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Silviculture: From the Cradle of Forestry to Ecosystem Management

Proceedings of the National Silviculture Workshop

Hendersonville, NC-November 1-4, 1993

COVER PHOTO: The Biltmore School, built in 1898, was the first forestry school in America. Several forestry students are pictured in front of the school with its founder, Dr. Carl Schenck (white shirt, black bow tie). Many of the school's 367 alumni became practicing professional foresters throughout the United States. The school was located at what is now known as the Cradle of Forestry.

In 1968, Congress passed legislation establishing the Cradle of Forestry on 6,400 acres of the Pisgah National Forest. The Cradle preserves the birthplace of forestry and forestry education in America for the public. It also promotes the development of forestry and modern forest management practices.

BACK COVER PHOTO: Dr. Carl Schenck, a German Forester, succeeded Gifford Pinchot as manager of Pisgah Forest. Dr. Schenck established the first forestry school in America.

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Southeastern Forest Experiment Station
P.O. Box 2680
Asheville, North Carolina 28802

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Foreword

The National Silviculture Workshop, hosted by the National Forests in North Carolina, the Southern Region (Region 8), and the Southeastern Forest Experiment Station, was held November 1993 at the Kanuga Conference Center, Hendersonville, NC. The purpose of this workshop was to review, discuss, and share silvicultural research information and management experience critical for implementing ecosystem management on National Forest System lands and other Federal and private forest lands. The authors represented a cross section of the forestry community and addressed the importance and role of silviculture in ecosystem management from the viewpoints of research, education, and land management. Some of the speakers were unable to prepare papers for this proceedings.

Field trips to the Bent Creek Experimental Forest, the Pisgah National Forest, and the Cradle of Forestry were hosted by their respective staffs. These trips gave the participants an opportunity to observe and discuss forest research and management activities in the Southern Appalachians. One of the highlights of the day was a special historical slide program and tour of the exhibits at the Cradle.

The Washington Office Timber Management (WO-TM) and Forest Management Research (WO-FMR) staffs appreciate the efforts of our Forest Service hosts in North Carolina. We thank David Loftis and Diana Quinn, Southeastern Forest Experiment Station; Ed Brown, National Forests in North Carolina; and Bobby Kitchens, Southern Region, for their leadership and support in planning, arranging, and hosting the workshop. We also commend the speakers for their excellent presentations, the moderators who led the sessions, the 160 people who represented all National Forest Regions and Research Stations, several Washington Office National Forest System and Research Staffs, and the special guests who participated in the workshop. Special recognition is extended to Art Rowe, District Ranger, Pisgah National Forest, for making the Cradle of Forestry available to our workshop visitors.

On September 16, 1994, William "Bill" Shands died. Forestry has lost a good friend. Bill was one of the keynote speakers during our workshop and a respected voice in the forestry community. He will be missed.

Papers published in this proceedings received limited editing to ensure a consistent format. Authors are responsible for the content and accuracy of their individual papers.

Dennis Murphy
Timber Management
Washington, DC

Nelson Loftus
Forest Management Research
Washington, DC

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Silviculture—Past and Present

National Forests and the Human Legacy: Some History

William E. Shands

Abstract

Today's national forests are the legacy of centuries of human action interacting with natural events. They reflect decisions and actions aimed at realizing basic human aspirations. These activities can be traced from woods burning by Native Americans, to farm clearing by early settlers, to cutting of the forests on a grand scale in the late 1800's to establishment of national forests during the Great Depression to relieve human suffering as well as to restore the land. Since World War II (WWII), timber harvesting has contested with a growing public concern over noncommodity resources and values. Ecosystem management responds to these new public values.

Introduction

My charge is to place ecosystem management in an historic context, with particular application to the national forests here in the Southern Appalachians. This morning, I will discuss how humans have influenced the forests, and how these influences have determined the silvicultural opportunities available to you today. While I will mainly use examples from the eastern national forests and the Southern Appalachians, those of you from the West should be able to extrapolate what I say to your own forests.

First, I want to show you some slides-not many, but they will help me make a point. This first group of slides shows scenes from Pennsylvania, taken shortly after the turn of the century. You can see how the original forest was removed, leaving badly eroded hillsides and an entire region vulnerable to flooding. Today, these hillsides again are forested, reflecting public investment, scientific management, and the resiliency of the eastern forests. These photos illustrate the history of much of the forest land of the East. Trees were cut to provide timber to meet the needs of a growing population-a response to human needs and values. Little attention was paid to how the trees were harvested, resulting in terrible erosion and floods. In recent years, again in response to changing values, there have been major investments in restoration and protection.

