Haverty Acting PL for forest disease unit. For Your Information. 1991(23 September): 1–2.
- Pacific Southwest Research Station [PSW]. 1991k.** Millar wins \$150,000 Pew Scholars Grant. For Your Information. 1991(15 July): 1–2.

- Pacific Southwest Research Station [PSW]. 1991l.** Station Director's message. For Your Information. 1991(16 December): 1.
- Pacific Southwest Research Station [PSW]. 1991m.** Verner to assess California spotted owl. For Your Information. 1991(29 July): 1.
- Pacific Southwest Research Station [PSW]. 1991n.** Weber announces priorities at meeting. For Your Information. 1991(11 March): 1.
- Pacific Southwest Research Station [PSW]. 1991o.** Weber assumes duties as acting director. For Your Information. 1991(11 February): 1.
- Pacific Southwest Research Station [PSW]. 1992a.** Albany move: update. For Your Information. 1992(10 February): 1.
- Pacific Southwest Research Station [PSW]. 1992b.** Albany move: it's bye, bye Berkeley. For Your Information. 1992(28 February): 1.
- Pacific Southwest Research Station [PSW]. 1992c.** Albany move: update. For Your Information. 1992(30 March): 1.
- Pacific Southwest Research Station [PSW]. 1992d.** Blacks Mountain research team formed. For Your Information. 1992(13 January): 1.
- Pacific Southwest Research Station [PSW]. 1992e.** Conard profiled as FS research leader. For Your Information. 1992(30 November): 1.
- Pacific Southwest Research Station [PSW]. 1992f.** Conferences/meetings/seminars. For Your Information. 1992(19 October): 2.
- Pacific Southwest Research Station [PSW]. 1992g.** A. Everette Wieslander dies. For Your Information. 1992(16 November): 1.
- Pacific Southwest Research Station [PSW]. 1992h.** Freeze on hiring employees outside FS. For Your Information. 1992(16 November): 1.
- Pacific Southwest Research Station [PSW]. 1992i.** FS releases final EIS on spotted owl. For Your Information. 1992(10 February): 1–2.
- Pacific Southwest Research Station. 1992j.** Global change program grants announced. For Your Information. 1992(8 June): 1.
- Pacific Southwest Research Station [PSW]. 1992k.** New description approved for research unit. For Your Information. 1992(26 May): 1–2.
- Pacific Southwest Research Station [PSW]. 1992l.** Outstanding scientist: Millar. For Your Information. 1992(28 December): 1–2.

- Pacific Southwest Research Station [PSW]. 1992m.** PSW headquarters move to Albany. For Your Information. 1992(16 March): 1.
- Pacific Southwest Research Station [PSW]. 1992n.** State of the labs at PSW, Albany. For Your Information. 1992(27 April): 1–2.
- Pacific Southwest Research Station [PSW]. 1992o.** Station budget up slightly in FY 1993. For Your Information. 1992(5 October): 1.
- Pacific Southwest Research Station [PSW]. 1992p.** A. Everette Wieslander dies. For Your Information. 1992(16 November): 1.
- Pacific Southwest Research Station [PSW]. 1993a.** Chase to retire on June 3. For Your Information. 1993(17 May): 1–2.
- Pacific Southwest Research Station [PSW]. 1993b.** Organization downsizing: the shrink is on. For Your Information. 1993(15 November): 1–2.
- Pacific Southwest Research Station [PSW]. 1993c.** Ostroina tracks “unseen killer.” For Your Information. 1993(22 February): 1.
- Pacific Southwest Research Station [PSW]. 1993d.** President proposes increases in FS research. For Your Information. 1993(14 June): 1.
- Pacific Southwest Research Station [PSW]. 1993e.** PSW no longer considering relocation. For Your Information. 1993(13 September): 1.
- Pacific Southwest Research Station [PSW]. 1993f.** RWUs in review: air deposition research. For Your Information. 1993(23 August): 1–2
- Pacific Southwest Research Station [PSW]. 1993g.** RWUs in review: aquatic ecosystems research. For Your Information. 1993(13 September): 1–2
- Pacific Southwest Research Station [PSW]. 1993h.** For Your Information. RWUs in preview: insect population research. 1993(26 July): 1–2.
- Pacific Southwest Research Station [PSW]. 1993i.** RWUs in review: recreation research. For Your Information. 1993(9 August): 1–2.
- Pacific Southwest Research Station [PSW]. 1993j.** Southland Fires: rebuilding, restudying. For Your Information. 1993(15 November): 1.
- Pacific Southwest Research Station [PSW]. 1993k.** Station projects no unfunded staff positions. For Your Information. 1993(8 March): 1.
- Pacific Southwest Research Station [PSW]. 1993l.** Station to study Sierra Nevada ecosystem. For Your Information. 1993(13 September): 1.

- Pacific Southwest Research Station [PSW]. 1993m.** Supply of “spotted owl” publication exhausted. For Your Information. 1993(12 October): 1.
- Pacific Southwest Research Station [PSW]. 1993n.** Thomas appointed new Forest Service Chief. For Your Information. 1993(29 November): 1–2.
- Pacific Southwest Research Station [PSW]. 1993o.** Thomas calls for new leadership in FS. For Your Information. 1993(13 December): 1.
- Pacific Southwest Research Station [PSW]. 1994a.** Change in station directorship announced. For Your Information. 1994(14 February): 1.
- Pacific Southwest Research Station [PSW]. 1994b.** FS annual report spotlights PSW research. For Your Information. 1994(5 December): 1.
- Pacific Southwest Research Station [PSW]. 1994c.** Mid-July set for Mare Island decision. For Your Information. 1994(13 June): 1.
- Pacific Southwest Research Station [PSW]. 1994d.** PSW headquarters to remain at Albany site. For Your Information. 1994(22 August): 1.
- Pacific Southwest Research Station [PSW]. 1994e.** PSW’s Vegetation R&D Program commended. For Your Information. 1994(3 January): 1.
- Pacific Southwest Research Station [PSW]. 1994f.** RWUs in review: conifer silviculture. For Your Information. 1994(22 August): 1–2.
- Pacific Southwest Research Station [PSW]. 1994g.** RWUs in review: forest regeneration research. For Your Information. 1994(3 January): 1–2.
- Pacific Southwest Research Station [PSW]. 1994h.** RWUs on review: wildlife ecosystem research. For Your Information. 1994(14 February): 1–2.
- Pacific Southwest Research Station [PSW]. 1994i.** Station regains fiscal services. For Your Information. 1994(18 January): 1.
- Pacific Southwest Research Station [PSW]. 1994j.** Task force presents plan to Hawaii Governor. For Your Information. 1994(19 September): 1–2.
- Pacific Southwest Research Station [PSW]. 1994k.** Thomas speaks about role of science. For Your Information. 1994(25 April): 1.
- Pacific Southwest Research Station [PSW]. 1994l. USDA reorganization launched.** For Your Information. 1994(24 Oct.): 1–2.
- Pacific Southwest Research Station [PSW]. 1994m. Director’s message.** For Your Information 1994(11 July) 1.

- Pacific Southwest Research Station [PSW]. 1994n.** Jim Space named Station Director of PSW. For Your Information. 1994(28 Feb.): 1–2.
- Pacific Southwest Research Station [PSW]. 1994o.** Director’s message. For Your Information. 1994(25 July): 1–2.
- Pacific Southwest Research Station [PSW]. 1995a.** RWU in review: Hawaii unit under change. For Your Information. 1995(1 May): 1–2.
- Pacific Southwest Research Station [PSW]. 1995b.** RWUs in review: Hawaii units under change. For Your Information. 1995(15 May): 1–2.
- Pacific Southwest Research Station [PSW]. 1995c.** RWUs in review: Hawaii units under change. For Your Information. 1995(30 May): 1–2.
- Pacific Southwest Research Station [PSW]. 1995d.** RWUs in review: Hawaii units under change. For Your Information. 1995(12 June): 1–2.
- Pacific Southwest Research Station [PSW]. 1995e.** RWUs in review: prescribed fire research. For Your Information. 1995(23 January): 1–2.
- Pacific Southwest Research Station [PSW]. 1995f.** Space to chair Sierra Nevada conference. For Your Information. 1995(13 February): 1–2.
- Pacific Southwest Research Station [PSW]. 1995g** FS offers revised reorganization plan. For Your Information. 1995(26 June): 1–2.
- Pacific Southwest Research Station [PSW]. 1995h.** Station budget cuts total \$2.7 million. For Your Information. 1995(21 Aug.): 1.
- Pacific Southwest Research Station [PSW]. 1995i.** “Unfunded” notices sent to employees. For Your Information. 1995(15 Sept.): 1.
- Pacific Southwest Research Station [PSW]. 1995j.** Appropriation bills in conference. For Your Information. 1995(23 Oct.): 1–2.
- Pacific Southwest Research Station [PSW]. 1995k.** Station Director’s message. For Your Information. 1995(18 Dec.): 1.
- Pacific Southwest Research Station [PSW]. 1995l.** WO restructuring sent to Congress. For Your Information. 1995(20 March): 1–2.
- Pacific Southwest Research Station [PSW]. 1995m.** PSW scientists in SNEP “final push.” For Your Information. 1995(23 October): 1–2.
- Pacific Southwest Research Station [PSW]. 1996a.** Station Director’s message. For Your Information. 1996(9 Dec.): 2.

- Pacific Southwest Research Station [PSW]. 1996b.** Year in review at PSW. For Your Information. 1996(12 Nov.): 3–4.
- Pacific Southwest Research Station [PSW]. 1996c.** PSW publications launched online. For Your Information. 1996(25 Nov.): 2–3.
- Pacific Southwest Research Station [PSW]. 1996d.** Dombeck appointed new FS Chief. For Your Information. 1996(23 Dec.): 3–4.
- Pacific Southwest Research Station [PSW]. 1996e.** PSW contributes to President’s Forest Plan. For Your Information. 1996(12 Aug.): 2–3.
- Pacific Southwest Research Station [PSW]. 1997a.** New Station Director offers views. For Your Information. 1997(18 Aug.): 1–2.
- Pacific Southwest Research Station [PSW]. 1997b.** Station’s name becomes “official.” For Your Information. 1997(7 July): 1.
- Pacific Southwest Research Station [PSW]. 1997c.** FS Chief Dombeck visits Bay Area. For Your Information. 1997(17 March): 1–2.
- Pacific Southwest Research Station [PSW]. 1997d.** Holiday message from the Director. For Your Information. 1997(22 Dec.): 1.
- Pacific Southwest Research Station [PSW]. 1997e.** Jim Space announces his retirement. For Your Information. 1997(4 Aug.): 1.
- Pacific Southwest Research Station [PSW]. 1997f.** RM and INT Research Stations merge. For Your Information. 1997(27 May): 1.
- Pacific Southwest Research Station [PSW]. 1997g.** Research in review: Blacks Mountain. For Your Information. 1997(31 March): 1–2.
- Pacific Southwest Research Station [PSW]. 1997h.** Kings River runs in *Forestry Research West*. For Your Information. 1997(29 Sept.): 1.
- Pacific Southwest Research Station [PSW]. 1997i.** Court decides in favor of marbled murrelet. For Your Information. 1997(3 March): 1.
- Pacific Southwest Research Station [PSW]. 1997j.** Changes planned for Albany headquarters. For Your Information. 1997(28 April): 1.
- Pacific Southwest Research Station [PSW]. 1997k.** FS reorganizes the Washington office. For Your Information. 1997(7 July): 1–2.
- Pacific Southwest Research Station [PSW]. 1997l.** New station director offers views. For Your Information. 1997(18 August): 1–2.

- Pacific Southwest Research Station [PSW]. 1997m.** Research in review: Kings River study. For Your Information. 1997(27 May): 1–2.
- Pacific Southwest Research Station [PSW]. 1997n.** FS Chief, ex-Chief offer views. For Your Information. 1997(3 March): 1–2.
- Pacific Southwest Research Station [PSW]. 1998a.** Chief sets agency's course for 21st century. For Your Information. 1998(16 March): 1–2.
- Pacific Southwest Research Station [PSW]. 1998b.** Leaders form framework to manage Sierra. For Your Information. 1998(2 March): 1.
- Pacific Southwest Research Station [PSW]. 1998c.** Chief announces restructuring of WO. For Your Information. 1998(11 May): 1–2.
- Pacific Southwest Research Station [PSW]. 1999a.** Chief urges restoration of land health legacy. For Your Information. 1999(16 Feb.): 1–2.
- Pacific Southwest Research Station [PSW]. 1999b.** Chief urges restoration of land health legacy. For Your Information. 1999(1 March): 1–2.
- Pacific Southwest Research Station [PSW]. 1999c.** Chief urges restoration of land health legacy. For Your Information. 1999(16 March): 1–2.
- Pacific Southwest Research Station [PSW]. 1999d.** USDA scientists report on Forest Service. For Your Information. 1999(29 March): 1.
- Pacific Southwest Research Station [PSW]. 1999e.** Regents approve PSW as tenant at Hilo, Hawaii. For Your Information. 1999(26 April): 1.
- Pacific Southwest Research Station [PSW]. 1999f.** Ziemer named Redwood Sciences Lab Director. For Your Information. 1999(26 April): 1.
- Pacific Southwest Research Station [PSW]. 1999g.** PSW offers proposals for FY 2001 budget. For Your Information. 1999(16 March): 1.
- Pacific Southwest Research Station [PSW]. 1999h.** Station Director's message. For Your Information. 1999(20 Dec.): 1.
- Pacific Southwest Research Station [PSW]. 1999i.** FS to implement President's Roadless Initiative. For Your Information. 1999(18 Oct.): 1.
- Pacific Southwest Research Station [PSW]. 1999j.** In memoriam. For Your Information. 1999(24 May): 1–2.
- Pacific Southwest Research Station [PSW]. 1999k.** In memoriam. For Your Information. 1999(28 June): 3.

Pacific Southwest Research Station [PSW]. 1999l. Retirements scheduled for year's end. For Your Information. 1999(22 Nov.): 1–2.

Pacific Southwest Research Station [PSW]. 1999m. PSW library starts move to Mare Island. For Your Information. 1999(25 Jan.): 1–2.

Pacific Southwest Research Station [PSW]. 1999n. More retirements at year's end. For Your Information. 1999(20 Dec.): 1–2.

Pacific Southwest Research Station [PSW]. 2000. MacDonald, Page retire in new year. For Your Information. 2000(December): 1–2.

Pacific Southwest Research Station [PSW]. 2001a. PSW Station celebrates 75th anniversary on July 1. For Your Information. 2001(May/June): 1–2.

Pacific Southwest Research Station [PSW]. 2001b. Alumni profile: Harry Fowells. Focus on Forestry. 2001(Winter 2001): various.

Pearce, R.B. 1986. Genetic engineering comes to forestry. Forestry Research West. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. 1986(November): 1–6.

Pearce, R.B. 1987a. Caspar Creek: discovering how watersheds respond to logging. Forestry Research West. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. 1987(August): 10–15.

Pearce, R.B. 1987b. Preharvest burning to control post-harvest vegetation. Forestry Research West. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. 1987(December): 11.

Pearce, R.B. 1987c. Shelterwood regeneration of true fir. Forestry Research West. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. 1987(August): 21.

Pearce, R.B. 1988a. Common shrubs of chaparral and related ecosystems. Forestry Research West. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. 1988(June): 25.

Pearce, R.B. 1988b. Trunk implants protect prime firs. Forestry Research West. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. (June): 18–22.

Pearce, R.B. 1988c. Where deer and cattle roam. Forestry Research West. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. 1988(September): 10–16.

- Person, H. 1933.** Redwood has few insect enemies. *Forest Worker*. 9: 15–16.
- Person, H. 1937.** Commercial planting on redwood cut-over lands. *Agric. Circ.* 434. Washington, DC: U.S. Department of Agriculture. 39 p.
- Person, H. 1939.** Problem analysis for silvicultural investigations in the redwood region. Berkeley, CA: U.S. Department of Agriculture, Forest Service, California Forest and Range Experiment Station.
- Peterson, M.R. 2000.** Discussion. Does the Forest Service have a future? In: Sedjo, R.A., ed. *A vision for the U.S. Forest Service: goals for its next century*. Washington, DC: Resources for the Future: 191–204.
- Pinchot, G. 1898.** Report of the Chief of the Division of Forestry. Washington, DC: U.S. Department of Agriculture, Division of Forestry. 4 p.
- Pinchot, G. 1900.** Report of the Forester. Washington, DC: U.S. Department of Agriculture, Division of Forestry.
- Pinchot, G. 1901.** Report of the Forester. Washington, DC: U.S. Department of Agriculture, Bureau of Forestry.
- Pinchot, G. 1902.** Report of the Forester. Washington, DC: U.S. Department of Agriculture, Bureau of Forestry.
- Pinchot, G. 1903.** Report of the Forester. Washington, DC: U.S. Department of Agriculture, Bureau of Forestry.
- Pinchot, G. 1904.** Report of the Forester. Washington, DC: U.S. Department of Agriculture, Bureau of Forestry.
- Pinchot, G. 1905.** Report of the Forester for 1905. Washington, DC: U.S. Department of Agriculture, Forest Service.
- Pinchot, G. 1906.** Report of the Forester for 1906. Washington, DC: U.S. Department of Agriculture, Forest Service.
- Pinchot, G. 1907.** Report of the Forester for 1907. Washington, DC: U.S. Department of Agriculture, Forest Service.
- Pinchot, G. 1908.** Report of the Forester for 1908. Washington, DC: U.S. Department of Agriculture, Forest Service.
- Pinchot, G. 1909.** Report of the Forester for 1909. Washington, DC: U.S. Department of Agriculture, Forest Service.
- Piper, R.U. 1855.** *The trees of America*. Boston, MA: W. White.