This second series of slides are scenes from the Shawnee National Forest in southern Illinois when it was acquired by the Federal Government in the mid-1930's. You can see that it was mainly farmland with severely eroded fields. Farm families, like those shown in some of the photos, found it hard to survive. The Shawnee is one of a score of eastern national forests established during the Great Depression. The Shawnee was established, in part, to help improve the lot of families like those shown in the slides. Again, these Depression Era-New Deal forests were established to achieve broad social goals-to relieve human suffering and help the nation recover from painful economic distress. The Shawnee is another success story; worn out farmland has been returned to forest and made productive once again.

My theme today-reflected in these photos-is this:

The forests on which you practice silviculture today are the legacy of centuries of human decisions and actions. These actions were as diverse as seasonal burning by Native Americans, reforestation by the Civilian Conservation Corps, control of wildfire, and the implementation of laws, policies and programs such as the Weeks Law and Multiple-Use Sustained Yield Act (MUSY).

And as the activities are diverse, so are the people who have left their mark on the land. The role includes Native Americans, explorer Hernando DeSoto, settlers from Great Britain, and in more recent times, George Perkins Marsh, Carl Alwin Schenck, Gifford Pinchot, Hubert Humphrey, and today's foresters, silviculturists, and researchers.

Some people would like to return the forests to some ideal point in the past. This infers that nature has some constant objective for the forests and if left to her own devices would eventually overcome centuries of human influence to achieve

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that objective. This is nonsense. Nature herself is chaotic and unpredictable. That the forests we see around us are the product of disturbance, **some** of which we would call "natural"-ice storms, blowdowns, drought. Over the centuries, human action has interacted with natural events to create the mosaics of species and age classes we see in the forests around us. The desire to "return" the forest to some primeval ideal is itself an arbitrary decision that reflects contemporary human values, not some natural order.

So, too, is the current drive toward ecosystem management a reflection of human values that directs management toward the achievement of human-derived objectives that reflect a heightened concern for "natural" systems.

Now, let's embark on a fast-forward trip through history. I have had to be selective, emphasizing events and trends that illustrate the evolution of human-forest interactions. How then have societal forces influenced the forests and through the evolution of knowledge and values brought us to ecosystem management?

The Native Americans

In the United States, we usually date the beginnings of human impact on nature from the date of European settlement. According to a widely held view, settlers ravaged the wild forest in their drive to conquer nature and domesticate the wilderness. Some recent writers differ, however, asserting that the aboriginal natives had a not-insignificant impact on the landscape (Cronin 1983, Williams 1989). For example, Williams writes that

> By the time European man landed on the eastern shores of America, portions of the woodlands were in the process of being changed to a more open, parklike vegetation, largely through the agency of Indian agriculture and the use of fire for clearing and hunting. Much of the 'natural' forest remained, but the forest was not the vast, silent, unbroken, impenetrable and dense tangle of trees beloved by many writers in their romantic accounts of the forest wilderness.

The Cherokee Indians in the hills and valleys around Franklin, NC, a few miles to the south of where we sit, are said to have been "the largest, strongest, and most highly civilized [of any Indian tribe] in the country" (Nesbitt 1941). While overall numbers were small compared to the numbers that populate these hills today, concentrations numbered in the thousands. The Cherokee had their own version of cities, suburbs, and rural developments with a well-developed civic organization, agriculture, and commerce.

Native Americans manipulated their environment to a significant extent, modifying it to meet their needs. In addition to their settlements, they cleared large areas in the forests to grow crops and repeatedly set fire to the underbrush to make it easier to move through the woods, to encourage the growth of berries and herbs for their own use, and to stimulate young growth favored by game.

Of the effect of Native Americans' use of fire, fire historian Stephen J. Pine (1982) has written, "So open were the woods, one author wrote with a touch of hyperbole, it was possible to drive a stagecoach from the eastern seaboard to St. Louis without benefit of a cleared road ... for this condition, Indian fire practices were largely responsible."