- Pratt, M.B. 1931.** The California State Forest Service: its growth and its objectives. *Journal of Forestry*. 29(April): 497–504.
- Prevedel, D.A.; Johnson, C.M. 2005.** Beginnings of range management: Albert F. Potter, first Chief of Grazing, U.S. Forest Service, and a photographic comparison of his 1902 forest reserve survey in Utah with conditions 100 years later. R4-VM 2005-01. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Region.
- Price, F. 1948.** Record of Civilian Public Service Camp Program in California National Forest Region, 1942–1946. On file with: Archives, U.S. Department of Agriculture, Forest Service, Pacific Southwest Region, Vallejo, CA.
- Price, R. 1976.** History of Forest Service research in the central and southern Rocky Mountain Regions, 1908–1975. Gen. Tech. Rep. RM-27. Fort Collins, Co.: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. p.
- Ralph, C.J.; Hunt, G.L., Jr.; Piatt, J.F., tech eds. 1995.** Ecology and conservation of the marbled murrelet. Gen. Tech. Rep. PSW-GTR-152. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 420 p.
- Reineke, L.H.; Bruce, D. 1931.** The correlation-alinement charts in forest research. Tech. Bull. 210. Washington, DC: U.S. Department of Agriculture. 88 p.
- Renner, F.G. 1938.** Selected bibliography on management of western ranges. Misc. Publ. 281. Washington, DC: U.S. Department of Agriculture.
- Rice, R.B.; Bullough, W.A.; Orsi, R.J. 1996.** The elusive Eden: a new history of California. 2nd ed. New York: McGraw Hill Companies, Inc.
- Righter, F.L. 1954** Forest tree improvement research in California. *Journal of Forestry*. 52(9): 681–682.
- Ritchie, M.W.; Powers, R.F. 1993.** User's guide to SYSTUM-1 (Version 2.0): a simulator of growth trends in young stands under management in California and Oregon. Gen. Tech. Rep. PSW-GTR-147. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 45 p.
- Robbins, W.G. 1985.** A history of national, state, & private cooperation. Lincoln, NE: University of Nebraska Press.

Robinson, J.W. 1980. A history of the Dalton and San Dimas watersheds and the San Dimas Experimental Forest. *Mt. San Antonio Historian*. 16(Spring): 46–77; (Summer): 106–137.

Rodgers, A.D., III. 1968. Bernhard Eduard Fernow: a story of North American forestry. Durham, NC: Forest History Society.

Roth, F. 1899. The work in timber physics in the Division of Forestry. In: Fernow, B.E., ed. Report upon the forestry investigations of the U.S. Department of Agriculture, 1877–1898. House Doc. No. 181, 55th Cong., 3^d sess.: 330–395.

Rowley, W.D. 1985. U.S. Forest Service grazing and rangelands: a history. College Station, TX: Texas A&M University Press.

Rowley, W.D. 1999. Historical consideration in the development of range science. In: Steen, H.K., ed. Forest and wildlife science in America: a history. Durham, NC: Forest History Society: 230–260.

Ruth, L. 2000. Changing course: conservation and controversy in the national forests of the Sierra Nevada. In: Sedjo, R.A., ed. A vision for the U.S. Forest Service: goals for its next century. Washington, DC: Resources for the Future: 213–256.

Salman, K.A.; Bongberg, J.W. 1942. Logging high risk trees to control insects in the pine stands of northeastern California. *Journal of Forestry*. 40(7): 533–539.

Sample, V.A. 2000. The more things change...the challenge continues. In: Sedjo, R.A., ed. A vision for the U.S. Forest Service: goals for its next century. Washington, DC: Resources for the Future: 205–212.

Sampson, A.W. 1913. Relation of grazing to timber production, Shasta National Forest. USDA Forest Service Investigation. 2: 18–24.

Sanderson, H.R.; Duncan, D.A. 1985. Publications from the San Joaquin Experimental Range, 1935–1965. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station.

Sargent, C.S. 1884. Report on the forests of North America (exclusive of Mexico). Tenth U.S. Census. Washington, DC: U.S. Department of the Interior, Census Bureau.

Schrepfer, S.R. 1983. The fight to save the redwoods: a history of environmental reform, 1917–1978. Madison, WI: University of Wisconsin Press.

- Sedjo, R.A. 2000.** Does the Forest Service have a future? A thought-provoking view. In: Sedjo, R.A., ed. A vision for the U.S. Forest Service: goals for its next century. Washington, DC: Resources for the Future: 176–190.
- Show, S.B. [N.d.].** The development of Forest Service organization, personnel and administration. Unpublished manuscript. On file with: Bancroft Library, University of California, Berkeley, CA.
- Show, S.B. 1924a.** The management of forest properties in the California pine region as a problem in applied ecology. *Scientific Monthly*. 9(November): 548–551.
- Show, S.B. 1924b.** Research work of the Forest Service in California. Lecture at U.C. Berkeley. 7 April 1924. On file with: S.B. Show, Box 22452, Accession No. 95-51-D0151, Federal Records Center, San Bruno, CA.
- Show, S.B. 1924c.** Some results of experimental forest planting in northern California. *Ecology*. 5(1): 83–94.
- Show, S.B. 1925.** Yield capacities of the pure yellow pine type on the east slope of the Sierra Nevada mountains in California. *Journal of Agricultural Research*. 31(12): 1121–1135.
- Show, S.B. 1930.** Forest nursery and planting practice in the California pine region. Circular 92. Washington, DC: U.S. Department of Agriculture. 74 p.
- Show S.B. 1932.** Timber growing and logging practice in the coast redwood region of California. Tech. Bull. 283. Washington, DC: U.S. Department of Agriculture.
- Show, S.B. 1965.** National forests in California: an interview with S. Bevier Show by Amelia Roberts Fry. Unpublished manuscript. On file with: Bancroft Library, University of California, Berkeley, CA.
- Show, S.B.; Kotok, E.I. 1923a.** Forest fires in California, 1911–1920: an analytical study. Circular 243. Washington, DC: U.S. Department of Agriculture.
- Show, S.B.; Kotok, E.I. 1923b.** The occurrence of lightning storms in relation to forest fires in California. *Monthly Weather Review*. 54(4): 175–180.
- Show, S.B.; Kotok, E.I. 1924.** The role of fire in the California pine forests. Bull. 1294. Washington, DC: U.S. Department of Agriculture. 80 p.
- Show, S.B.; Kotok, E.I. 1925.** Fire and the forest (California pine region). Circ. 358. Washington, DC: U.S. Department of Agriculture.

- Show, S.B.; Kotok, E.I. 1929.** Cover type and fire control in the national forests of northern California. Circular 1495. Washington, DC: U.S. Department of Agriculture.
- Show, S.B.; Kotok, E.I. 1930.** The determination of hour control for adequate fire protection in the major cover types of the California pine region. Tech. Bull. 208. Washington, DC: U.S. Department of Agriculture.
- Show, S.B.; Kotok, E.I. 1937.** Planning, constructing, and operating forest-fire lookout systems in California. USDA Circular 449. Washington, DC: U.S. Department of Agriculture.
- Show, S.B.; Kotok, E.I. 1938.** Principles of forest-fire detection on the national forests of northern California. Tech. Bull. 574. Washington, DC: U.S. Department of Agriculture.
- Silcox, F.A. 1934.** Report of the Forester. Washington, DC: U.S. Department of Agriculture, Forest Service.
- Silcox, F.A. 1935a.** Report of the Chief of the Forest Service. Washington, DC: U.S. Department of Agriculture, Forest Service.
- Silcox, F.A. 1935b.** Science in the service of society. Speech delivered at the semi-centennial celebration of the Minnesota Agricultural Experiment Station, 15 June 1935. On file: F.A. Silcox, Box 22452, Accession No. 95-51-D0151, Federal Records Center, San Bruno, CA.
- Silcox, F.A. 1936.** Report of the Chief of the Forest Service. Washington, DC: U.S. Department of Agriculture, Forest Service.
- Sinclair, J.D. 1936.** Watershed management research. Trails Magazine. 1936(Spring): 17, 20.
- Sinclair, J.D. 1960.** Watershed management research in southern California's brush covered mountains. Journal of Forestry. 58(April): 266–268.
- Sinclair, J.D.; Hamilton, E.L.; Waite, M.N. 1958.** A guide to the San Dimas Experimental Forest. On file: Alphabetical author's publications: Boxes 1232521-1232526, Accession No. 95-63-0532, Federal Records Center, San Bruno, CA.
- Skok, R.A. 1999.** Forest science at universities in the United States. In: Steen, H.K., ed. Forest and wildlife science in America: a history. Durham, NC: Forest History Society: 129–148.
- Smith, D.H. 1930.** The Forest Service: its history, activities and organization. Washington, DC: The Brookings Institution. 268 p.

- Starr, F. 1866.** American forests: their destruction and preservation. In: Report of the Commissioner of Agriculture for the year 1865. Washington, DC: U.S. Department of Agriculture: 210-235.
- Steen, H.K. 1976.** The U.S. Forest Service: a history. Seattle, WA: University of Washington Press. 356 p.
- Steen, H.K., ed. 1994.** View from the top: Forest Service research by Arnold, R. Keith, M.B. Dickerman, and Robert E. Buckman. Durham, NC: Forest History Society.
- Steen, H.K. 1998.** Forest Service research: finding answers to conservation's questions. Durham, NC: Forest History Society. 102 p.
- Steen, H.K. 2004.** The U.S. Forest Service: a history. Centennial ed. Durham, NC: Forest History Society. 356 p.
- Stewart, R. 2004.** PSW: wood, water, fire, recreation, and people: the contributions of research. Paper presented at Regional Centennial Forum, USDA Forest Service, Pacific Southwest Region, Sacramento, July 1. On file with: U.S. West Research, Inc., 2395 Fisher Lane, Salt Lake City, UT 84109.
- Stockwell, P.; Righter, F.I. 1947.** Hybrid forest trees. In: Yearbook of Agriculture 1943–1947. Washington, DC: U.S. Department of Agriculture: 465–472.
- Stockwell, P.; Walker, C. 1948.** The Institute of Forest Genetics. Parks and Recreation. 31(7): 388–391.
- Stone, L.C. 1968.** The Institute of Forest Genetics: a legacy of good breeding. Forest History. 12(October): 20–29.
- Storey, H.C. 1975.** History of Forest Service Research: development of a national program. Unpublished manuscript. On file with: Rocky Mountain Research Station Library, Ogden, UT.
- Storey, H.C. 1982.** The San Dimas Experimental Forest: a 50-year review. On file: Box 6, Pacific Southwest Research Station Archives, Pacific Southwest Research Station, Albany, CA.
- Stuart, R.Y. 1928.** Report of the Forester. Washington, DC: U.S. Department of Agriculture, Forest Service.
- Stuart, R.Y. 1929.** Report of the Forester. Washington, DC: U.S. Department of Agriculture, Forest Service.

- Stuart, R.Y. 1930.** Report of the Forester. Washington, DC: U.S. Department of Agriculture, Forest Service.
- Stuart, R.Y. 1931.** Report of the Forester. Washington, DC: U.S. Department of Agriculture, Forest Service.
- Stuart, R.Y. 1932.** Report of the Forester. Washington, DC: U.S. Department of Agriculture, Forest Service.
- Stuart, R.Y. 1933.** Report of the Forester. Washington, DC: U.S. Department of Agriculture, Forest Service.
- Sudworth, G.B. 1897.** Nomenclature of the arborescent flora of the United States. Washington, DC: Government Printing Office.
- Sudworth, G.B. 1927.** Check list of the forest trees of the United States. Misc. Circ. 92. Washington, DC: U.S. Department of Agriculture. 295 p.
- Talbot, M.W. 1940.** Scope, problems, and objectives of the several divisions of the California Forest and Range Experiment Station. On file with: Research Program General, 1939 to 1952, Box 25986, Accession No. 95-59-B0496, Federal Records Center, San Bruno, CA.
- Talbot, M.W. 1941.** C.L. Hill retires. California Ranger: Region 5. 12(7): 2.
- Talbot, M.W. 1954.** Some recent developments in California range management. Journal of Forestry. 52(8): 597–598.
- Territory of Hawaii, Division of Forestry. 1914 (2 February).** Letter from Ralph Hosmer to District Forester. On file with: Ralph S. Hosmer, Boxes 24721-24726, Accession No. 95-54-760, Federal Records Center, San Bruno, CA.
- Thomas, J.W. 2000.** What now? From a former Chief of the Forest Service. In: Sedjo, R.A., ed. A vision for the U.S. Forest Service: goals for its next century. Washington, DC: Resources for the Future: 10–43.
- Thomas, J.W.; Forsman, E.D.; Lint, J.B.; Meslow, E.C.; Noon, B.B.; Verner, J. 1990.** A conservation strategy for the northern spotted owl. Portland, OR: U.S. Department of Agriculture, Forest Service.
- Thorton, M.V. 1994.** An overview of the origin and development of CDF. Archaeological Rep. 17. Sacramento, CA: California Department of Forestry and Fire Protection Archaeology Office.

- Tilden, P.E. 1983.** History of the Miami Forest Insect Laboratory. Unpublished manuscript. On file with: Box 6, Pacific Southwest Research Station Archives, Pacific Southwest Research Station, Albany, CA.
- Toumey, J.W. 1919.** Need for a unified forest research program. *Journal of Forestry*. 27(March): 281–289.
- Twiss, R.H.; Streatfield, D.; Kojan, E.; Magill, A.W. [N.d.] (circa 1969)** Nicasio: hidden valley in transition. San Rafael, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station; Marin County Planning Department. 50 p. plus illustrations.
- U.S. Congress. 1958.** Forest fire control in southern California. Washington, DC: House committee on interior and insular affairs.
- U.S. Department of Agriculture, Bureau of Entomology and Plant Quarantine [USDA BEPQ]. 1939.** Forest insect research: California Region. [Pamphlet]. Berkeley, CA: Forest Insect Laboratory. On file with: Rocky Mountain Research Station Library, Ogden, UT.
- U.S. Department of Agriculture, Forest Service [USDA FS]. [N.d.].** Establishment report: Teakettle Creek Research Natural Area within the Teakettle Creek Experimental Forest, Sierra National Forest, Fresno County, California. On file with: Box 1, Pacific Southwest Research Station Archives, Albany, CA.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1910.** Proceedings of the Supervisor's meeting, District 5. San Francisco, California, December 13–19. On file: Box 1: Historic Manuscripts, 1902–1913, Record Group 95, National Archive Record Center, San Bruno, CA.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1912.** Proceedings of the Supervisor's meeting, District 5. San Francisco, California, February. On file with: USDA Forest Service, Pacific Southwest Region Archives, Vallejo, CA.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1922.** Annual investigative program, District 5. On file with: Box 4, Pacific Southwest Research Station Archives, Pacific Southwest Research Station, Albany, CA.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1923.** Annual investigative report for 1923 and program for 1924, District 5. On file with: Box 4, Pacific Southwest Research Station Archives, Albany, CA.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1924a.** Annual investigative report for 1924 and investigative program for 1925, District 5. On file with: Box 4, Pacific Southwest Research Station Archives, Albany, CA.

- U.S. Department of Agriculture, Forest Service [USDA FS]. 1924b.** The Madison Conference: proceedings of the Forest Experiment Station conference, Forest Products Laboratory, Madison, Wisconsin, March 10–22, 1924. On file with: Box 2, Pacific Southwest Research Station Archives, Albany, CA.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1927.** Annual investigative report for 1926 and investigative program for 1927, District 5, January 24, 1927. On file with: Pacific Southwest Region Archives, Vallejo, CA.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1928.** Report—District investigative meeting—District 5, March 12 to 14, 1928. On file with: Rocky Mountain Research Station Library, Ogden, UT.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1930.** Forest research in the California Region 1929–1930: annual investigative report for 1929 and programs for 1930, District Investigative Committee Meeting, January 27 to 29, 1930. On file with: Rocky Mountain Research Station Library, Ogden, UT.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1931.** Forest research in the California Region, 1930–1931: report of Region 5 Investigative Committee Meeting, March 2 to 4, 1931. On file with: Rocky Mountain Research Station Library, Ogden, UT.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1932a.** Copeland Resolution report: Senate Resolution 175. Pacific Southwest Region Archives, Vallejo, CA.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1932b.** Forest research in the California Region, 1931–1932: report of Region 5 Investigative Committee Meeting, January 18 to 20, 1932. On file with: Rocky Mountain Research Station Library, Ogden, UT.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1932c.** Region 5 Investigative Committee: minutes of meeting of January 18–20, 1932. On file with: Research Programs, Meetings, Annual Investigative, 1926–1952, Box 25986, Accession No. 95-59-B0496, Federal Records Center, San Bruno, CA.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1933.** A national plan for American Forestry. Report to the 73rd Congress, 1st session, Senate Doc. 12. Washington, DC. 1677 p. 2 vols.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1934.** Branch of Research Forest Experiment Station monthly research reports. Berkeley, CA: Branch of Research.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1935. Branch of Research Forest Experiment Station monthly research reports. Berkeley, CA: Branch of Research.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1936. The western range: a great but neglected natural resource. Sen. Doc. 199, 74th Congress, 2nd session. Washington, DC: Government Printing Office

U.S. Department of Agriculture, Forest Service [USDA FS]. 1937a. Principles of forest-fire detection on the national forests of northern California.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1937b. Region 5: fire control handbook.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1937c. Report of the Chief of the Forest Service. Washington, DC.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1937d. The work of the California Forest and Range Experiment Station 1936–1937: a condensed summary of the station’s annual report and plan with helpful collateral information. Berkeley, CA: California Forest and Range Experiment Station.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1938a. The Blacks Mountain Experimental Forest of the California Forest and Range Experiment Station. Berkeley, CA: California Forest and Range Experiment Station. On file with: Blacks Mountain Experimental Station, Box 22450, Accession No. 95-51-D0151, Federal Records Center, San Bruno, CA.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1938b. Report of the Chief of the Forest Service. Washington, DC.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1939a. Annual report of the California Forest and Range Experiment Station, 1938–1939. Berkeley, CA: California Forest and Range Experiment Station.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1939b. Memorandum from C.L. Hill to Director Kotok, 9 October 1939. On file with: Research Program General, 1939 to 1952, Box 25986, Accession No. 95-59-B0496, Federal Records Center, San Bruno, CA.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1940a. Annual report: California Forest and Range Experiment Station, 1939–1940. Berkeley, CA: California Forest and Range Experiment Station.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1940b. Branch stations of the California Forest and Experiment Station. On file with: Research Program General, 1939 to 1952, Box 25986, Accession No. 95-59-B0496, Federal Records Center, San Bruno, CA.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1940c. The problems of California. On file with: California Forest and Range Experiment Station Articles, Boxes 761147-761158, Accession No. 95-59-0744, Federal Records Center, San Bruno, CA.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1940d. Report of the Chief of the Forest Service. Washington, DC.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1941a. Annual report: California Forest and Range Experiment Station, 1940–1941. Berkeley, CA: California Forest and Range Experiment Station.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1941b. Forests and people: report of the Chief of the Forest Service. Washington, DC.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1941c. A planning basis for adequate fire control on the southern California national forests.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1942a. Annual report: California Forest and Range Experiment Station, 1941–1942. Berkeley, CA: California Forest and Range Experiment Station.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1942b. Report on Challenge Experimental Forest Plumas National Forest, California. On file with: Box 1, Pacific Southwest Research Station Archives, Albany, CA.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1943. Annual report: California Forest and Range Experiment Station, 1943. Berkeley, CA: California Forest and Range Experiment Station.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1944. Annual report: California Forest and Range Experiment Station. Berkeley, CA: California Forest and Range Experiment Station.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1945. Departmental war records project, California Forest and Range Experiment Station, 1941–1945. On file with: Box 761134, Accession No. 95-57-0268, Federal Records Center, San Bruno, CA.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1946. Annual report: California Forest and Range Experiment Station. Berkeley, CA: California Forest and Range Experiment Station.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1947. Annual report: California Forest and Range Experiment Station. Berkeley, CA: California Forest and Range Experiment Station.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1948a. Annual report: California Forest and Range Experiment Station, Berkeley, CA: California Forest and Range Experiment Station.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1948b. Tree breeding at the Institute of Forest Genetics. Misc. Publ. 659. Washington DC.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1949a. Annual report: California Forest and Range Experiment Station, Berkeley, CA: California Forest and Range Experiment Station.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1949b. Reappraisal of research program of the California Forest and Range Experiment Station. On file with: Research Program General, 1939 to 1952, Box 25986, Accession No. 95-59-B0496, Federal Records Center, San Bruno, CA.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1950. The forest research program and summary. On file with: Research Program General, 1939 to 1952, Box 25986, Accession No. 95-59-B0496, Federal Records Center, San Bruno, CA.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1951a. Annual report: California Forest and Range Experiment Station, Berkeley, CA: California Forest and Range Experiment Station.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1951b. Cooperation in forest and range management research. On file: Research Program, General, 1939–1952, Box 25986 Accession No. 95-59-B0496, Federal Records Center, San Bruno, CA.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1951c. Reappraisal of research program of the California Forest and Range Experiment Station. September. On file: Research Program, General, 1939–1952, Box 25986 Accession No. 95-59-B0496, Federal Records Center, San Bruno, CA.

- U.S. Department of Agriculture, Forest Service [USDA FS]. 1951d.** Research program conference. On file with: Research Program, Meetings, Annual Investigative, 1926–1952, Box 25986 Accession No. 95-59-B0496, Federal Records Center, San Bruno, CA.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1951e.** Visitors' guide to the Institute of Forest Genetics. Misc. Pap. 5. Berkeley, CA: California Forest and Range Experiment Station.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1951f.** The work of the California Forest and Range Experiment Station. On file with: Research Program, Meetings, Annual Investigative, 1926–1952, Box 25986 Accession No. 95-59-B0496, Federal Records Center, San Bruno, CA.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1951g.** Cooperation in Forest and Range Management Research. Washington, DC: U.S. Department of Agriculture, Forest Service.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1952a.** Annual report: California Forest and Range Experiment Station, Berkeley, CA: California Forest and Range Experiment Station.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1952b.** The work of the California Forest and Range Experiment Station. On file with: Loose material, Marilyn Hartley office. Pacific Southwest Research Station Archives, Albany, CA.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1953.** Annual report: California Forest and Range Experiment Station, Berkeley, CA: California Forest and Range Experiment Station.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1954a.** Annual report: Forest Research in California. Berkeley, CA: California Forest and Range Experiment Station.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1954b.** The Harvey Valley Experimental Range. On file with: Pacific Southwest Region Archives, Vallejo, CA.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1955a.** Annual report: forest research in California. Berkeley, CA: California Forest and Range Experiment Station.

- U.S. Department of Agriculture, Forest Service [USDA FS]. 1955b.** Biographical data for George M. Jemison. On file with: Box 7, Pacific Southwest Research Station Archives, Albany, CA.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1955c.** Forest statistics for California. Forest Resource Survey Report. Berkeley, CA: California Forest and Range Experiment Station.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1956.** Annual report: forest research in California. Berkeley, CA: California Forest and Range Experiment Station.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1957a.** Annual report: forest research in California. Berkeley, CA: California Forest and Range Experiment Station.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1957b.** Report on proposed additions to the Challenge Experimental Forest. On file with: Box 1, Pacific Southwest Research Station Archives, Albany, CA.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1958a.** Annual report: cooperation in wildland research. Berkeley, CA: California Forest and Range Experiment Station.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1958b.** Annual report supplement: a guide to the field laboratories of the California Forest and Range Experiment Station. Berkeley, CA: California Forest and Range Experiment Station.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1958c.** Federal-state partnership in wildland research: projects, reports, facilities. On file with: Box 2, Pacific Southwest Research Station Archives, Albany, CA.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1958d.** Timber resources for America's future. Res. Rep. 14. Washington, DC. 713 p.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1959a.** Annual report: Pacific Southwest Forest and Range Experiment Station. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1959b.** Guide to Susanville Research Center. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station.

- U.S. Department of Agriculture, Forest Service [USDA FS]. [Circa 1960].** Pacific Southwest Forest and Range Experiment Station. [Pamphlet]. Berkeley, California. On file with: Box 7, Pacific Southwest Research Station Archives, Albany, CA.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1960a.** Annual report: Pacific Southwest Forest and Range Experiment Station. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1960b.** Research at the San Joaquin Experimental Range. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1961.** Annual report: Pacific Southwest Forest and Range Experiment Station. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1962.** Annual report: Pacific Southwest Forest and Range Experiment Station. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1963.** Annual report: Pacific Southwest Forest and Range Experiment Station. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1964a.** Annual report: Pacific Southwest Forest and Range Experiment Station. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1964b.** War disaster plan for Region 5 and Pacific Southwest Forest and Range Experiment Station. Washington, DC.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1965a.** Evaluation of chemicals for control of forest insects—a research and development project of the Pacific Southwest Forest and Range Experiment Station. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1965b.** Forestry research—a report from John R. McGuire, Director. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1965c.** Research at the Institute of Forest Genetics: a bibliography, 1927–1965. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station.

- U.S. Department of Agriculture, Forest Service [USDA FS]. 1966a.** Forestry research in 1966: Pacific Southwest Forest and Range Experiment Station. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1966b.** Stopping the big ones...through fire research. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1967.** 1967 forestry research: Pacific Southwest Forest and Range Experiment Station. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1968a.** Central Sierra Snow Laboratory. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1968b.** Institute of Forest Genetics, Placerville, California. [Pamphlet]. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1968c.** Research progress 1968: Pacific Southwest Forest and Range Experiment Station. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1968d.** Zectran—for control of spruce budworm. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1968e.** Report of general integrating inspection: Pacific Southwest, June–July 1968. On file with: Pacific Southwest Region Archives, Vallejo, CA.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1969a.** Forest Service research program for the seventies. Washington, DC.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1969b.** Research progress 1968: Pacific Southwest Forest and Range Experiment Station. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1970.** Framework for the future: Forest Service objectives and policy guides. Washington, DC.

- U.S. Department of Agriculture, Forest Service [USDA FS]. 1971.** Forest fire research at the Pacific Southwest Forest and Range Experiment Station. [Pamphlet]. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1972a.** Snow research in the Sierra Nevada, California. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1972b.** Welcome to the Institute of Forest Genetics, Placerville, California. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1974.** FIRESCOPE: an action plan for the wildlands of southern California. [Pamphlet]. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1977a.** Hawaii forest insect and disease research. PSW-2207. On file with: Box 7, Pacific Southwest Research Station Archives, Albany, CA.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1977b.** Long range plan for the Teakettle Creek Experimental Forest. Unpublished manuscript. On file with: Box 1, Pacific Southwest Research Station Archives, Albany, CA.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1977c.** Maintenance of native Hawaiian forest ecosystems. PSW-1752. On file with: Box 7, Pacific Southwest Research Station Archives, Albany, CA.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1977d.** Pacific Islands (Territories) forestry research. PSW-1252. On file with: Box 7, Pacific Southwest Research Station Archives, Albany, CA.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1977e.** Timber and watershed management research in Hawaii. PSW-1251. On file with: Box 7, Pacific Southwest Research Station Archives, Albany, CA.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1977f.** Urban Forestry Research Work Unit. PSW-1902. On file with: Box 7, Pacific Southwest Research Station Archives, Albany, CA.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1978.** Field evaluation of chemical insecticides. PSW-2206. On file with: Box 7, Pacific Southwest Research Station Archives, Albany, CA.

- U.S. Department of Agriculture, Forest Service [USDA FS]. 1980a.** Genetics of western forest trees. PSW-1401. On file with: Box 7, Pacific Southwest Research Station Archives, Albany, CA.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1980b.** Pacific Islands (Territories) forestry research. PSW-1252. On file with: Box 7, Pacific Southwest Research Station Archives, Albany, CA.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1984.** Research for tomorrow's forests: 1983 research accomplishments. Washington, DC: U.S. Department of Agriculture, Forest Service.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1985.** Advancing knowledge of forests and rangelands: 1984 research accomplishments. Washington, DC.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1986a.** Making our forests and rangelands more productive: 1985 research accomplishments. Washington, DC: U.S. Department of Agriculture, Forest Service. 177 p.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1986b.** Central Sierra Snow Laboratory, Forest Service, USDA, Soda Springs, California. Marilyn Hartley office files (loose), Pacific Southwest Research Station Archives, Albany, CA.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1987.** Protecting and enhancing America's forests and rangelands: 1986 research accomplishments. Washington, DC.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1992.** Research attainment report: fiscal year 1992. On file with: Pacific Southwest Research Station Archives, Albany, CA.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1993.** Research attainment report: fiscal year 1993. Pacific Southwest Research Station Archives, Albany, CA.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1994.** Research attainment report: fiscal year 1994. Pacific Southwest Research Station Archives, Albany, CA.
- U.S. Department of Agriculture, Forest Service [USDA FS]. 1995.** Research attainment report: fiscal year 1995. Pacific Southwest Research Station Archives, Albany, CA.

U.S. Department of Agriculture, Forest Service [USDA FS]. 1998. Research attainment report: fiscal year 1997. Pacific Southwest Research Station Archives, Albany, CA.

Verner, J.; Boss, A.S., tech. coord. 1980. California wildlife and their habitats: Western Sierra Nevada. Gen. Tech. Rep. PSW-37. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station.

Verner, J.; McKelvey, K.S.; Noon, B.R.; Gutiérrez, R.J.; Gould, G.I., Jr.; Beck, T.W., tech. coords. 1992. The California spotted owl: a technical assessment of its current status. Gen. Tech. Rep. PSW-GTR-133. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 285 p.

Vitas, G. 1966. General functional inspection (A&E) report: California Region and more briefly the Pacific Southwest Forest and Range Experiment Station. On file with: Pacific Southwest Region Archives, Vallejo, CA.

Wagar, J.A. 1985. SOLPLOT: an aid to controlling sunlight and shade. Forestry Research West. 1985(April): 5–7.

Wallace, H. 1931. A national plan for American forestry. The report of the Forest Service of the Agricultural Department on the forest problem of the United States. 73rd Congress, 1st Session, Senate Doc. No. 12, 2 vol. Washington, DC: Government Printing Office. 1677 p.

Watts, L.F. 1951. Edward Norfolk Munns. Journal of Forestry. 49(November): 798–799.

Watts, L.F.; Stewart, G.; Connaughton, C.; Palmer, L.J.; Talbot, M.W. 1936. The management of range lands. In: The western range. Sen. Doc. 199, 74th Congress, 2nd session. Washington, DC: Government Printing Office: 501–502.

Weeks, D.; Wieslander, A.E.; Hill, C.L. 1934. The utilization of Eldorado County land. University of California Bulletin 572. Berkeley, CA: Giannini Foundation.

Whitney, J.D. 1869. The Yosemite book. New York: New York Lithographing, Engraving, and Printing Co.

Wickman, B.E. 2005. Harry E. Burke and John M. Miller: pioneers in western forest entomology. Gen. Tech. Rep. PNW-GTR-638. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 163 p.

- Wieslander, A.E. 1935.** First steps of the forest survey in California. *Journal of Forestry*. 33(10): 877–884.
- Wieslander, A.E. 1986.** A.E. Wieslander, California forester: mapper of wildland vegetation and soils (an oral history conducted in 1985 by Ann Lange). Berkeley, CA: Regional Oral History Office, Bancroft Library, University of California. 316 p.
- Williams, M. 2000.** The USDA Forest Service—the first century. Washington, DC: U.S. Department of Agriculture, Forest Service.
- Williams, M. 2004.** The origin and construction of knowledge. *Environment and History*. 10(May): 127–131.
- Wilm, H.G. 1946.** The status of watershed management concepts. *Journal of Forestry*. 44(November): 968–971.
- Wilson, C.C. 1956.** HELITACK. On file with: Alphabetical author's publications: Boxes 1232521-1232526, Accession No. 95-63-0532, Federal Records Center, San Bruno, CA.
- Wilson, C.C. 1957.** A bird's eye view of forest fire research in the United States. On file with: Alphabetical author's publications: Boxes 1232521–1232526, Accession No. 95-63-0532, Federal Records Center, San Bruno, CA.
- Wilson, C.C. 1958.** Firefighting aircraft—the new look in forest fire control. On file with: Alphabetical author's publications: Boxes 1232521–1232526, Accession No. 95-63-0532, Federal Records Center, San Bruno, CA.
- Wilson, C.C. 1976.** A semi-centennial almanac of forest fire research in California. On file with: Box 6. Pacific Southwest Research Station Archives, Pacific Southwest Research Station, Albany, CA.
- Wilson, C.C. 1984.** History of the development of the fire research program in California. On file with: Boxes 6 and 8. Pacific Southwest Research Station Archives, Albany, CA.
- Wilson, C.C.; Davis, J.B. 1988.** Forest Fire Laboratory at Riverside and fire research in California: past, present, and future. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station.
- Wood, M. 1975a.** Imagery may aid wildland inventory. *Forestry Research: What's New in the West*. Pacific Southwest Forest and Range Experiment Station. 1975(September): 11–12.

- Wood, M. 1975b.** Managing true fir in California. Forestry Research: What's New in the West. Pacific Southwest Forest and Range Experiment Station. 1975(December): 4–6.
- Wood, M. 1978a.** Developing alternatives for California's chaparral. Forestry Research: What's New in the West. Pacific Southwest Forest and Range Experiment Station. 1978(October): 12–16.
- Wood, M. 1978b.** Managing forests on unstable sands. Forestry Research: What's New in the West. Pacific Southwest Forest and Range Experiment Station. 1978(July): 1–5.
- Wood, M. 1979a.** California researchers develop true fir management guidelines. Forestry Research West. Pacific Southwest Forest and Range Experiment Station. 1979(August): 10–13.
- Wood, M. 1979b.** Scientists "voiceprint" forest birds. Forestry Research West. Pacific Southwest Forest and Range Experiment Station. 1979(November): 1–4.
- Wood, M. 1979c.** WESTFORNET aids wildland managers. Forestry Research West. Pacific Southwest Forest and Range Experiment Station. 1979(January): 4–6.
- Wood, M. 1980a.** Forestry challenges in Hawaii and Micronesia. Forestry Research West. Pacific Southwest Forest and Range Experiment Station. 1980(February): 8–11.
- Wood, M. 1980b.** Managing Sierra Nevada wildlife habitat. Forestry Research West. Pacific Southwest Forest and Range Experiment Station. 1980(May): 4–7.
- Wood, M. 1980c.** Risk-rating systems developed for firs. Forestry Research West. Pacific Southwest Forest and Range Experiment Station. 1980(November): 12–14.
- Wood, M. 1980d.** Stopping seed and cone insects. Forestry Research West. Pacific Southwest Forest and Range Experiment Station. 1980(August): 8–11.
- Wood, M. 1981a.** Ozone-damaged forests studied in California. Forestry Research West. Pacific Southwest Forest and Range Experiment Station. 1981(June): 10–13.
- Wood, M. 1981b.** Researchers evaluate insecticides. Forestry Research West. Pacific Southwest Forest and Range Experiment Station. 1981(September): 1–5.
- Wood, M. 1981c.** Studies show strength of tree roots. Forestry Research West. Pacific Southwest Forest and Range Experiment Station. 1981(March): 6–9.

- Wood, M. 1982a.** Classifying plant communities—a new way. Forestry Research West. Pacific Southwest Forest and Range Experiment Station. 1982(June): 8–11.
- Wood, M. 1982b.** Is your fire management program “economically efficient?” Forestry Research West. Pacific Southwest Forest and Range Experiment Station. 1982(September): 5–9.
- Wood, M. 1982c.** Managing California’s young-growth forests. Forestry Research West. Pacific Southwest Forest and Range Experiment Station. 1982(February): 11–14.
- Wood, M. 1983.** Growing successful seedlings. Forestry Research West. 1983(January): 1–4.
- Woodbury, T.D. 1912.** Yield and return of blue gum in California. Circular No. 210. Washington, DC: U.S. Department of Agriculture, Forest Service.
- Woodbury, T.D. 1927.** Summary of planting situation in District Five with recommendations for future work. On file with: T.D. Woodbury, Boxes 24721–24726, Accession No. 95-54-760, Federal Records Center, San Bruno, CA.
- Wyckoff, S.N. 1949.** The work of the California Forest and Range Experiment Station. In: Neyman, J., ed. Proceedings of the Berkeley symposium on mathematical statistics and probability. Berkeley, CA: University of California Press: 459–463.
- Zon, R. 1930.** The search for forest facts. American Forests and Forest Life. 36(July): 421–423, 482.