Of the effect of the Native Americans, historian Williams concludes that "... the Indians were a potent, if not crucial ecological factor in the distribution and composition of the forest."

The Era of Settlement

The early European settlers pushed into the woods, clearing them for villages, homesites, and fields in which to grow their croplands. They continued the practice of seasonal burnings, and enlarged the clearings made by Native Americans. But as the numbers of settlers grew, land clearing also increased. Trees were required for homes and fences, and above all-for firewood. But trees also had to be removed to make way for crops and over the decades, the amount of forest land in the East inexorably shrank as the area in farm fields expanded (MacCleery 1992). By the time the logging industry began cutting the forests in earnest in the mid-1800's, much of the Northeast and Central Atlantic States had been cleared and settled.

Nonetheless, extensive forests remained in the Appalachian Mountains and to the west of the settled areas. In the late 1800's, travelers in the Southern Appalachians reported stands of mixed hardwoods with trees more than a hundred feet tall and 4 to 7 feet in diameter. In the coves below Mount Mitchell, government surveyors found "A forest of oaks, hickories, maples, chestnuts, and tulip poplars, some of them large enough to be suggestive of the giant trees on the Pacific Coast" (Ayres and Ashe 1902).

The three upper Lake States-Michigan, Wisconsin, and Minnesota-especially contained a rich lode of timber. Surveyors in the 1830's estimated that standing pine timber in Michigan amounted to 150 billion board feet (bbf), said to be sufficient to build ten million six-room houses (Maybee 1960).

The Industrialization of the Forests

We can date the industrialization of the forests from about 1850. Simple demographics account for the tremendous increase in pressure on the remaining forests of the East. Between 1820 and 1870, the nation's population quadrupled-from 9.6 million to 38.6 million. And from 1870 to 1900, it nearly doubled again-to 76.2 million. This was the era of westward expansion. Timber was required to build Chicago and other Midwestern cities, for crossties for the railroads that soon would span the continent, and for mine timbers.

In the middle of the century, the logging industry developed the technology to cut, transport, and mill immense quantities of timber required to satisfy the needs of a growing, westward-spreading population. The railroad became a common mode of transportation, and found its way into the woods. Steam engines became more efficient, driving the saws that milled the timber into lumber swiftly and efficiently. Between 1850 and 1910, the nation's annual timber production increased eightfold, from 5.4 bbf to 44.5 bbf.

In areas where there were deposits of iron ore, timber was cut to make charcoal to fuel the iron furnaces. In the mountains of western Virginia, now in the George Washington National Forest, there were 54 charcoal iron furnaces in operation at different times throughout the 19th century. Depending on the number and size of trees, it took between 50 and 150 acres of trees each year to provide charcoal for a furnace. Over time, woodsmen cut virtually every living tree within hauling distance of a furnace, with some stands recut on what amounted to 30-year rotations.

Commercial logging on a grand scale came to Michigan in the 1860's, and shortly thereafter to Wisconsin and Minnesota. The magnificent white pines were cut first. In 1892, some 9 bbf of white pine lumber was produced in the three States. That was the end of the pine, and loggers turned to other species-maple, oak, hemlock, cedar, poplar, and jackpine, seeking opportunistic markets.

With the Lake States' supply diminished, the industry turned southward. In 1899, Indiana was first among States in timber production. The lands that are now the Hoosier National Forest were cleared of timber between 1870 and 1910. The story was repeated a few years later in the South.

In the Southern Appalachians, the industry cut the mixed pine and hardwoods with an approach that might be termed extensive high-grading; whatever trees were of value at any given time were cut with little consideration of future species or quality. Harvesting of the timber often was followed by wildfire-with devastating effect on the forest soils. Of the Southern Appalachians, a Federal forester wrote in 1917:

> It is very probable that the productive capacity of forest soils throughout most of this region have been greatly decreased by repeated fires, so that the present forest growth is poorer in composition and quality than it once was (Frothingham 1917).

The Rise of the Conservation Movement and the Birth of Forestry

George Perkins Marsh's powerful 1864 volume, *Man and Nature or Physical Geography as Modified by Human Action* provided the intellectual foundation for the ensuing campaign to protect the nation's forests. People saw the eradication of forests on a grand scale. They experienced floods that seemed to be worse following the removal of timber from hillsides and fire that often raged through the slash. The environmental movement of the era gained momentum, reflecting a shift in public values from exploitation to protection.