Index of People

A

Abell, C.A., 205–206, 246, 249
Allen, Edward Tyson, 36, 36n, 49n
Allen, S.W., 58n
Amidon, Elliott L., 358, 388
Anderson, Henry W., 303, 351
Arnold, Richard Keith, 272–273, 273n, 273fig., 274–276, 276n, 277, 279n, 280, 282, 288, 304, 306n, 318, 323n, 331, 331n, 332, 335–336, 338, 338n, 339, 355, 359, 442
Ashe, W.W., 75
Aune, Philip S., 409n, 440, 440n
Austin, Lloyd, 163, 163n, 164–165, 179n, 184, 186, 186n, 187
Avakian, Annie M., 177
Ayers, Robert W. “Bummer,” 34n, 48, 48n, 65

B

Babcock, Ernest B., 162
Bacon, E.M., 332–334
Baker, F.S., 261n
Baker, Harold L., 294n
Barnes, John S., 163, 163n, 164
Barnes, William “Will” C., 34n, 78n
Barrett, L.A., 50fig.
Barrett, Reg, 397n
Barro, Sue, 385n
Bates, Carlos G., 42, 209n
Baxter, L.O., 114
Bay, Roger R., 383, 383n, 384, 384fig., 385–387, 389–391, 391n, 401
Bedard, William D., 348, 348n
Beeson, Russell W., 238
Bega, Robert V., 350, 370, 388, 388n, 440, 440n
Behre, C. Edward, 113n
Bell, Enoch, 403
Benedict, H.A., 72
Bennett, Hugh Hammond, 119n
Benson, Ezra Taft, 267
Bentley, Jay R., 225, 238, 250–251, 297–298
Berg, Neil H., 351, 393, 416, 421, 435n
Bernardi, Gene, 338, 339fig., 383
Betts, Howard S., 78, 78n, 79, 112
Biswell, Harold H., 225, 426n
Blanchard, R.K., 236
Boe, Kenneth N., 370
Boerker, Richard H., 64, 64n
Bongberg, Jack W., 191n, 232n
Bonner, Frank E., 50fig.
Boss, Allan S., 398
Brewer, William H., 45n

Brewster, Donald B., 42
 Broido, A., 306n
 Brown, A.A., 143, 206
 Brown, George E., 429–430
 Brown, J.D., 5
 Bruce, N. Donald, 74, 89, 108n, 135, 135n, 205, 236
 Brundage, M.R., 120, 124, 132, 206–208
 Buck, Charles C., 204n, 206, 246, 249, 305, 307n
 Buckman, Robert “Bob,” 339, 339n, 340fig., 342n, 344, 378, 389n
 Burbank, Luther, 162, 163n, 185n
 Burke, Harry E., 69, 69n
 Burks, George F., 252, 294n
 Burris, P., 60n
 Bury, Richard L., 315
 Bush, George H.W., 405
 Busse, Kelly, 435n

C

Callaham, Robert Z., 288, 342, 342n, 343fig., 344, 346n, 362, 377–378, 384, 386, 391
 Camp, Harry W., 275n, 317, 335, 335n, 336fig., 337–338, 339fig., 346n, 369n
 Campbell, Fred M., 22
 Campbell, W.W., 116fig.
 Capper, Arthur, 90, 90n
 Carson, Rachel, 2, 321, 321fig., 323, 323n, 346, 380
 Carter, James “Jimmy,” 344
 Cermak, Robert W., 37
 Chamisso, Louis Charles de, 6
 Chandler, Craig C., 307n
 Chapline, W.R., 112
 Charlton, R.H., 55, 65
 Chase, Richard, 425, 425n
 Chavez, Deborah, 431
 Church, James E., 351
 Clapp, Earle H., 76, 76n, 77–78, 87, 91–92, 94, 109, 111–112, 112n, 113, 113n, 114, 120, 123, 144–145, 152, 159–160, 162, 165, 169, 169n, 172, 172n, 173–174, 174n, 175–176, 179, 182–183, 199, 199n, 224, 236, 257, 264–265, 292, 315–316, 327–328
 Clar, C. Raymond, 125, 125n
 Clements, U.A., 60n
 Clements, V.A., 124, 310n
 Cliff, Edward P., 331
 Cline, McGarvey, 43, 43n
 Clinton, Bill, 435n, 439n
 Clos, W.C., 34
 Coffman, J.D., 65
 Cole, Tom, 416
 Colman, E.A., 300, 302n
 Colver, Chuck, 385n
 Colville, Frederick V., 14, 14n

Colwell, Robert N., 366–367
Conard, Susan G., 385, 385n, 424, 424n
Conkle, M. Thompson, 366, 392n, 404, 409, 440, 440n
Connaughton, Charles A., 276, 328n, 381
Conrad, C. Eugene, 388, 400, 413–414
Conrad, Susan, 416, 423
Conti, Samuel, 383, 386, 401
Coolidge, Calvin, 103
Cooper, Albert W., 35–36
Cooper, F.R., 49, 49n
Copeland, Royal S., 169n
Cornelious, Donald R., 299
Cossitt, Floyd, 320
Countryman, Clive M., 307n, 354
Crafts, Edward C., 252, 273–275
Craighead, Frank C., 317
Crisp, Carl E., 347
Cronemiller, F.P., 152, 152n
Crowell, John B. Jr., 377–378, 387
Curry, John R., 143, 203, 203n, 206
Cutler, Rupert, 344

D

Dana, Samuel T., 93
Dassman, Raymond F., 323
Davis, James B., 354, 385n, 425, 425n
Davis, Maureen, 435n
Davis, Wendell E., 215
Dayton, William A., 45n, 128n
Deering, R.L., 50fig.
Demmon, E.L., 113n
Dickerman, Murllyn Bennet “Dick,” 338, 338n, 339, 339n
Dolph, Leroy, 409–410
Dombeck, Michael P., 437, 437n, 438
Dravnieks, Daina, 360n
Dubois, Coert, 49n, 51, 51n, 59–61, 65, 65n, 66fig., 82, 84, 98, 104, 140, 171n, 200
Dudley, W.R., 27
Duffield, John W., 289
Duffy, Paul, 319
Dunford, Earl G., 275n
Dunn, Paul H., 385n, 400n, 429
Dunning, Don A., 363
Dunning, Duncan, 60n, 82, 82n, 83fig., 93–94, 94n, 95–97, 97n, 106n, 114n, 124, 129, 188, 191n, 192, 193n, 194, 196–197, 248, 253, 253n, 275, 282–283, 369n
Dunston, C.E., 120–122, 205
Durgin, Philip B., 372
Dutton, W.L., 253, 253n, 254–256

E

Eaton, Charles B., 310n
 Eddy, James G., 162–163, 163n, 164, 267n, 292, 392n
 Egleston, Nathaniel H., 11, 32, 38
 Eisenhower, Dwight D., 267, 280, 315n
 Elliott, M.B., 49n
 Ellison, Lincoln, 316
 Elsner, Gary, 358
 Emerson, George B., 9, 9n
 Engle, Clair, 309
 Ericksen, L.N., 208, 235, 319
 Eschscholtz, Ivan Ivanovith, 6
 Ewell, Jack, 413
 Ewell, Kathy, 416
 Ewert, Alan, 430

F

Fairfield, Henry, 90
 Fernow, Bernhard E., 12, 12n, 13, 13fig., 14n, 15, 15n, 16, 16n, 18, 23, 25–26, 29, 32, 37–38, 42n, 108n
 Ferrell, George, 370, 411
 Fiddler, Gary, 411
 Fitch, Henry S., 226n
 Flintham, B., 117n
 Fons, Wallace L., 206, 307n
 Forbes, R.D., 113n
 Forsling, Clarence L., 113n, 173, 173n, 174–175, 175n, 209n, 242, 257n
 Fowells, Harry A., 196, 196n, 231n, 287
 Franklin, Jerry, 381
 Friday, Katie, 413n
 Friedman, Sharon, 408
 Friesen, Rex, 414
 Frothingham, Earl H., 113n, 170, 170n
 Fujioka, Francis, 425–426

G

Gaines, Edward M., 354
 Gallagher, W.H., 84
 Gardner, W.J., 34
 Garetz, Sara, 436n
 Garland, Hereford, 252
 Garlough, F.E., 159
 Gisborne, Harry T., 99, 99n, 269n
 Glading, Ben, 226n
 Gleason, C.H., 236
 Glickman, Dan, 438n
 Godwin, David P., 65
 Gordon, Aaron, 225
 Gordon, Donald T., 369

Gore, Al, 406, 433
Gould, Ernest M., Jr., 317
Gowen, George M., 143, 201, 203, 203n, 204n, 206
Graham, Charles A., 299, 363
Grant, Madison, 90n
Graves, Henry Solon, 34n, 59, 59n, 75, 76, 76fig., 77, 78n, 80
Gray, Asa, 9, 9n
Greeley, William Buckout, 92, 92n, 94, 95fig., 98, 98n, 102, 108, 110n, 165, 171n
Green, Lisle R., 354
Greenamyre, H.A., 60, 60n, 61
Griffith, E.M., 31
Groncki, Al, 360
Grosenbaugh, Lewis R., 289, 289n, 358
Guilbert, H.R., 225

H

Haddock, P.G., 60n
Hager, William A., 360n
Hall, Ansel, 122
Hall, Ralph C., 108n, 310n
Hall, William Hammond, 21
Hall, William L., 31, 31n
Hallin, William E., 198, 236, 283
Hamilton, Everett L., 215
Hanson, P.D., 206, 206n
Haraguchi, Janis, 414
Harcksen, Kathy, 409–410, 436n
Harper, Verne Lester, 262n, 264, 264n, 265, 265n, 266, 268, 271–272, 280–281, 281n, 292, 316–317, 324–325–328, 335–336, 344, 368
Harris, Robert W., 341, 341n, 342, 343fig., 346n
Hassel, Austin A., 60n, 124, 189, 289n
Hastings, A.B., 108n
Hatton, John H., 49, 49n, 70n, 71–72
Haverty, Michael I., 427–428
Headley, Roy, 64, 98–99
Heller, Robert, 367–368
Henry, A.J., 209n
Hilgard, Eugene W., 16, 16n, 17fig., 22, 37, 115fig.
Hill, Cary Leroy, 93–94, 96, 96n, 97, 108n, 120, 124, 136, 136n, 137, 137n, 139, 139fig., 178, 207–208, 208n
Hill, L.W., 236
Hirsch, Ernest, 360n
Hirsch, Stan, 355
Hodge, William Churchill, Jr., 34, 34n, 35–36
Hodges, Charles S., 376, 387
Hogue, A.H., 101n
Homans, George M., 49, 49n
Hoover, Herbert, 103n, 110n
Hopkins, Andrew Delmar, 70, 70n

Hopkins, Walter S., 318
 Hormay, August “Gus” Ludwig, 60n, 126, 153, 225, 225n, 238, 251, 271, 297–299, 363, 440
 Horn, E.E., 159–160, 229
 Hornibrook, Ezra M., 366
 Horton, J.S., 357
 Hosmer, Ralph S., 31n, 36, 36n, 37, 53, 54fig., 54n, 82–83, 165
 Hotchkiss, W.E., 136n
 Hough, Franklin B., 8–9, 9fig., 10, 10n, 11, 21, 32, 38, 89–90
 Houston, David F., 75, 78n
 Howard, H.E. 332–334
 Hoyt, W.G., 209n
 Hubbard, Richard L., 364
 Hubres, Robert, 360n
 Hunt, Loren, 28
 Hutchinson, C.B., 250
 Hutchinson, Wallace I., 34n, 50fig.
 Hyman, Julius, 347, 347n

I

Ilch, David M., 236, 300
 Irwin, Bob, 355

J

Jacobs, Cynthia K., 441
 Jardine, James Tertius, 44, 45, 45n, 72, 78n, 86, 103n, 117n
 Jardine, William M., 103, 103n
 Jemison, George M., 269, 269n, 270, 270fig., 271–272, 272n, 276, 280–282, 284–285, 302, 310, 327–328, 331, 335–336, 338n, 339, 344, 385n, 442
 Jenkinson, James L., 369, 370n, 416n
 Jensen, Herbert A., 245, 252
 Jepson, Willis Linn, 37, 162n
 Johnson, Hiram, 32n, 92, 92n, 102
 Johnson, Lydon Baines, 378n
 Johnston, William A., 147
 Josephson, H.R., 178, 228, 228n, 229
 Judd, Charles, 82–84

K

Keen, F. Paul, 310n
 Keffer, Charles A., 25
 Kelleter, Paul D., 35
 Kelley, E.W., 65
 Kellogg, Albert, 18, 18n
 Kennedy, Gerald, 58n
 Kie, John, 417, 419
 Kimmey, James W., 313
 Kinney, Abbott, 14, 14n, 16, 18–19, 22, 24, 24n, 37, 52n
 Kirby, Malcolm W., 360n
 Kirk, B.M., 236

Kittredge, Joseph A., 60n, 94n, 146n, 261n
Klinger, Keith, 306n
Koerber, Thomas W., 427, 428
Koonce, Andrea “Andi,” 426
Kotok, Edward I., 81fig., 85, 85n, 86, 86fig., 94, 98–100, 102–104, 107, 113n, 114–115, 115n, 116fig., 116, 117n, 119–120, 122–126, 132, 137, 140–142, 142n, 143, 145–146, 149, 149n, 153, 155, 160, 162, 165, 169n, 170n, 175, 175n, 177–181, 183, 186–188, 193n, 198–201, 203, 203n, 206, 210–211, 215–216, 222, 228–229, 237, 250, 257, 262–263, 263n, 264, 292, 385n, 441–442
Kraebel, Charles J., 119, 119n, 124, 130, 131fig., 145, 187n, 195, 211, 215, 251, 300, 300n, 357
Krugman, Stanley L., 366

L

Laacke, Robert Jim, 372, 411
Lachmund, H.G., 82
Laner, Stephen, 360n
Langley, Philip G., 368
Larson, Geraldine “Geri” B., 385n
Laudenslayer, Bill, 419
Le Master, Dennis C., 379
Leavitt, Scott, 209n
LeBaron, Russell K., 283, 319
Ledig, F. Thomas, 366, 392, 392n, 408–409
Leen, Rosemary, 414
Lemmon, John G., 20, 20n, 36
Lemmon, Julia, 37
Lemmon, Sara Plummer, 20
Leonard, Rose, 409
Leonard, Walter, 411
Leopold, Aldo, 108n, 380, 380fig.
Lindquist, James L., 372
Lineberger, Walter F., 102
Linnaeus, Carolus, 14n
Little, Elbert L. Jr., 128n
Litton, R. Burton, Jr., 362, 395
Lord, Philip, 363
Loring, George B., 11
Loveridge, E.W., 253, 253n, 254–256
Lowdermilk, Walter C., 119, 119n, 124, 126, 126fig., 127, 146–147, 147n, 149, 151, 195, 209n, 211, 211n
Lukens, Theodore P., 52, 52n
Lull, George B., 49n, 52, 52n
Lumsden, H.M., 163, 163n, 164
Lux, Linda, 386n
Lynch, Donald W., 275n
Lyon, Harold, 83
Lyon, William S., 21

M

- Mace, Jim, 306n
 Maddox, R.S., 59, 60n
 Magill, Arthur W., 317, 430–431
 Marcus, Leslie F., 317
 Margolin, Louis, 50, 161n
 Markin, George, 415
 Marsh, George Perkins, 6–7, 7fig., 8
 Marsh, Raymond E., 112, 173
 Mason, Garland N., 441
 Mason, I.J., 124
 May, Richard H., 284
 McArdle, Richard E., 272, 272n
 McCarthy, E.F., 113
 McCulley, Robert D., 330, 330n, 331fig., 332, 335, 346n
 McDonald, John K., 337
 McDonald, Philip M., 411–412, 440, 440n
 McGuire, John R., 317, 324–326, 328, 328n, 329, 329fig., 330, 330n, 338, 346n, 354, 361, 368, 382n, 406n, 442
 McGurk, Bruce, 435n
 McKelvey, Kelvin, 418, 435n
 McKennan, Russell B., 273–275
 McKinley, William, 26, 32
 McMahan, James A., 381
 McMasters, A.W., 306n
 Meinecke, Emilio Pepe Michael, 14n, 50fig., 66, 67, 67fig., 68n, 82, 158, 160, 160n, 316
 Merriam, John C., 90n
 Merrill, E.D., 116fig.
 Michaux, Andre, 5, 167
 Michaux, Francois Andre, 5
 Millar, Connie, 408, 435n
 Miller, Joaquin, 20
 Miller, John M., 68, 68n, 69fig., 101, 157–158, 231, 310n
 Miller, L.C., 34, 34n
 Miller, Paul R., 350, 429
 Mirov, Nicholas T., 184, 184n, 186n, 187, 187n, 235, 242, 243fig., 275n, 289, 291
 Mitchell, J.A., 81–82
 Mohr, Charles, 14
 Moore, Arthur D., 347
 Moore, Shirley A., 385
 Morrow, Earl A., 124, 204n
 Muir, John, 9n
 Mulford, Walter, 73, 73n, 74, 103, 103n, 114–115, 115n, 124n, 133n, 162, 165, 261, 261n
 Munger, Thorton T., 113n
 Munns, Edward Norfolk, 58, 58n, 60n, 82, 94, 94n, 108n, 112, 117n, 130, 144–145, 149, 209n, 210n
 Murphy, James L., 307n, 354

N

Naparst, Stanley, 358
Neal, Don, 364, 417
Neal, Robert L. Jr., 370, 388
Nelson, Jesse W., 50fig., 152, 224, 250
Nelson, R.F., 60n
Nelson, Robert E., 276, 318–319, 373, 375
Neuns, Alva G., 299
Newby, Floyd L., 362
Newell, Len, 413
Newman, Tom, 364
Nixon, Richard M., 330, 335
Noon, Barry R., 382, 416, 418–419
Noyes, D.K., 60–61
Nuttall, Thomas, 6

O

Offord, H.R., 299
Ohman, John H., 389n
Oliveira, Ronald A., 362
Oliver, William W., 372, 409–410
Olmsted, Frederick E., 28, 28n, 49, 49n, 51, 51n, 59, 61, 65n, 70n, 171n
Olson, David, 388
Orly, Roxanne, 441
Osborne, Henry Z., 92
Otrosina, Bill, 428n

P

Pack, Charles Lathrop, 109, 109n, 183n
Pardee, George Cooper, 32, 32n, 33, 33fig.
Patterson, John E., 232
Paysen, Tim, 400
Pearce, Richard B., 337
Pearson, G.A., 42, 113n, 152
Peavey, George, 49, 49n
Person, Hubert L., 133, 133n, 134, 178, 197–199, 231n, 248n, 284
Peterson, David L., 429
Peterson, R. Max, 382n, 387, 388fig.
Pickford, Gerald D., 319
Pirskoon, Arthur R., 307n
Pinchot, Gifford, 14n, 18, 22n, 24–25, 25 fig., 26, 26n, 28, 28n, 29, 30–36, 36n, 37–39, 41, 42n, 43–44, 48, 54n, 59n, 81n, 85n, 108n, 110n, 162n, 264, 324, 406
Piper, R.U., 5
Plumb, Timothy R., 299
Poli, Adon, 294n
Poth, Mark A., 385n, 429
Potter, Albert F., 34, 34n, 35, 78n, 101–102
Powers, Bob, 409–410
Price, Jay, 142

Q

R

Rachford, Christopher E., 49n, 101, 101n, 102
 Rains, Michael, 413n
 Ralston, Robert A., 335
 Ratliff, Ray, 419
 Reagan, Ronald, 3, 355, 377, 379, 383, 386–387, 391, 393, 401, 405
 Redington, Paul G., 50fig., 65, 65n, 93, 96, 98, 100–102
 Reinke, L.H., 124, 135
 Renner, Frederic G., 220n
 Renner, F.G., 126, 153
 Rice, Raymond M., 303, 352, 372, 396, 396n, 416n
 Richards, Lucille G., 303
 Richie, Martin, 411
 Rider, W.P., 65
 Riggan, Phil, 430
 Righter, “Pete” Frances, 164, 164n, 184, 186, 186n, 187, 247, 247n, 289
 Robertson, F. Dale, 382, 382n, 383fig., 402, 406
 Robertson, Jacqueline “Jackie” L., 385, 385n, 427–428
 Rogers, D.H., 236
 Roosevelt, Franklin D., 144, 166–167, 169, 175–176, 180, 230, 236n
 Roosevelt, Theodore, 32, 32n, 109n
 Ross, Eldon, 407
 Roth, Filibert, 15, 15n
 Rowe, P.B., 127, 210
 Rowntree, Rowan, 429, 435n
 Roy, Douglass F., 284, 284n, 287–288, 368, 388, 409

S

Salman, Kenneth “Ken” A., 191n, 232, 232n
 Salwasser, Harold “Hal,” 382, 433–434, 434n, 438–441
 Sampson, Arthur W., 45, 45n, 46fig., 89, 116fig., 225, 250, 261n
 Sanderson, H. Reed, 363
 Sanderson, William, 363
 Sandquist, Roger E., 427–428
 Sargent, Charles S., 10, 10n
 Scharpf, Robert F., 370, 388n, 394, 428
 Schrenk, Hermann Von, 27, 27n, 46n
 Schroeder, Mark J., 307n, 354, 357n
 Schubert, Gilbert H., 196, 287–288, 299
 Schwarzbart, Gideon, 360n
 Scowcroft, Paul 414
 Sederoff, Ronald, 392, 392n
 SESCO, Jerry, 389n
 Sharpnack, David A., 358
 Shea, Patrick J., 348, 427, 440, 440n

Show, Stuart Bevier “S.B.,” 50fig., 60n, 61n, 78n, 81, 81fig., 81n, 82, 84, 85–87, 93–94, 94n, 97–102, 104–106, 106n, 107, 108n, 112n, 113, 113n, 114–115, 119n, 122–123, 129–130, 134n, 140–142, 142n, 143, 155, 155n, 169n, 170n, 172, 172n, 175, 179–180, 189, 192, 193n, 199, 199n, 201, 203, 203n, 206, 219n, 230, 235, 309

Siggins, Howard W., 60n, 93, 114, 130n, 187

Silcox, Ferdinand A., 171, 171n, 172, 175–176, 210–211, 228, 230n

Simontachhi, A., 236

Sinclair, J. Donald, 127, 211, 211n, 215

Skinner, Carl, 435n

Skolmen, Roger G., 319, 373n, 376

Smith, A. W., 50fig.

Smith, C. Stowell, 49, 61, 62n, 63, 84, 227n

Smith, James L., 351

Smith, Richard H., 310, 348n

Smith, Zane, 390

Space, James C., 404n, 407, 433, 433n, 434

Spillman, W. J., 44n

Stanford, Leland, 22, 22n

Starr, Frederic, 7–8

Steger, George, 417

Stennis, John, 281n

Stevens, Robert E., 310n

Stewart, Ronald E., 333n, 382, 391, 401, 401n, 402, 402fig., 407, 417

Stockwell, Palmer, 184, 184n, 247, 247n

Stone, Edward C., 288

Storey, Herbert, 215

Strothman, Rudolph O., 372

Struble, George R., 133, 133n, 158, 310n, 347

Stuart, Robert Y., 110, 110n, 111fig., 171, 171n

Sudworth, George Bishop, 14, 14n, 26, 108n, 128n

Sundling, H. L., 124

Sutro, Adolph, 20

Swingle, Charles Fletcher, 132, 132n

T

Tagawa, Tom K., 318

Talbot, Murrell “Tally” W., 126, 153–154, 183, 183n, 220–221, 221fig., 222, 225, 224n, 235, 237, 242, 246, 250, 254, 385n

Taylor, R. W., 60n

Tetlow, Robert J., 395

Thomas, Frederick, 58n

Thomas, Jack Ward, 404n, 406, 406n, 407, 437, 437n

Tilden, Paul E., 348

Toumey, James W., 88, 88n, 91

Troxell, H. C., 209n

Tugwell, Rexford, 171n

Turner, Spence D., 117n

Twiss, Robert H., 361

U

V

Valfer, Ernst, 360n
 Vanderbilt, George, 26
 Verner, Jared “Jerry,” 365, 398, 416–419, 440, 440n
 Vinther, Dagmar, 114
 Vischer, Hubert, 19–20
 Vitas, George, 329

W

Wagar, J. Alan, 362
 Wagnon, Kenneth A., 225
 Wagoner, Luther, 19–20
 Wahlenberg, W.G., 164, 164n
 Waihee, John, 413
 Walker, Clyde, 266
 Wallace, Henry C., 90, 169
 Warner Mountains Forest Reserve, 33
 Watts, Frederick, 8
 Watts, Lyle Ford, 225n, 257
 Weatherspoon, Charles “Phil,” 411, 435n
 Weaver, Roscoe B., 117
 Weber, Barbara C., 402, 402n, 403, 403fig., 405, 405n, 406–407, 412, 428, 433
 Weeks, David, 207
 Wegner, Dwain C., 360n
 Weidman, R.H., 113n, 237
 Weis, Howard F., 44, 78, 78n, 79
 Wells, Wade, 385n
 West, A.S., Jr., 232n
 West, Allen J., 303
 Westcom, Robert, 413n
 Wheeler, Benjamin Ide, 37
 White, Stewart Edward, 100, 100n, 101
 Whitesell, Craig D., 373n, 413, 416
 Whiteside, Jack, 232n
 Whitney, Josiah D., 9, 9n
 Whitten, Jamie Lloyd, 262n
 Wickard, Claude R., 235
 Wickman, Boyd E., 310n
 Wickson, E.J., 37
 Wiese, David R., 426
 Wieslander, Albert Everett, 73, 73n, 74fig., 114, 114n, 120–122, 124–125, 127, 155, 155n, 177, 188, 205, 207, 222, 242, 252, 259, 385n, 432
 Wiggins, G.H., 61
 Willen, Donald W., 351
 Wilm, H.G., 215
 Wilson, Carlisle “Cap” P., 275n, 307n, 354, 357, 385n
 Wilson, R.C., 198, 294n

Wilson, Pete, 429
Wohlgemuth, Pete, 385n
Wong, Peter, 360n
Wood, David L., 348n
Wood, Hulton B. “Hutch,” 423
Wood, Marcia, 337
Woodbury, T.D., 49, 49n, 50fig., 57–58, 95, 129, 192
Wyckoff, Stephen B., 158, 183n, 256, 258, 258n, 259fig., 260–262, 262n, 263, 269, 271,
282–283, 309, 385n

X

Y

Yerke, Bruce, 360

Z

Zabel, Cynthia J., 419
Ziemer, Robert R., 372, 416, 422
Zon, Raphael, 42, 42n, 43fig., 44, 59, 78, 79, 108n, 113n
Zschotte, T.C., 61

Index of Subjects

A

Adirondack Experiment Station, 175
 Agricultural Adjustment Administration (AAA), 238, 240
 Agricultural War Board, 240
 air pollution and/or smog, 3, 323, 327, 327n, 332, 334, 334n, 346, 350, 350n, 367, 396n, 399, 400n, 423, 429
 Alameda County, 20, 246
 Alleghany Experiment Station, 113n
 Amador County, 19
 American Association for the Advancement of Science (AAAS), 8, 8n, 16n, 77
 American Breeders Association, 162n
 American Forestry Association (AFA), 12n, 87–88, 92, 109, 109n, 157n
 American Forestry Association of California, 14n
 American Samoa forestry research, 374, 374n, 376, 413n
 American Tree Association, 109, 109n
 Amherst Experiment Station, 92–93
 Angeles Forest Protective Association, 117n
 Angeles National Forest, 18, 52n, 55, 57–58, 58n, 65, 87, 117n, 130, 144, 155, 181, 211n, 355n
 Appalachian Experiment Station, 113n, 170n, 173n, 269n, 272n
 applied or practical science studies, 2–3, 5, 13, 15, 78–79, 95fig., 99, 105, 186n, 263, 274, 279, 280, 280n, 282, 290, 307, 335
 Arbor Day, 20, 20n
 Arnold Arboretum, 10n
 Arrowhead Reservoir Company, 27
 Ashville Experiment Station, 92
 Audubon Society, 365n

B

Badger Wells Research Unit, 181
 Balanced Budget and Emergency Deficit Control Act (1985), 388
 Bald Mountain fire lookout, 35
 Bankhead-Jones Farm Tenant Act (1937), 173, 173n
 basic, pure, theoretical and/or fundamental science, 5, 14–15, 74, 78, 87–89, 93, 95fig., 99, 177, 179, 186n, 280, 280n, 282, 288–289, 291, 299, 307, 314, 328, 335, 426–427
 Bass Lake Work Center, 251
 Biltmore Forest School, 49n
 Blacks Mountain Station and Experimental Forest (BMEF), 1–2, 180, 188–189, 190fig., 191, 191fig., 192–194, 197, 208, 226, 240, 248, 252, 254, 254n, 255, 260, 267, 270, 278, 283, 310, 345n, 369, 369n, 395, 409–410, 435, 436n
 Budget Impoundment and Reform Act (1974), 378, 378n
 Burgess Springs Experimental Range (BSER), 1–2, 181, 226–227, 250–251, 260, 267, 271, 278, 297
 Butte County, 35
 Butterfly Valley Research Unit, 181
 Buttermilk Game-Browse Area, 299, 315

C

Calaveras County, 19

California Agricultural Experimental Station, 16n

California (see also individual forest reserves and national forests)

Board of Agricultural Transactions, 7

Board of Air Resources, 429

Board of Forestry (CBF), 12, 12n, 14n, 16, 18–21, 21n, 22, 23–24, 24n, 37, 39, 53, 85, 92n, 101n, 115n, 119n, 125, 125n, 130, 269, 272n, 279, 287, 370n, 416n

Board of Trade, 24

Board of Water Resources, 327n

Department of Natural Resources, 161, 262, 295

Division of Beaches and Parks, 274

Division of Fish and Game, 225, 278

Division of Forestry, 161, 161n, 279, 294, 298, 300, 304–306, 307n, 308, 310, 355, 360, 397

Department of Fish and Game, 279, 298, 364, 365n, 417

Department of Forestry and Fire Protection, 354n, 356, 391, 396, 400, 424

Department of Parks and Recreation, 431

Department of Water Resources, 274, 279, 302, 305

State Emergency Relief Administration (SERA), 211, 236

California Development Association (CDA), 111

California Economic Research Council (CERC), 136, 136n, 155, 178

California Environmental Quality Act (1970) (CEQA), 330, 331fig.

California Federation of Women's Clubs, 37

California Forest and Range Experiment Station (CFRES) (see also individual research fields), 1, 73n, 82, 83fig., 86fig., 127, 132, 138–147, 151–152, 154–154, 156, 158–159, 161, 165–166, 169, 176n, 178–179, 181, 181n, 183, 183n, 184, 187–189, 192, 194–196, 198–201, 203, 203n, 204n, 206–207, 207n, 210, 210n, 211, 211n, 212, 214, 220, 222, 224, 224n, 225, 227–229, 231, 235–237, 239–249 (*passim*), 251, 254–255, 257–259, 262n, 267, 275, 282–284, 296, 299, 301–302, 309, 313

administrative reorganization, 2

anniversaries, 266–267

appropriations, budgets, and funding, 2, 145–146, 169, 177, 189, 193, 233, 236–237, 254, 260–261, 269–270, 274n, 289

experimental stations and forests (see also individual stations and forests), 180

Forest Problems of California, 182, 182n

facilities and locations, 233, 261

Forest Utilization Service (FUS), 267, 292–294, 319

founding, 126

General Integrated Inspection Reports (GII), 253–256, 260, 272–275, 290

Institute of Forest Genetics acquisition, 179

intensive management, 271, 271n, 285

library, 177–178

mission statements, 26

name change, 276, 276n

new divisions, 268, 303, 310, 313

new research attitude, 137

personnel, 1, 177, 196n, 236, 272, 275, 275n, 285

reorganization, 175–176

- statistical services section, 178
- visitors, 178
- California forest and vegetative conditions and forestry practices, 7, 19, 24, 39, 45n
- California Forest Experiment Station (CFES), 1, 31, 41, 73n, 85, 96, 104–105, 108, 110, 113n, 117n, 136, 136n, 138, 152, 154, 432
 - amalgamation with District 5's Office of Forest Products, 112
 - anniversary, 385, 385n
 - appropriations and budget, 112, 114, 123–124
 - buildings, 114, 124, 124n, 125fig.
 - forestry students, 115n, 125, 165, 177
 - founding, 102–103
 - personnel, 165, 177
 - regional unification, 120
 - research natural areas (RNAs) (see individual RNAs), 121–123
 - substations (see also individual substations and nurseries), 116–117
- California Forest Pest Control Council (CFPCC), 309
- California Forest Protection Act (1905), 36–37
- California Forest Protection Association (CFPA), 263
- California Insect Eradication Law (1923), 100
- California Institute of Technology, 278, 288
- California National Forest, 65
- California Polytechnic State University, 353
- California Professional Foresters Licensing Act, 370n
- California Redwood Association (CRA), 61, 198, 198n, 207, 263
- California Society for Conserving Waters and Protecting Forests (CSCWPF), 24
- California State Forest Practices Act, 416n
- California State University at Fresno, 326n, 434n
 - Forestry Sciences Laboratory, 344, 389, 397, 418, 438, 440, 440n, 441
 - Methods and Guidelines for Monitoring Wildlife Populations RWU, 416, 418
 - Protection and Management of Sensitive Species RWU, 398
 - Wildlife/Range Population Monitoring RWU, 397, 405, 411
- California Water and Forest Association, 24
- California Water Plan (CWP), 301–303
- Capper Resolution and Report (1920), 90–91, 127n, 169n
- Carnegie Foundation, 179
- Central Arizona Project (CAP), 151, 151n
- Central, Pacific, and Northern Pacific Railroad, 22n
- Cerro Alto nursery, 57
- Challenge Experimental Forest (CEF), 2, 121n, 240 278, 285–286, 286n, 287, 287fig., 345n, 365n, 369, 369n, 395, 409–410, 441
- Chico Creek Experiment Planting Station, 21, 21n, 23, 23n
- Civil Rights Act (1964), 338
- Civil War, 6–7
- Civilian Public Service (CPS), 236, 236n, 237, 250–251, 253, 259–260, 300
- Civil Service Commission (CSC), 265n
- Clarke-McNary Act (1924), 90n, 161, 161n, 162, 276
- Clean Air Acts (1967) (1970), 327n
- Cleveland National Forest, 52, 57, 71, 244, 309, 355
- Coconino National Forest, 42, 42n

Committee for Planning National Goals, 280
Commonwealth of the Northern Mariannas, 413n
Contra Costa County, 246
Converse Flats Experiment Station and nursery, 58, 58n, 65, 80, 82, 94n, 130, 144–145
cooperative forestry research and funding, 13, 52, 55, 262, 276, 279, 324, 331, 333, 431
Copeland Report (see *National Plan for American Forestry*)
Cornell University and School of Forestry, 16, 22, 29, 34n, 42, 52n, 73n, 76, 164n
Craig's Creek Research Natural Area, 123fig.