It was this public pressure that resulted in passage of the Forest Reserve Act in 1891 and establishment of the national forests. That legislation permitted the President to withdraw forested portions of the public domain-which existed mainly in the West-from vulnerability to private claims. The objective was to protect the forests from overexploitation and maintain forested watersheds for water supply (Dana and Fairfax 1980). This marked the beginning of a true Federal forest policy.

The late 1800's also saw the birth of forestry in the United States, and the origins of Federal and State policies for the protection and management of forests. It was in 1892 that 27-year-old Gifford Pinchot, in his words, brought "forestry to America." The place was George W. Vanderbilt's Biltmore Estate near Asheville, NC.

Pinchot (1947) later recalled:

> The old way of lumbering at Biltmore, and everywhere else, was to cut out of the way all the young growth that would interfere with cheap and easy logging, and leave desolation and a firetrap behind. It was no easy matter to break this habit and train the loggers to respect all small trees of valuable species, no matter how much they stood in the way of chopper or sawyer.

In 1894, Pinchot was succeeded at Biltmore by a German forester, Carl Alwin Schenck. In 1898, Schenck founded the Biltmore Forest School at the site on today's Pisgah National Forest that we call "the Cradle of Forestry" (Schenck 1974). It was about this time that Cornell and Yale Universities established schools of forestry. Thus, at the turn of the century there was a growing band of people interested in managing forests for multiple benefits and who were developing the skills to do so.

And during this period, Gifford Pinchot was developing fundamental tenets of public forest management that endure to this day. Pinchot set out his philosophy in a letter he wrote to himself for Agriculture Secretary James Wilson in 1905 as Pinchot and the new Forest Service took over administration of the forest reserves:

> In the administration of the forest reserves it must be borne in mind that all land is to be devoted to its most productive use for the permanent good of the whole people and not for the temporary benefit of individuals or companies. All the resources of forest reserves are for use and this must be brought about in a thoroughly prompt and businesslike manner, under such restrictions only as will ensure the permanence of these resources ... Where conflicting interests must be reconciled the question will always be decided from the standpoint of the greatest good to the greatest number in the long run (Pinchot 1947).

Creation of the Eastern National Forests

Evolving public values and the influences of broad public policy on natural resources is reflected no more dramatically than in the establishment and management of the Eastern national forests up to WWII. As we sit here in the shadow of the first Weeks Law forest, it is worth examining the history of these lands and how they are intertwined with social aspirations of local people and the nation.

The forests in the East were created in two major bursts-the first dating from enactment of the Weeks Law in 1911, the second occurring during the Depression. Remember, the original forest reserves were established from the public domain, and mainly were located in the West. In the States of the original 13 colonies, there was no Federal public domain, so any land for forest reserves would have to be purchased. However, there was no authority for the Federal Government to purchase land for forest reserves.

The campaign for forest reserves in the East focused first on the Southern Appalachians and the White Mountains of New Hampshire. In the Southern Appalachians, boosters were interested in the creation of a national park, believing that the area's scenic beauty would attract tourists and enrich local economies. While the

White Mountains also were impressive features of the landscape, there was growing concern over flooding attributed to the removal of forests at the White Mountain headwaters of major streams. A flood in the late 1880's had damaged cotton mills in Manchester, NH, and left 6,000 workers jobless.

A 1902 report by Agriculture Secretary James Wilson on forest conditions in the Southern Appalachians favored a forest reserve rather than a national park. Wilson built his case on watershed protection, arguing that because their importance for agriculture, water power, and navigation, the region's rivers were "absolutely essential for the well-being of the nation." He argued that conservation of the forests was the key to regulation of the rivers (Wilson 1902). But the opposition, led by House Speaker Joe Cannon ("Not one cent for scenery"), was formidable.

Although support for the acquisition of forest reserves had spread to other parts of the East, flooding again proved decisive. In 1907, Pittsburgh was devastated by floods originating in the headwaters of the Monongahela River in West Virginia. Two years later the West Virginia State legislature enacted legislation permitting the Federal Government to buy land for what became the Monongahela National Forest (Shands and Healy 1977).

In 1911, Cannon's opposition was finally overcome. The Weeks Law permitted the purchase of "forested, cut-over, or denuded lands within the watersheds of navigable streams ..." Thus, Federal acquisition of forests was linked to the Federal Government's authority over interstate commerce.