D

Dartmouth University, 65n
Del Norte County, 123fig., 134, 198–199, 284
dendrology science and research, 38, 47–48, 128
Devil Canyon Station and nursery, 117, 118fig., 120, 125, 127, 130–131, 131 fig., 144–147, 156, 165, 181, 187n, 210, 243–245, 251
Devils Garden RNA, 156
Diamond Match Lumber Company, 35, 68n
Diamond Mountain Forest Reserve, 47n, 71n
Diamond Mountain National Forest, 71
Doyle Game-Browse Area, 299, 315
Duke University, 264, 269n, 440n

E

Earhart Plant Research Laboratory, 288
Ecological Institute of America, 353
ecological studies, 105, 128
ecosystems and ecosystem management, 3, 378–382, 383n, 399–400, 409–410, 413–415, 427, 436n, 437, 437n, 438–439
Eddy Tree Breeding Station, 129, 162–165, 365
Eldorado County, 207
Eldorado National Forest, 65, 67, 72, 85, 85n, 156, 398, 410
Environmental Defense Fund, 393n
environmental movement and era, 2–3, 321, 323–324, 327, 330–331, 331n, 332–334, 362, 374, 377, 379–380, 382, 418n
environmental research, 350
equal opportunity and affirmative action issues, 2, 333, 333n, 336n, 342, 386
 Gene Bernardi et al. v. Earl Butz, 2, 338
 Bernardi Consent Decree, 338, 339fig., 383–384, 384fig., 385–386, 391, 391n, 401–402, 402fig., 403–404
 minorities, 342, 343fig., 405
 women, 338, 342, 343fig., 384, 384fig., 386, 402, 402n, 405
experiment stations and system (see also individual stations), 10–11, 18, 20, 23, 42, 77, 80, 87, 90–93, 105, 113, 113n, 167, 170n, 174, 179–181
experimental forest and range system (see also individual forests and ranges), 120
experimental forests (see also individual experimental forests), 10, 156, 233

F

Feather River Experiment Station and nursery, 58–61, 66fig., 80–82, 82n, 84–85, 94n, 95, 116, 121, 124–125, 129–130, 156, 165, 184n, 187n, 188, 193, 194fig., 195, 253, 267, 267n

- Feather River Experimental Forest (FREF), 121, 121n, 180, 193, 194–195, 197, 255
- Feather River Lumber Company, 59
- Federal Soil Conservation and Domestic Allotment Act, 216, 216n
- Fern Canyon Research Natural Area, 353
- Flathead National Forest, 383n
- Flukey Spring Game-Browse Area, 298–299, 315
- Forest and Rangeland Renewable Resources Research Act (1978) (F&RRRA), 112, 329fig., 340fig., 341, 341n, 344, 389, 389n
- Forest and Rangeland Resources Planning Act (1974) (RPA), 340, 340n, 341, 341n, 342, 344–345
- forest economics research and studies, 1, 52, 76, 80, 96, 104, 111, 116, 119, 133, 136, 154–156, 165, 172, 174, 177, 179, 227–229, 207, 208n, 227–229, 233, 252, 259, 268, 275, 294–296, 345–346
 - taxation and public finance, 228
- forest engineering, 268, 324
- forest entomology research and studies, 30, 51, 65–70, 93, 100–101, 231–232, 367
- forest influences research and studies (water supply, floods, and erosion control), 1, 15, 38, 51–52, 60, 104, 119, 123, 126–127, 144–151, 165, 172, 174, 177, 179, 181, 209–218 (*passim*), 233, 236–237, 251–252, 257, 260, 260n, 268, 323, 396
 - watershed management, protection, storage, and rehabilitation (see also San Dimas Experimental Forest), 2, 18, 30–31, 52n, 58n, 84, 106–108, 126, 126fig., 129–130, 152–153, 155, 174, 182n, 200, 225, 229, 255, 269, 271, 274–275, 295, 300–305 (*passim*), 308, 319, 324, 345–346, 350–353, 389, 397, 421–422, 434, 435n, 436n, 437
 - acid rain, 393, 393n
 - Central Sierra Snow Laboratory (CSSL), 269, 278, 300, 302, 302n, 303, 304fig., 344, 350–352, 393, 421, 440n
 - Cumulative Effects of Resource Management on Forest Watersheds, Aquatic Ecosystems, and Fish Communities, 421
 - Environmental Hydrology of the California Snow Zone RWU, 393, 416
 - Nuclear Profiling Snow Gage, 351
 - Snow Hydrology RWU, 386n
- erosion and streamflow control studies, 11n, 65, 111, 117, 120, 126–127, 145, 149, 211, 211n, 212, 212n, 215, 221, 227, 346, 353, 422
- hydrophobic soils, 352, 353fig.
- lysimeter studies, 147, 148fig., 148–149, 151, 212, 214–215, 300–301, 423–424
- Operation WET BLANKET, 302, 302n
- quality and pollution, 327, 327n, 334
- Sierra Ecology Project, 351–352
- Snow Zone Hydrologic RWU, 352
- snow zone management and research, 302–303, 350, 352, 393
- Wagon Wheel Gap study, 209n
- watershed research (see also San Dimas Experimental Forest), 3, 34, 45n, 58, 65, 127, 146, 181, 212, 212n, 214n, 252n, 300–301
- forest management (silvics, silviculture, and mensuration) research and studies, 1, 47, 93, 105–106, 111, 123, 128–135, 165, 181, 184–206 (*passim*), 247–253 (*passim*), 260, 266, 268, 275, 282–289 (*passim*), 326, 368–372, 412, 435n, 436n
- chaparral and brush lands research, 34–35, 59, 65n, 120–121, 129–131, 135, 140–141, 144–145, 147, 181, 205, 210–211, 212n, 214n, 247, 255, 266, 274, 282, 295–296, 298, 303–304, 316, 344, 345n, 352–354, 357, 385n, 395, 398–399, 424, 426

- harvest cutting methods and practices, 42, 47, 52, 59, 76n, 95, 105, 129, 132, 135, 137, 188–189, 191, 193–194, 196, 208, 237, 248, 280, 283–284, 287, 372, 382, 405n
- mensuration studies (growth, volume, and yield studies) 58–59, 89, 95, 104–105, 125, 129, 135, 184n, 237, 274, 282, 284, 288–289, 367–368, 409
- permanent, sample and temporary plots, 42, 81, 94, 130, 132, 145, 184n, 189, 193, 196, 223, 224n, 244, 255, 288, 296, 316
- prescribed burning, 283, 358, 358n, 395, 398–399, 411, 424, 426, 426n
- public and private management of forests, 182, 182n, 248
- silvics, 128–129, 172, 177, 184–189, 247
- silvicultural science, research, and studies, 29, 38, 42, 51–63, 65, 70n, 74–75, 81–84, 91, 94–96, 104, 129–135, 187–199 (*passim*), 207, 237, 282–287 (*passim*), 368–369
- thinning, 29, 42, 74, 135, 188–189, 283, 358, 370–372, 410
- Unit Area Control (UAC), 266, 282, 282n, 283
- windthrow, 132, 285
- working plans, 42
- forest pathology, 51, 65–68, 68n, 69–70, 80, 93, 213–232
- forest protection (disease, fires, and insects), 116, 117n, 139–144, 165, 172, 267, 399
 - disease research, 3, 38, 46, 46n, 68, 71, 78, 94, 104, 113, 128, 139, 182n, 231, 237, 268, 274n, 275, 280, 295, 312–315, 324, 327, 345–346, 366, 391, 409n, 411n, 428
 - blister rust, 47, 47n, 48fig., 113n, 158–159, 159n, 186, 186n, 231, 258, 258n, 268, 313–315, 366, 392
 - Forest Disease RWU, 386n, 388n, 393, 428
 - fungi and fungicides, 314
 - heart rot disease, 314–315
 - herbicides, 299, 299n, 314, 345n, 358, 415n
 - mistletoes, 46, 66, 139, 314, 314n, 315, 369–370, 394
 - mycology (fungi), 66
 - root diseases, 394, 440
 - western gall rust, 366, 392
- fire control, detection, prevention, protection, and suppression, 1, 18, 34–36, 38, 51, 52n, 63–64, 66fig., 76, 85, 98–99, 104–107, 123, 135, 139–143, 161, 174, 182n, 192, 200–206 (*passim*), 237, 270n, 274, 280, 308–309, 319–320, 332, 354, 357n
 - 1970 fire season, 355, 355n, 357–358
 - 1987 fire season, 424, 424n
 - 1993 fire season, 426n
 - air attack program, 307, 307n, 329, 354
 - Bailiff Fire, 345n
 - cooperative fire protection, 85
 - fire danger rating (FDR) system, 204, 204n, 249–250, 255n, 305, 308
 - firebreaks, 188, 204, 204n, 205fig., 250
 - Fork Fire, 355n
 - lookout system, 201, 201n, 202fig., 203, 250
 - forest fuel hazard modification, 20, 357–358, 358n
 - Ham Station Fire, 85
 - Inaja Fire, 309
 - Johnstone Fire, 305, 308, 352
 - Laguna Fire, 355
 - Matilija Fire, 203
 - Milestone Blaze, Idaho, 64

Mount Baldy Fire, 306n
 Rattlesnake Fire, 306n
 retardants, 307–308
 Waterman Canyon Fire, 64, 144
 fire management and research (see also individual fire research laboratories), 3, 26–27, 35, 63–65, 80–81, 84–86, 97–100, 104, 119, 124–128, 139–143, 161, 179, 181, 233, 237, 249–250, 252n, 255, 255n, 260, 268, 270, 272n, 273, 275, 284, 295, 301, 305–309, 324–325, 327, 345–346, 354–358, 389, 389n, 399–400, 424–426, 438, 441–442
 Barranca Burn Study, 145
 defense against nuclear attacks, 306, 306n
 fire danger rating system, 98–99, 99n
 fire ecology, 140
 fuelbreak program, 333, 354, 358, 359n
 “hour of control” policy, 141, 204n
 human-caused, 141–142
 incendiarism, 141–142
 large-fire behavior, 249–250, 305, 354, 442
 “let burn” policy, 98, 141
 light burning, 19, 19n, 63–64, 84, 97, 100, 101n, 134n, 140, 358
 lightning caused, 97, 99, 142
 Mather Field Fire Conference, 98, 98fig.
 Operation FIRECAST, 400, 400n
 Operation FIREScope, 3, 342, 356–357, 357n, 425n
 Operation FIRESTOP, 249n, 270, 272–273, 306n, 307–308, 355
 Operation FUELBREAK, 271, 308
 Operation HELITACK, 307, 307n
 Project FLAMBEAU, 354
 Project FOCUS, 357n
 Project INFORMAP, 354
 statistical analysis, 140–141
 insect control research, 3, 38, 44, 47, 66, 68, 68n, 78, 94, 104, 128, 133, 139, 157, 157n, 158, 182n, 193, 208n, 231–232, 237, 240n, 242, 242n, 275, 280, 295, 309–312, 324–325, 327, 345–347, 348n, 349–350, 366, 391, 411n, 426–427
 3-Bug Program (1974), 338, 348
 artificial sex attractants, 347–348, 349fig., 440
 bark beetles including western pine beetle, 47, 69fig., 71fig., 100–101, 113n, 157–158, 158n, 191–192, 232, 254–255, 283, 310, 311–312, 346, 348, 348n, 367, 394fig., 427, 440
 Biology and Control of Insects Adversely Affecting Regeneration and Establishment of Western Forests RWU, 427
 Chemical Ecology and Management of Western Forest Insects RWU, 427
 Disease Pests of California Forests RWU, 428
 five-spined engraver, 312
 flatheaded borer, 312
 Forest Insect Population Genetics and Biochemistry RWU, 427, 434
 Forest Pest Management RWU, 393–394
 gypsy moth, 339

- Improved Technology for Integrated Management of Western Forest Insects RWU, 427
- Insect and Biological Control RWU, 428
- insecticides and pesticides, 310, 311n, 329, 329n, 332–333, 339, 339n, 346–347, 347n, 394–395, 441
- Insecticide Evaluation RWU, 385n
- INSEX, 428
- lodgepole needle-miner, 310, 310n, 311, 347
- Pest Impact Assessment RWU, 428
- pyrethrins, 347, 347n
- residual-type sprays, 310, 310n, 311
- San Joaquin Project, 100–101, 101n
- southern pine beetle, 339
- spruce bud worm, 346–347, 349, 395, 428
- tussock moth, 310, 310n, 339, 339n, 346, 347n, 348–349, 394, 394fig.
- virus and bacterial treatments, 347
- forest range management research and science (forage, animal husbandry, and carrying capacity), 1, 3, 34n, 126, 44–46, 51, 70–73, 86–87, 91, 94, 101–102, 104, 107, 116, 151–154, 165, 172, 174, 177, 179, 182n, 183n, 219–227 (*passim*), 233, 237–238, 250–251, 255, 260, 266, 275, 280, 295–299, 315, 325–327, 345–346, 363–364, 397, 422, 436n
- Annual-Plant and Related Ranges RWU, 364
- aquatic ecosystems, 421
- cattle-deer interactions, 364, 417
- classification of range types, 72
- commercial fertilizers, 296–298, 364, 398, 411
- driveways, 70n
- erosion-streamflow and flood control studies, 45, 73, 107, 130, 135, 144, 238, 250–251, 269, 284, 300–301, 332, 372
- experimental range improvements, 72, 398
- foothill-range management, 153–154, 296–297
- grazing industry and research, 35, 44, 45n, 70n, 78, 105–106, 123, 125–126, 274n
- Harvey Valley Experimental Range (HVER), 271, 297, 299, 363
- mountain-land range management, 296–297
- overgrazing, 27, 45, 45n, 71, 73, 126, 135, 219n
- Perennial Grass Ranges RWU, 364
- Pine-Range project, 154
- poisonous plant eradication, 45, 87, 152
- range conditions and capacity, 71, 73, 104
- reconnaissance surveys, 45, 72, 86
- rest-rotation grazing, 297, 299, 363, 440, 442
- winter range, 298
- Forest Reserve Act (1891), 16n, 18, 24
- Forest Resources Survey (FRS), 127, 127n, 154n, 155, 174, 237, 248, 252, 259, 259n, 293–294, 294n, 295–296, 318, 365–368
- remote sensing research, 366–368
- Remote Sensing of the Forest Environment RWU, 366–367
- forestry movement and education, 6, 37–40
- Forestry Omnibus Bill, 208

forestry science and national research, 5, 13, 18, 22, 38–39, 41–47, 77, 103, 261, 261n, 328, 331–332, 432
 Fort Valley Experiment Station, 42, 92
 Fremont Experiment Station, 42, 42n
 Fresno County, 12, 27
 Fruit Growers' Supply Company, 132

G

genetics research (see also Institute of Forest Genetics), 1, 3, 128–129, 162–166, 179, 179n, 185, 233, 237, 242, 247, 267, 274n, 275, 289–292, 342n, 345–346, 365–366, 387, 389, 391–393, 436n, 438, 441
 hybridization, 289–290, 325, 365, 365n, 366, 441
 isozyme analysis and use, 392, 392n, 408, 408n
 reproductive characteristics of pine, 291–292
 starch gel electrophoresis, 366, 366n, 367fig.
 Giannini Foundation, 207, 228
 global warming and climate change, 429–430, 438
 Golden Gate Park, 144
 Gramm-Rudman-Hollings Act (1985), 388
 Granger-Thye Act (1950), 262n, 279n
 Great Basin Experiment Station, 45n, 75, 102, 107, 113n, 151n, 173n
 Great Depression, 112–113, 117, 127n, 155, 164, 166, 169
 Great Plains Forest Experiment Station, 174, 174n
 Griffith Park, 30, 53, 53n
 Guam forestry research, 2–3, 374, 374n, 376, 413n

H

H.J. Andrews Experimental Forest, 380
 Hackamore Field Laboratory, 232, 232n
 Harrison, Benjamin, 16n
 Harvard University and Forestry School, 36n, 54
 Harvey Valley Experimental Range, 2, 271, 271n, 278
 Hat Creek Insect Laboratory, 2, 232, 278, 311
 Hatch Act (1877), 10n
 Hawaii Territory, State and Government, 31–32, 83–84, 104, 161, 276, 318, 342, 344, 361, 386, 427, 434, 439, 441–442
 Board of Agriculture and Forestry, 31, 318,
 Bureau of Forestry, 31n
 Department of Lands and Natural Resources, 401
 Department of Social Services, 344
 Division of Forestry, 54fig., 318, 320, 344n, 374–375, 401
 Waiakea Arboretum, 344n
 Hawaiian forest conditions, 36n, 54n, 318–319
 Hawaiian forestry research, 2–3, 31, 53–54, 82–84, 161, 161n, 276, 276n, 318–320, 332, 373, 373n, 374–377, 387, 401, 412–416, 438
 American/Pacific Island Forestry RWU, 412, 412n, 413, 416
 Control of Invasive, Nonindigenous Weeds RWR, 413–414
 fire research, 374–377
 forest economics, 373
 forest products and marketing, 373, 373n

Forest Protection RWU, 387
Forested Wetlands RWU, 413, 416
Hawaii Experimental Tropical Forest, 412
Hawaii Forest Insect and Disease RWU, 375–376
Hawaii Forest Management RWU, 401, 413
insect and disease research, 373, 373n, 374
Institute of the Pacific Islands Forestry (IPIF), 344, 373–376, 401, 411, 413–415, 438–439
Institute of Tropical Islands Forestry, 271
Maintenance of Native Hawaii Forest Ecosystems RWU, 375–376
noxious weeds and other plants, 374–375, 401, 413, 415
Pacific Islands (Territories) RWU, 375, 412n
range management, 373n
recreation management, 373n
Restoration of Ecosystem Processes RWU, 413
Timber and Watershed Management RWU, 376–377
Timber/Wildlife RWU, 405
timber management, 373, 389
 banana poka, 415, 415n
 faytree, 415, 415n
 gorse, 415, 415n, 416
 koa forests, 376, 400, 413, 415
 Koster's curse, 415, 415n
 mamane forests, 375–376
 ohia lehua forests, 375–376, 413
 reforestation, 161, 373n, 377
 strawberry guava, 415, 415n
watershed management, 373, 373n, 377
Watershed Management RWU, 387n
wildlife, 374
 feral animals, 374–375
 palilas, 375

Hawaii Tropical Forestry Recovery Act (HTFRA), 412–413
Hawaii Volcanoes National Park, 36n, 54n, 415n
Hawaiian Planters Association, 83
Henninger Flats nursery, 30–31, 52–53, 55
Hesperia Experiment Planting Station, 21, 23
Hubbard Brook Experimental Forest, 380
Humboldt County, 134, 182, 312, 326fig.
Humboldt State College, 325, 325n, 370, 440n
Hyman Laboratories, 347n

I

Indiana Summit RNA, 156, 157fig., 157n
Institute of Forest Genetics (IFG), 1–2, 164n, 165, 177, 179, 184, 184n, 185, 185fig., 186, 186n, 187, 235–237, 247n, 253, 255, 263, 267, 267n, 271, 278, 281n, 289–290, 292, 314, 325, 332, 344, 359, 365–366, 386, 387n, 392, 392n, 408–409, 438, 438n, 440n, 441
Intermountain Forest and Range Experiment Station, 113n, 173n, 175n, 316, 337, 341n, 342n, 383n, 433n

international forestry, 341, 341n
 International Forestry Cooperation Act (IFCA), 412
 Inyo County, 12n, 315
 Inyo National Forest, 72, 122, 157, 157fig.
 Izaak Walton League, 90, 90n

J

Jackson State Forest, 372
 John Hopkins Medical School, 242
 Joint Congressional Committee on Forestry (JCCF), 175–176, 176n, 182, 199, 262
 Jornada Experiment Range, 113n, 173n
 Jornada Range Reserve, 75, 75n, 86, 102, 107, 151–152

K

Kamuela nursery, 320
 Kansas Pacific Railroad, 20
 Kern County, 12n
 Kings River Branch Station, 181, 210, 216–217, 217fig., 218, 218fig., 251, 253
 Big Creek Unit, 2, 181, 216, 251, 278
 Teakettle Creek Experiment Forest and Unit, 2, 181, 216, 218, 218n, 219fig., 251, 269,
 278, 300, 302, 302n, 303, 345n, 350, 352, 419
 Klamath Forest Reserve, 47n
 Klamath National Forest, 65, 67–68, 70, 99, 101
 Knutson-Vandenberg Act (1930), 117, 117n
 Korean War, 339n