Through 1923, 11 forests were established, beginning with the Pisgah National Forest. While their number included the White Mountain in New Hampshire and the Allegheny in northwestern Pennsylvania, the rest were located in the central and Southern Appalachians. In 1924, Congress enacted the Clarke-McNary Act, which added production of timber as a purpose for establishment of national forests. This was a response to an interest in national forests in States where protection of water flows was not critical.

The Depression and the New Deal Forests

The second pulse of eastern national forest establishment occurred during the Great Depression. The New Deal forests-22 in number-were created out of the suffering of land and people- land that had been abused and people trapped in economic despair. These forests responded to the economic imperatives of the era, particularly the deterioration of farm-based economies. They also provided a base of operations for the Civilian Conservation Corps.

On these new national forests, the Forest Service concentrated on acquiring land, controlling wildfires, and beginning the process of restoration. Nationally, however, management of all the national forests was custodial. Timber was harvested, but in relatively small amounts by current standards; the Forest Service was seen as the trusted custodian of the national forests, protecting them from fire, erosion, pests, and timber thieves.

The Post-War Era and Multiple Use

All that changed following WWII. A new wave of conservation emerged and policy was to be increasingly shaped by new and powerful interest groups. As the economy boomed and a pent-up demand for housing was released after the war, the national forests were subject to unprecedented pressures for timber-especially for softwood sawtimber used in construction. In the Pacific Northwest, particularly Washington and Oregon, industry had sustained the wartime demand by cutting its lands beyond sustainable yields. However, abundant supplies of old-growth softwood species remained on the national forests in the region. In 1952, the National Forest System supplied only 14 percent of the nation's softwood sawtimber; in 1970, it was providing 29 percent (Shands and others 1979). Total national forest timber sales increased from 3.4 bbf in 1950 to 13.4 bbf in 1970.

But it was recreation that focused the public's attention on the national forests as never before. The rise in demand for timber following WWII was accompanied by an even sharper increase in recreation use of the national forests as they were discovered by people eager to camp, backpack, and otherwise experience the outdoors. Recreation interests, under the banner of resource conservation, became a powerful advocacy group. At the core of the coalition were traditional sportsmen-hunters and fishermen-who were joined by growing numbers of campers, hikers, backpackers, and others who enjoyed the outdoors.

With recreation use burgeoning, the Forest Service thought it useful to explicitly recognize its concern for outdoor recreation and other nontimber uses of the national forests. In 1960, the Forest Service persuaded the Congress to enact the MUSY Act. That Act, which codified long-standing Agency policy, provided that the national forests were to be managed for "outdoor recreation, range, timber, watershed, and wildlife and fish." The MUSY Act also explicitly reaffirmed that wilderness was consistent with multiple use.

The MUSY Act required "the management of all the various renewable surface resources of the national forests so that they are utilized in the combination that will best meet the needs of the American people." Further, the Act provided that "some land will be used for less than all the various resources," implying that some uses could be accorded primacy in some places. However, passage of MUSY by no means assured equity among the resources or a deemphasis in timber.

The assertion of new values was given impetus by the Outdoor Recreation Resources Review Commission (ORRRC). During the 1950's, recreation and conservation organizations continued to grow in numbers and influence. In 1958, they were able to persuade Congress to establish the Outdoor Recreation Resources Review Commission, commonly referred to by its acronym ORRRC. Chaired by conservation leader Laurance S. Rockefeller, with bipartisan representation by some of the most powerful members of Congress, its 1962 report focused public attention on proposals that conservationists had been promoting for years. Delivered to a sympathetic administration, the ORRRC report loosed a torrent of legislation and administrative action. National systems of wilderness, wild and scenic rivers, and trails were established. The Land and Water Conservation Fund (LWCF) was created to provide money for acquisition of land by localities, States, and Federal agencies. Finally, a new agency-the Bureau of Outdoor Recreation-was created to provide a locus of Federal outdoor recreation policy and to administer the LWCF.

Actions taken in response to ORRRC's recommendations had profound implications for management of the national forests.

- With LWCF money, 1.2 million acres of land with exceptional outdoor recreation potential were added to the national forests.
- By Congressional action, millions of acres of national forest lands and waters were given special designations-as wilderness, wild and scenic rivers, national recreation areas-that forbid or limited some uses, especially timber production.
- And as a result of the indepth studies of potential wilderness areas and the inventories of potential wild and scenic rivers, the public became more aware of the national forests' superb back-country and their scenic, wildlife, and ecological values.

Changing public values also were reflected in an array of environmental legislation as the condition of the nation's environment attracted public attention and concern. The National Environmental Policy Act (NEPA) was to have a profound impact on how all Federal agencies, including the Forest Service, conducted the public's business.

Increasingly, the Forest Service found itself in a dilemma: how was it to allocate resources and uses when demands for all uses were intensifying and often in conflict on specific parcels of land? As recreation use soared, the Forest Service also was under pressure from Congress and the executive branch to sell more timber to meet the demands of a growing population and expanding economy. Whereas Congress provided funding to sell 5.6 bbf in 1950, it appropriated funding to sell 12.8 bbf in 1969.

And the Forest Service made another decision that led to greater attention to its timber program. In the 1950's and 1960's, the Forest Service linked its overall budget to timber harvest levels. Thus, in order to get more money from Congress, it had to cut more timber (Crafts 1969). As timber harvests soared, conservationist interest in the national forests solidified.

Clearly, new values were colliding with the agency's views of how the national forests should be managed. The tide was clearly running with those who favored greater attention to environmental quality and less to the production of commodities. In 1972, then-Forest Service Chief Ed Cliff told Forest Service personnel that "Our programs are out of balance to meet the public's needs for the environmental 70's. Our direction must be, and is being, changed" (USDA Forest Service 1970).

From its awakening under the banner of recreation, public interest in noncommodity resources and values of the national forests broadened and deepened. This is reflected in the major laws affecting the Forest Service enacted between 1960 and 1980. During that two-decade period, Congress enacted no less than 30 laws affecting national forest management whose major thrust was resources conservation, recreation, or environmental quality.

Environmentalism, Clearcutting, RPA, and NFMA

In the 1970's, the public began looking at what was taking place on the national forests as it never had before. Management practices, first on the Bitterroot National Forest in Montana and then on the Monongahela in West Virginia, stimulated Congressional review of national forest policy. In both cases, local citizens aided by national conservation and environmental organizations, challenged Forest Service management. The result was a body of law that narrowed the Agency's management discretion, mandated a complex, localized planning process for individual national forests, and required that the public be consulted throughout the planning process. This, combined with the Forest Service's own provisions for public appeal of its management decisions, have given interest groups considerable power to affect Agency decisions. Most importantly, these new laws disputed the premise that forest management involved technical decisions best insulated from politics. The era of the "trust us, we know what's best" brand of forestry, had come to a close.

The Forest and Rangeland Renewable Resources Planning Act of 1974 was a partial response to the building controversy. Its intent was to rationalize forest policy, and perhaps eliminate some of the conflicts. In introducing the legislation that began the RPA, Humphrey said, "... To put it bluntly, we have a mess on our hands. Instead of having a comprehensive plan for the governing and protection of our resources, we have tended to focus on each problem individually."

Humphrey believed that from the collection of information (the RPA Assessment), rational policy would emerge (the RPA Program and the President's Statement of Policy). Its detractors notwithstanding, RPA has generated information and made it widely available. But, perhaps its greatest benefit-and one not widely recognized-is the stimulation of discussion about issues at the highest levels within the Forest Service.

Then came the National Forest Management Act of 1976. Strictures on Forest Service management, cumbersome procedures that leave the Agency vulnerable to legal action and the mandate for public involvement all reflect the loss of Agency credibility that can be traced back to that fateful 1950's decision to link Agency budgets to the timber program.

Some Forest Service personnel see forest planning as an onerous burden. Others, however, are beginning to see forest planning as an opportunity to engage in a dialogue with the forests' clients. Certainly, Chief Robertson consistently exhorted the Agency to engage in a higher level of dialogue with its clients and to "promote grass-roots participation in [the agency's] decisions and activities."

On to Ecosystem Management

Which brings us to ecosystem management. Let's recap, briefly.

We have seen how the public's concern-indeed, outrage-over intensive cutting of the forests in the East and the attendant environmental effects resulted in the creation of forest reserves in the West and later, enactment of the Weeks Law and the establishment of national forests in the East.