L

Lake Bigler [Tahoe] Forestry Commission (1883), 11–12
 Lake States Forest Experiment Station, 113n, 338n, 339n
 Lake Tahoe region, 35
 Lassen Peak Forest Reserve, 47n
 Lassen National Forest, 64, 72, 73n, 94, 114n, 121–122, 152, 156, 180–181, 188–189, 206n,
 220, 226, 232, 271n, 297, 311, 315, 363, 369n, 395, 408
 Lava Beds RNA, 156
 Livermore Experiment Planting Station, 21, 23
 livestock industry (cattle, goats, and sheep) (see also forest range management), 24, 27,
 44n, 72, 153, 226n, 238, 364, 411, 414
 Los Angeles Basin, 332
 Los Angeles Chamber of Commerce, 117n, 147
 Los Angeles County, 12n, 14, 19, 274, 306n, 355, 391, 424
 Fire Department, 304–306, 308, 354n
 Forestry Department, 147
 Los Padres National Forest, 198, 229, 244, 355n, 365n
 Los Prietos nursery, 57
 lumber industry and production, 24, 35, 73, 76, 106, 227n, 239, 295, 325n
 Lytle Creek nursery, 55

M

Madera County, 222, 225
 Marcos Pass nursery, 53, 55

Marin County, 335
Mariposa County, 12n, 19
McCloud Company cooperative fire control study, 35
McIntire-Stennis Cooperative Forestry Research Act (1962), 10n, 281, 321
McSweeney-McNary Forest Research Act (1928), 1, 76n, 109–114, 124–15, 127, 133, 136n, 137, 140–141, 152, 154, 157n, 158, 166–167, 170n, 172–174, 174n, 175, 259n, 341, 341n
Mendocino County, 134, 182, 198
Mendocino National Forest, 202fig., 306n
Merced County, 225
Merced Experiment Planting Station, 21, 23
Merrick Canyon nursery, 57
Miami Insect Laboratory, 2, 232, 278, 311–312, 348, 348n
mining and minerals, 24, 345n
Mississippi Valley Laboratory, 46n
Missoula Experiment Station, 92
Modoc County, 364
Modoc Forest Reserve, 33, 101n
Modoc National Forest, 101, 122, 152, 156–157, 181, 220, 226, 231–232, 232n, 297, 315
Mono County, 12n
Mono National Forest, 67, 122, 156
Monterey County, 35
Monterey Forest Reserve, 47n
Monterey National Forest, 53
Morrill Act (1862), 10n
Mount Hamilton Experiment Planting Station, 23n
Mount St. Helens National Volcanic Monument, 381

N

National Conservation Congress, 109n
National Environmental Policy Act (1969) (NEPA), 330, 331fig., 382n
 Nicasio, California study, 335
National Forest Management Act (1976) (NFMA), 329fig., 341, 341n, 344, 382n, 388fig., 398, 410, 417
National Forest Reservation Commission, 171n, 198
National Industrial Recovery Act (NIRA), 168, 168n, 169, 178, 219n, 220
National Plan for American Forestry (Copeland Report), 169, 169n, 170–171, 171n, 172, 174–175, 200, 207, 220, 224, 227, 262, 265
National Program of Forest Research, 108–110, 112n, 144, 152, 159–160, 167, 315–316
National Science Foundation (NSF), 308
National War Garden Commission, 109n
naval stores industry, 30, 63
New Deal period and programs, 1, 142n, 144, 166–169, 171, 171n, 176, 180, 184n, 187n, 188, 197–198, 200–201, 211–212, 219, 227, 231, 233, 236
 Civil Works Administration (CWA), 167–169, 210, 212, 220, 220n
 Civilian Conservation Corps (CCC), 1, 144, 169, 180, 187n, 189, 191–192, 196, 199, 201, 203, 204, 206, 212, 214, 218–219, 222, 222n, 226, 231–232
 Emergency Conservation Work (ECW), 169, 196
 Public Works Administration (PWA), 1, 169, 196, 220

Works Progress Administration (WPA), 1, 168, 178–179, 189, 199, 212, 214, 216, 229, 231, 236, 240, 259

New England Forest Emergency Project, 183, 183n, 269n

Norris-Doxey Cooperative Farm Forestry Act (1937), 173, 173n

North Central Experiment Station, 113n, 330n, 383n, 389, 402n

North Fork Experiment Station and Work Center, 147, 148fig., 251

North Mountain Experimental Area (NMEA), 345, 345n

Northeastern Forest Experiment Station, 113n, 175n, 179n, 194, 264, 316, 328n, 338n, 361

Northern Redwood Purchase Unit (NRPU), 198–199, 199n

Northern Rocky Mountain Forest and Range Experiment Station, 113n, 175n, 258n, 269n, 338

O

Oak Grove nursery, 57

Omnibus Flood Control Act (1936), 214n, 216, 300

Onion Creek Experimental Forest, 345n, 350, 350n, 352, 421

Orange County, 12n

Oregon Agricultural Experiment Station, 45n

Oregon State University, 401n, 423, 440n

Organic Act (Forest Service) (1897), 24

Orleans Insect Laboratory, 2, 278, 311–312

P

Pacific Northwest Forest (PNW) and Range Experiment Station, 113n, 256, 258n, 301n, 337, 341n, 348, 369n, 401n, 406n, 427, 433

Pacific Southwest Forest (PSW) and Range Experiment Station, 2–3, 41, 272n, 294, 317, 319, 321, 324–325, 327–328, 328n, 329–330, 330n, 335, 338, 341n, 342, 346–347, 347n, 348, 351–352, 357–358, 358n, 359–360, 362, 368, 383n, 386–389, 391–393, 395, 397, 397n, 403, 404n, 406–407, 407n, 408, 413, 417–418, 427–428, 432–433, 433n, 434, 434n, 438, 441–442

achievements, 407n

administrative changes, 2, 328–329

anniversaries, 434, 441

annual reports, 280–281, 334, 337

attainment reporting system, 407–408

boundary extension, 318

budgets, 3, 277, 344, 359, 377–378, 378n, 386–387, 389–391, 405, 428–429, 434, 438, 441

buildings and facilities, 277, 278fig., 335, 390, 390fig., 403fig., 404–405, 405n

CALFORNET (California Forest Research Information Network), 360–361

competitive grants, 3

computer use, 359–361, 405

ecosystem research and management, 382–383, 407–408

environmental studies, 3

employee union, 336fig., 337

facilities and locations, 330n, 343fig., 344, 387

functional divisions, 336, 336n

General Functional Inspection (GFI), 324, 329

General Integrated Inspection (GII), 324, 332–334

General Research Inspection (GRI), 324–326, 368, 391
Management Services Staff (MaSS), 359–360, 360n, 407n
name change, 276, 276n
nuclear attack preparation, 328n, 354n
PACFORNET (Pacific Coast Forest Research Information Network), 361, 361n
personnel issues and retirements, 3, 335, 337 343fig., 344–345, 385, 386–390, 405, 428, 434–435, 435n, 440–441
publications, 2, 329, 337, 405, 436, 436n
relocation of headquarters, 3
reorganization, 325, 327–328, 434
research work units (RWUs) (see also individual RWUs), 2, 335–336, 345–346, 387, 391–392, 405, 407n, 408, 434, 438–439, 439n
technology transfer, 335
utilization, marketing, and economics division, 294, 296, 317, 335n
WESTFORNET (West Forest Research Information Network), 361n

Pasadena nursery, 55
Permanente Metals Corporation, 239, 239n
Pilgrim Creek Fire Laboratory (see also Shasta Experimental Fire Forest), 2, 278, 308
Pilgrim Creek nursery, 57, 57n, 82
Pine Mountain Forest Reserve, 24
Pinnacles Forest Reserve, 47n
plants (non-indigenous) research, 3, 84
Plumas Forest Reserve, 47n
Plumas National Forest, 58–59, 71, 94, 94n, 121, 121n, 130, 156, 180–181, 193–194, 220, 226, 240, 267, 410
Pomona College, 353
Portland Experiment Station, 92
Prairie Creek Redwoods State Park, 326fig.
Prairie States Forestry Project, 183
Priest River Experiment Station, 42, 42n, 92, 99, 113n
Purdue University and Testing Laboratory, 28, 62n

Q

R

railroads and railroad ties, 27, 27n, 28, 55, 138fig.
Reagan Meadow RNA, 156
recreation management and land-use planning research, 3, 160, 182n, 200, 225, 230, 268, 274, 316–317, 317n, 320, 324, 335n, 345–346, 358, 361–362, 389, 430–431, 437, 437n 438, 442
Redding Silviculture Laboratory, 288, 288n, 325, 325n, 326, 329, 332, 344, 365, 368–369, 395, 409, 411, 438, 441
Effects of Forest Management on Hillslope Processes, Fishery Resources and Stream Environments RWU, 416, 422
Forest Regeneration Research RWU, 411
Hillslopes Process/Fishery RWU, 416, 416n
Long Term Soil Productivity Cooperative Study (LTSP), 410
Silviculture of California Conifer Types RWU, 388, 409

Timber Management/Wildlife Interactions in Northern California Forest Types RWU, 416–417, 419

Vegetation Management Research and Development Program, 409, 409n, 411

Redwood Experimental Forest (REF), 344, 370–371

Redwood National Forest, 198

Redwood Sciences Laboratory, 286fig., 325n, 344, 365, 370–371, 371n, 371fig., 372, 387n, 389, 395–396, 396n, 396fig., 419, 438, 441

Sustained Wildlife Communities and Key Ecosystem Linkages in Montane Forests of the Sierra Nevada RWU, 418

Timber/Wildlife Habitat RWU, 397

reforestation and regeneration research (see also nurseries), 11, 11n, 19–20, 29–31, 34, 38–39, 51–52, 52n, 53–55, 57–58, 76, 91, 94–95, 106, 108, 115, 117n, 120, 129, 132, 134n, 171n, 182n, 188–189, 247, 274n, 280, 283, 287–288, 333, 370, 370n, 372, 411, 428

artificial reseeding or direct seeding reproduction, 26, 30, 44n, 45, 52n, 57–58, 60, 79, 104, 130, 134, 134n, 152, 162n, 187, 187n, 188, 196, 196n, 227, 244, 250–251, 255, 272n, 283, 287–288, 315

natural reproduction or regeneration, 26, 104, 129–130, 132, 134, 134n, 152, 162n, 187, 198–199, 227, 285, 287–288, 298

nurseries (see also individual nurseries), 20–21, 39, 46, 80, 104, 129, 164, 319, 392

old-growth stands, 370, 383fig., 387, 397, 397n, 406n, 419

planting studies, 42, 74, 82, 105–106, 120, 193–194, 198, 231n, 255, 283, 287–288, 290, 369n, 411–412

research natural areas (RNAs), 121–122, 156–157, 157n

Republic of the Marshall Islands, 413n

Resources for the Future, Inc., 291

Riverside Forest Fire Laboratory (RFL), 309, 332, 342, 344, 354, 356, 357n, 385n, 388–389, 389n, 397–398, 399fig., 424, 424n, 425n, 426, 429–430, 438, 441

Atmospheric Deposition on Montane Forests of the West RWU, 400, 429

Chaparral Ecology and Fire Effects RWU, 385, 385n, 387n, 399

Chaparral Management RWU, 358

Chaparral Prescribed-Fire RWU, 400

Ecology and Fire Effects in Mediterranean Ecosystems RWU, 416, 423

Ecology of Chaparral and Associated Ecosystems RWU, 424

Fire Economics RWU, 400

Fire Management in the Wildland-Urban Interface RWU, 424–426, 426n

Fire Management Planning and Economics RWU, 424–425

Meteorology for Fire Severity Forecasting RWU, 424–425

Prescribed Fire Research RWU, 424, 426

Site-Specific Fire Prescriptions for Chaparral and Related Ecosystems RWU, 424

Urban Forestry/Landscape RWU, 389n, 395

Wildlife Prevention RWU, 388

Wildlife Recreation and Urban Culture RWU, 389n, 430

Rockefeller Foundation, 291

Rocky Mountain Forest and Range Experiment Station, 172, 175n, 272n, 337, 433

S

Sacramento Municipal Utility District (SMUD), 301

Sacramento Valley and River Basin, 182, 210, 226, 300, 372

Sagehen Experimental Watershed Research Area, 2, 278

San Benicito County, 224
San Benito County, 225
San Bernardino County, 12n, 14, 19
San Bernardino Forest Reserve, 12n, 24–35
San Bernardino National Forest, 53, 63–64, 144, 181, 211n, 350, 355n, 400, 400n, 426, 429
 Lake Arrowhead area, 332, 350
San Diego County, 14, 19, 307, 309
San Dimas Experimental Forest (1934) (SDEF), 1–2, 147, 149, 150figs., 177, 181, 210–216
 (*passim*), 236–237, 245, 250–252, 253, 255, 259, 263n, 267, 270, 272n, 278, 300–301,
 303, 305, 308, 308n, 325, 345n, 352–353, 385n, 400, 423
 Fire Ecology RWU, 424
 Man and the Biosphere program, 353
San Dimas Water Company, 147, 211
San Gabriel Forest Reserve, 12n, 18, 24, 30, 35, 54
San Gabriel nursery, 55
San Jacinto Experiment Planting Station, 21, 23
San Jacinto Forest Reserve, 24, 35
San Joaquin Experimental Range (SJER), 2, 181–182, 220–226 (*passim*), 229, 236,
 250–251, 253, 255, 260, 263, 267, 274, 278, 297, 299, 325–326, 326n, 344, 363, 398,
 419, 419n, 420figs.
San Joaquin Valley, 34, 153–154, 181, 210, 216, 218, 220–221, 225, 250, 259, 296
San Luis Obispo Forest Reserve, 47n
San Luis Obispo National Forest, 53, 57
Santa Barbara County, 355
Santa Barbara Forest Reserve, 24, 31, 35, 48, 53–54, 68n
Santa Barbara National Forest, 52n, 57, 101n, 198n, 203
Santa Barbara nursery, 55
Santa Catalina Research Natural Area, 121n
Santa Inez Forest Reserve, 24
Santa Monica Experimental Planting Station, 21, 21n, 23, 23n
Santa Rita Range Reserve, 75, 75n, 86, 102, 151n, 152
Save the Redwoods League, 89–90, 90n, 134, 285
Selective Training and Service Act (1940), 236n
Sequoia National Forest, 92n, 94, 153, 355n, 357n, 363, 440n
Sequoia-Kings Canyon National Park, 101, 311, 418
Shasta County, 210n
Shasta Experimental Fire Forest (SEFF), 141–142, 142n, 143, 165, 180–181, 200–201,
 202fig., 203–204, 250, 267, 278, 278n, 308
Shasta Forest Reserve, 47n
Shasta National Forest, 45n, 57, 57n, 65n, 67, 72, 81n, 82, 82n, 85, 85n, 94, 142, 181, 220,
 226, 231, 255
Shasta-Trinity National Forest, 288n, 325, 440n
Sierra Club, 24, 285, 285n, 333
Sierra Forest Reserve, 12n, 24, 27, 47
Sierra National Forest, 67–68, 70, 70n, 72, 87, 94, 96n, 101, 147, 153, 157–158, 181, 208n,
 216, 218, 222, 222n, 231n, 232, 251, 330n, 410, 418
 King River Sustainable Forest Ecosystems Project, 435, 435n
Sierra Nevada Conservation Framework (SNCF), 439
Sierra Nevada Ecosystem Plan (SNEP), 406, 406n 421, 426, 435, 435n, 439

Simpson Redwood Company, 284
 Siskiyou County, 35
 Six Rivers National Forest, 123, 344, 440n
 Society of American Foresters (SAF), 28n, 36n, 49n, 54n, 78, 94, 108, 108n, 109, 144, 175, 266
 Soil Conservation Service (SCS), 119n, 132n, 173, 210, 214n, 225, 238, 260n, 298, 300, 421
 Soil Erosion Service, 179
 soil management, 333, 410
 Sonoma County, 134
 Soper-Wheeler Company, 286
 Southern California Academy of Sciences, 14n
 Southeastern Forest Experiment Station, 269n, 433
 Southern California Forest and Water Society, 14n
 Southern California Pomological Society, 14n
 Southern Forest Experiment Station, 92, 113n, 164n, 235, 263n, 264, 289n, 381
 Southern Pacific Railroad, 20
 Southern Redwood Purchase Unit (SRPU), 198
 Southwestern Forest and Range Experiment Station, 113n, 175n, 152, 263n
 St. Paul Experiment Station, 92
 Stanford University, 22, 22n, 23, 33, 68, 69n, 81n, 184n, 242, 244
 Stanislaus-Tuolumne Experimental Forest (SEF and STEF) 2, 180, 180n, 184n, 188, 195, 195fig., 196–197, 255, 263, 267, 278, 283, 345n, 409
 Stanislaus Forest Reserve, 24
 Stanislaus National Forest, 59n, 65, 67, 70, 70n, 71, 87, 94, 117, 121, 137–138, 153, 196–197, 231, 366, 417
 Stony Creek Forest Reserve, 47n
 Summit Camp RNA, 156
 Susanville Research Center, 271, 297, 328–329
 Susanville Station and nursery, 117, 117n
 Swain Mountain Experimental Forest (SMEF), 2, 121, 122fig., 156, 165, 180, 188–189, 270, 278, 285, 303, 316, 345n, 350, 369, 369n, 395, 411
 Sweetwater RNA, 156
 Syracuse University, 341n

T

Tahoe Forest Reserve, 24
 Tahoe National Forest, 67, 71–72, 84, 94, 220, 226, 316, 385n, 410, 440n
 Tanbark Flats Station and nursery, 117n, 149, 213fig., 214, 215fig., 236, 300, 305, 332, 423, 429
 telegraph, telephone and power poles, 28, 48, 55, 62
 Threatened and Endangered Species Act (1973), 382n, 383fig.
 timber famine, shortage and/or depletion or exploitation, 5–6, 38, 88, 90–91, 137, 162, 228, 248, 293, 293n
 timber management and research, 36, 182n, 266, 270, 274n, 295, 324, 342, 345, 346, 369, 387, 391
 acacia trees, 11, 21, 23, 48
 black oak, 63, 210n, 369n
 cedar, 67, 208, 210n
 chinchona, 11

- clearcutting and cutover lands, 94, 134, 134n, 155, 193, 227n, 284–285, 333, 369, 371, 381, 395
- coniferous trees, 20
- cork oak, 10, 243–244, 247
- Douglas-fir studies, 208, 240n, 243, 258, 271, 283, 284n, 288, 310n, 312, 314n, 325, 371n, 372, 427
- even-age management, 285, 410
- hardwood forest management and industry, 19–20, 57n, 412, 440
- industrial forestry (tractor and truck logging), 106, 107fig., 121, 156, 197–198, 208, 397–398
 - road construction, 372, 396, 414, 437n
- Jeffrey pine, 196, 208n, 210n, 218, 314
- lodgepole pine, 218
- logging damage and milling investigations, 132–134, 137, 156, 206–208, 369n, 371
- madrone, 369n
- marking practices and rules, 132, 137, 248
- Monterey pine and cypress, 128
- Pickering Lumber Company Study, 137–138
- pine forest management and region research, 3, 28, 30, 106, 119, 123, 123n, 124–125, 129, 132, 140, 147, 165, 171n, 179, 188, 192, 196–197, 203n, 207–208, 226, 227n, 233, 237, 239, 248, 258, 282–283, 288, 325, 359, 369
- Ponderosa pine (see pine forest management and region research)
- production, 225, 227, 258, 276
- redwood forest management and region research, 3, 9n, 17fig., 19, 27, 30, 52, 61, 74, 90n, 100n, 106, 123, 123n, 124–125, 133–134, 134n, 135, 171n, 178–179, 182, 184n, 197–199, 208, 227n, 231n, 233, 237, 239, 248n, 255, 258, 270–271, 283–286, 286fig., 288, 324–325, 325n, 365, 370, 372
- risk rating systems, 370
- salvage or sanitation cutting, 67, 67n, 193, 254, 312n, 346
- Scotch pine, 194
- second-growth forests, 286, 286n, 293, 371
- selection cutting, 371, 381
- shelterwood removal, 287, 369
- softwoods (red and white fir) 67, 180, 196, 207n, 208, 218, 243, 248, 252, 283, 285, 310n, 314, 350n, 365, 369–370, 395
- slash disposal, 286–287
- sugar pine, 196–197, 227n, 231
- sustained yield timber research, 192–193, 197–198, 228, 248, 282
- tanoak, 369n
- timber resource review (TRR), 293, 293n, 295
- timber-stand improvement (TSI), 286–287
- Torrey pine, 48, 350
- True Fir Task Force (TFTF), 369–370
- true-fir types and research, 188–189, 270, 285, 314n, 368, 410
- yucca trees, 30
- Trabuco Canon Forest Reserve, 12n, 24, 35
- Trinity Forest Reserve, 47n
- Trinity National Forest, 65, 70, 87, 99, 156, 199

Trust Territory of the Pacific Islands (Federated States of Micronesia) forestry research, 374, 374n, 376, 401, 413n

Tulare County, 12n, 22–23, 27

Tuolumne County, 19, 310n

U

United States, Army, 354n

United States, Army Air Force, 246

United States, Army Corps of Engineers, 244–245, 269, 300, 319

United States, Atomic Energy Commission, 351

United States, Department of Agriculture (USDA), 41, 50, 75, 86, 109, 114, 151, 168, 235, 262, 301n, 341, 383, 433, 433n

Agricultural Research Service (ARS), 268, 297, 390–391, 404, 438

Bureau of Agricultural Economics (BAE), 214, 260n

Bureau of Animal Husbandry (BAH), 44n, 71

Bureau of Biological Survey (BBS), 159, 170, 170n, 226, 229, 231, 231n

Bureau of Chemistry and Soils (BCS), 29–30, 170

Bureau of Entomology (BE), 30, 30n, 47, 68, 68n, 69, 69n, 70, 70n, 78n, 93, 100, 108, 110n, 113n, 116n, 133, 133n, 139, 157–158, 170, 231n, 243, 244

Bureau of Entomology and Plant Quarantine (BEPQ), 231, 231n, 232, 252, 268, 309

Bureau of Fisheries, 170

Bureau of Forestry, 26–34 (*passim*), 38, 40, 44n, 46n, 52n, 69n, 73n, 167

California-Bureau of Forestry Joint Forest Survey, 33, 33fig., 34–36, 38–39, 52n

Bureau of Plant Industry (BPI), 44, 44n, 46, 46n, 66, 75n, 78n, 86, 93, 108, 132n, 139, 157–158, 170, 179, 225, 258, 316

Bureau of Plant Industry, Soils, and Agricultural Engineering (BPISAE), 113, 231, 268

Division of Agrostology, 44n

Division of Botany, 44n

Division of Dendrology and Range Forage Investigations, 128n

Division of Entomology, 30n

Division of Forestry, 11–12, 16n, 18, 23, 25–26, 28, 29, 34n, 36n, 38, 49n, 50, 54n, 167

Division of Pathology, 268

Division of Soils, 36n, 54n

Forest Service, 38–44, 47, 77, 78n, 86, 91, 102, 108, 108n, 117n, 120, 127n, 128, 128n, 130, 137, 144, 147, 151, 151n, 152, 155, 158n, 159–161, 161n, 162n, 167–168, 168n, 169, 170, 170n, 171, 171n, 172, 174, 176, 184, 184n, 187, 191, 199, 199n, 203n, 204n, 209, 209n, 210, 214n, 219–220, 229–230–232, 235, 241, 243fig., 252, 258n, 261, 262n, 263n, 274, 276, 279–280, 294, 302, 302n, 306n, 307n, 309, 316, 318, 320, 323, 325n, 326–328, 330, 330n, 331, 335, 336fig., 337, 337n, 340, 340fig., 341n, 342, 346, 348, 355, 365–366, 367fig., 375, 380–381, 382, 382n, 383–385, 385n, 386–387, 389, 389n, 391, 396n, 398, 400n, 401n, 402n, 403, 406, 406n, 407, 407n, 408, 409n, 410–411, 413n, 418, 421, 425, 429–431, 433, 433n, 434n, 437n, 438n, 439, 439n, 440n, 442

Branch of Forest Products, 43, 62

Branch of Grazing, 44–45, 78n, 151

Branch of Research (BR), 59n, 75–77, 80–81, 87, 91, 112, 128, 128n, 151, 167, 169, 170, 170n, 172–175, 224, 242, 262, 263, 263n, 264, 265, 265n, 266, 268, 268n, 280–281, 281n, 324, 330n, 331

Central Investigative Committee (CIC), 44, 59n, 60, 60n, 75, 144

District 5, 28n, 34n, 43, 47, 49–50, 52, 57–58, 58n, 59–60, 63n, 65, 65n, 66, 72–73, 89, 94–95, 96n, 98–100, 101n, 102, 104, 116, 116n, 117, 141, 144–145, 151–152, 157, 193, 195, 208n, 227n, 337n

Branch of Grazing, 86
Branch of Research, 105, 115, 129
Branch of Timber Management, 49n
cooperative insect control work, 70
Division of Range Management, 224
experimental forest and range system (see also individual forests and ranges), 120, 166, 259
investigative committee (D5-IC), 44, 115n, 116, 116n, 119–122, 132n, 136, 145, 152, 160, 162, 164
Office of Fire Control, 156
Office of Forest Management, 156
Office of Forest Products, 62–63, 112, 120, 135–136, 136n
Office of Grazing, 107
Office of Range Management, 151–152, 156
research program, 93–94, 129
supervisors meetings, 50, 68, 76n, 85
Division of Forest Economics Research, 173
Division of Forest Influences, 58n, 210
Division of Special Investigations, 42, 42n, 43fig.
Division of State and Private Forestry, 183
Division of Wood Products, 292
Forest Plan for the Pacific Northwest, 435, 435n
Forest Products Laboratory (FPL), 43n, 44, 51, 59, 63, 63n, 75–78, 78n, 79, 84, 87, 91–92, 96, 113, 136, 136n, 137, 137n, 177, 206, 207n, 236, 236n, 237, 240n, 243, 280n, 292, 319, 340, 375
Framework for the Future, 331
L-20 Regulations, 119–120, 197
Molecular Genetics Laboratory (MGL), 409
National Agricultural Library, 360
National Forest Genetics Electrophoresis (NFGEL), 408, 408n, 409
National Oceanic and Atmosphere Administration, 421
New Perspectives in Forestry, 382
Office of Experiment Stations, 58n, 94n
Office of Forest Entomology, 157
Office of Forest Investigations, 76, 79
Office of Grazing Research, 151
Office of Industrial Investigations, 76
Office of Silvics, 76fig.
Region 1 (Northern Region), 355n
Region 3 (Southwest Region), 355n
Region 4 (Intermountain Region), 354
Region 5 (Pacific Southwest Region), 34n, 119n, 137, 141, 142n, 153, 158, 171n 177–178, 181, 189, 194, 198, 200–201, 203, 203n, 204, 204n, 208, 219n, 221, 222n, 226, 227n, 229, 230, 230n, 231, 231n, 235–238, 238n, 243–245, 252–255, 255n, 258, 262, 267, 274, 274n, 275, 283, 285n, 295–297, 297n, 298, 307n, 310, 313, 315, 315n, 317n, 328n, 329, 332–334, 355, 360–361, 365, 367, 369–370, 381, 385, 385n, 386n, 387, 387n, 391–392, 399–400, 403, 404n, 405n, 411, 413n, 424, 425n, 434n, 439
Division of Forest Management, 49n
Division of Timber Management, 207

Division of Range and Wildlife Management, 152n, 224, 315n
 Division of State and Private Forestry, 360
 General Integrated Inspection (GII), 332
 Genetics Electrophoresis Laboratory, 411
 Investigative Committee (R5-IC), 132, 132n, 137, 146, 267
 Office of Fire Control, 156
 Office of Forest Management, 156
 Office of Range Management, 156
 reforestation plans, 119, 171n
 research natural areas (RNAs) (see individual RNAs), 121–123, 198
 Silviculture Development Unit, 411
 Region 6 (Pacific Northwest Region), 348, 354, 355n, 405n
 Region 8 (Southern), 355n
 State and Private Forestry, 357n, 439
 Office of Biological Survey, 113–114, 116n
 Office of Blister Rust Control, 116n, 124n, 155, 158
 Office of Grazing Studies, 173n
 Office of Pathology (OP), 82, 116n, 136n, 157–158
 Weather Bureau, 113–114, 116n, 146, 170, 170n, 204n, 300
 United States, Department of Defense, 270n
 Armed Forces Special Weapons Project, 273
 Office of Civil Defense (OCD), 245–246, 249, 294n, 354
 United States, Department of Interior, 38, 41, 50, 168, 173, 257n, 374n
 Biological Survey, 225
 Bureau of Land Management (BLM), 345n, 354, 419, 431, 437, 437n
 Bureau of Reclamation (BOR), 351
 Division of Grazing Service, 173, 257n
 General Land Office (GLO), 12, 16n, 24, 30, 32, 47, 47n, 105, 171n
 National Park Service (NPS), 116n, 119n, 122, 124n, 227n, 311, 363
 United States, Department of War, 30, 57, 168
 Chemical Warfare Service, 246
 Presidio Military Reservation, 30
 United States, Federal Emergency Management Agency (FEMA), 357n
 United States, Food and Drug Administration, 310n
 United States, Environmental Protection Agency (EPA), 310n, 339n, 348, 348n, 349, 393
 United States, General Accounting Office (GAO), 335
 United States, General Services Administration (GSA), 277, 390
 United States, Fish and Wildlife Service, 253, 315, 327n, 348, 375, 418n, 419
 Bureau of Sport Fisheries and Wildlife, 365n
 United States, Geological Survey (USGS), 27, 49n, 146n, 155, 227n
 United States, National Aeronautics and Space Administration (NASA), 367
 Earth Resources Technology Satellite (ERTS), 368
 United States, Office of Management and Budget (OMB), 408
 United States, Patent Office, 30n
 United States, Public Health Service, 350
 University of Arizona, 152, 184n
 University of California, Berkeley, 1–2, 16n, 22–23, 33, 37–38, 45n, 46fig., 48, 55, 61, 73,

73n, 74, 82n, 83fig., 89, 103, 103n, 114–115, 115fig., 119n, 124, 124n, 125fig., 133, 133n, 134–135, 135n, 136n, 138, 146, 146n, 147, 148fig., 155, 162n, 163n, 178, 184n, 191n, 196n, 205, 207, 211n, 224, 225n, 226, 228, 228n, 231n, 232, 242–244, 244n, 252, 256, 259fig., 261, 261n, 262, 264, 270, 273, 273n, 274n, 276–277, 277n, 279, 291, 295, 297–298, 311, 313n, 314, 325, 330n, 333, 338n, 342n, 348n, 360–363, 366, 383, 385n, 386, 389, 395, 408, 426, 432, 434n, 439, 440n, 441

University of California, Chico, 431

University of California, Davis, 314, 344, 362, 385n, 386n, 417, 438, 440n, 441

Insect Chemical Ecology RWU, 411, 438

Urban Forestry RWU, 438

University of California, Irvine, 431

University of California, Richmond, 278, 308

University of California, Riverside, 333, 350, 423

University of Chicago, 347n

University of Hawaii, 401, 438

University of Idaho, 341n, 383

University of Michigan, 58n, 73n, 85n, 96n, 163n, 272n, 273n, 331n, 339n

University of Minnesota, 339n, 383, 437n

University of Missouri, 183

University of Nebraska, 173n

University of Pennsylvania, 328n

University of Southern California (USC), 22–23

utilization of wood and other forest products (see also forest economics), 1, 11, 14, 28, 32, 38, 43–44, 47–48, 51, 61–63, 74, 76, 84, 91, 96–97, 104, 111, 116, 123, 125, 135–139, 165, 170n, 172, 174, 178–179, 182n, 206–209, 233, 236–237, 252, 275, 284, 292–294, 319, 324, 346, 368

air drying and kiln seasoning processes, 57, 61, 79, 96, 136, 206, 208n, 240n, 292, 294

blue stain in lumber, 136, 136n

eucalyptus plantations and research, 10, 19–21, 23, 28, 34, 48, 52n, 55–56, 56fig., 57–58, 61, 82–83, 120, 161n, 319

extension work and product information, 47–48, 53, 139

heptane production study, 138–139, 139fig., 208n

lumber depreciation study, 138

marine wood borers and pilings, 55, 62, 62n, 96, 136, 136n, 206, 208n, 240

marketing, 268, 294, 324

nailing techniques, 292

pulpwood and paper, 62, 79, 96

saw filing system, 292

tannin and tanbark studies, 29–30, 48, 61

timber testing and physics, 13–14, 25, 27–28, 43, 61–62, 78n, 79

vegetation-soil survey mapping, 125, 127, 154–155, 222, 227n, 294, 294n, 295

wood chemistry, 62

wood fiber and residues, 252, 293

wood preservation, 27, 27n, 46, 48, 62–63, 63n, 79, 84, 96, 135–136, 206

urban forestry, 3, 332, 332n, 362, 392, 429, 442

V

Ventura County, 355, 426n

Vietnam War, 299n, 354, 378

Vilmorin Corporation, 162n

W

Warner Forest Reserve, 101n
 Washington State University, 69n, 440n
 Weeks Act (1911), 85–86, 171n, 220
 West Virginia Experiment Station, 70n
 Western and Eastern Defense Command (EDC and WDC), 244, 245–246
 Western Pine Association, 263
 Western Range Survey, 262
 Wilderness Society, 333
 wildland management and research, 279–280, 295–296, 301, 309, 424n
 wildlife habitat and management research, 159–160, 197, 225, 227, 229–230, 296, 315–316, 323, 327, 345–346, 362–365, 397–398, 435n, 437
 feral animal research, 3, 31, 45, 414
 Forest Recreation and Landscape Management RWU, 362
 Land Use and Landscape Planning Methodology RWU, 362
 Landscape Management and Urban Forestry RWU, 362, 395, 405
 marbled murrelet, 435n, 436, 436n
 spotted owl research and controversy, 3, 389, 397, 397n, 406n, 418, 418n, 419fig., 419, 435n, 440n, 442
 threatened and endangered species, 326n, 346, 365, 365n, 375, 382, 418, 418n, 438
 VIEWIT, 358
 World War I, 41, 49n, 58n, 73n, 79–80, 82, 84, 87–88, 91, 92, 94n, 98, 101–102, 105, 110n, 117n, 227n
 10th Engineers, 92n, 119n, 130, 135–136, 140, 145
 20th Engineers, 171n
 World War II, 1, 60, 176, 179, 182, 183n, 184n, 189, 193–194, 199, 205–206, 208, 220, 225, 229–230, 230n, 232–233, 235–256 (*passim*), 257, 259, 259n, 260n, 263n, 264, 276, 280, 283, 285n, 286n, 287–288–289, 289n, 292, 294–296, 297n, 298, 299n, 300, 302, 305, 306n, 310, 313, 320, 323, 328, 335, 338n, 339, 347n, 364
 Guayule Emergency Rubber Project, 214, 241fig., 242–244, 252
 Office of Price Administration (OPA), 239–240, 252, 338n
 War Manpower Commission (WMC), 240, 252
 War Production Board (WPB), 238–240, 252, 338n

X**Y**

Yale University, Forestry School, and Testing Laboratory, 28n, 34, 36n, 49n, 54n, 59n, 62, 65n, 73n, 78n, 81n, 88, 88n, 92n, 110n, 269n, 273n, 289n, 328n, 433
 Yosemite National Park, 68n, 122, 278, 311–312, 347
 Yuba County, 365n
 Yuba Forest Reserve, 47n
 Yurok (Redwood) Branch and Experimental Forest (1940), 1–2, 199–200, 200fig., 255, 263, 270, 278, 284

Z

Zaca Lake Forest Reserve, 24

This publication is available online at www.fs.fed.us/psw/. You may also order additional copies of it by sending your mailing information in label form through one of the following means. Please specify the publication title and series number.

Fort Collins Service Center

Web site	http://www.fs.fed.us/psw/
Telephone	(970) 498-1392
FAX	(970) 498-1122
E-mail	rschneider@fs.fed.us
Mailing address	Publications Distribution Rocky Mountain Research Station 240 West Prospect Road Fort Collins, CO 80526-2098

Pacific Southwest Research Station
800 Buchanan Street
Albany, CA 94710



Federal Recycling Program
Printed on Recycled Paper