Similarly, we have seen how burgeoning timber harvests following WWII combined with a growing interest in recreation and concern over the quality of the environment generally brought us to a new assessment of policies for the national forests. The result: ecosystem management.

What of the future? Here is what I foresee:

A rejuvenated spirit of innovation. Launched in 1990 as the Forest Service's response to public discontent over national forest management, New Perspectives released change agents throughout Forest Service Research and the National Forest System. This spirit of innovation will continue to be a hallmark of ecosystem management.

Growing recognition of the complexity of forest management. Ecosystem management-concern for all the bits and pieces of the forest-is extremely complicated. Ecosystem management will require skilled silviculturists who can manage vegetation beyond timber for the full range of benefits and values.

An increased interest in the use of public lands to provide goods and services for which they are especially well suited. This approach, which I call management for distinctive values, emphasizes the special values of each individual national forest. Each forest will provide a range of values and uses, but not compete with what is offered by other public and private lands in its area (Shands 1988).

More collaborative planning with the public as participants in decisionmaking. The "Trust me, I know what's best" era of forestry is gone forever. Ordinary people are demanding a voice in decisions that effect their lives. This will result in better decisions and greater Agency credibility. And new, stronger relationships between Forest Service Research, the National Forest System, and the public. No longer can anyone work in isolation. Many people can contribute pieces of solutions. No mater what your job description, you have a responsibility to help forge these new cooperative relationships.

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Ecosystem Management in the Forest Service

Ann M. Bartuska

Abstract

The adoption of ecosystem management as a policy for the Forest Service was announced in June 1992. The policy emphasized using an ecological approach in the management of natural resources, incorporating the best available science, forming partnerships in the accomplishment of management objectives, and working with stakeholders to define short- and long-term objectives for the land. Ecosystem management recognizes that ecologic, social, and economic factors must be integrated in order to accomplish our objectives.

Background

Why does it seem that ecosystem management is the current "buzzword" that everyone is using? The answer is obvious if we look at the issues that we, as natural resource scientists and managers, are contending with every day. On the one hand, we are trying to provide wood products for homes, paper, and other uses; to provide abundant clean water for agriculture and human development; and to provide abundant and diverse recreational opportunities. As technical specialists who understand how "nature" functions, we are also charged with the conservation of biological diversity, to provide free-flowing waters for fisheries, to protect sacred places, and to look ahead several decades to ensure ecosystem sustainability. This is a challenge! In 1990, the Forest Service initiated the New Perspectives program as a pilot effort to provide a mechanism and an incentive to change how national forests were managed. Many of the projects undertaken through New Perspectives were successful in that they enabled the managers to look at their natural and human resources differently, and ultimately, to think differently. The adoption of a policy on ecosystem management is a natural outgrowth-and evolution-of New Perspectives.

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Definition and Guiding Principles

On June 4, 1992, at that time Chief of the Forest Service, Dale Robertson, announced a commitment to implement a policy of ecosystem management throughout the Agency. In the letter to employees, the policy was described thusly:

> "Ecosystem management means using an ecological approach to achieve the multiple-use management of National Forests and Grasslands by blending the needs of people and environmental values in such a way that National Forest and Grasslands represent diverse, healthy, productive and sustainable ecosystems."

There are several concepts embedded in this "definition" that are important to emphasize. First, multiple-use is the Forest Service's legal mandate; however, it can be accomplished using ecological principles. Second, humans are recognized as being an integral part of ecosystems-they help shape and are shaped by ecosystem structure and function. This does not mean that human needs take pre-eminence over the other components of the ecosystem, but the needs should be factored into management objectives. Finally, and ultimately, the policy says that our overarching goal is to achieve ecosystem sustainability, which means we must better understand how ecosystems function and must incorporate that knowledge into our short- and long-range planning.

From the policy statement, four Guiding Principles have been identified to guide the implementation of ecosystem management. These statements come from the USDA Forest Service Mission, **Vision and Guiding Principles:**

- We will use an ECOLOGICAL APPROACH to multiple-use management.
- We will form PARTNERSHIPS to achieve shared goals.
- We will promote grass-roots PARTICIPATION in our decisions and activities.
- We will use the best SCIENTIFIC KNOWLEDGE in making decisions and select the most appropriate technologies in management of the resources.

Integrating these four principles calls us to assess the function and structure of ecosystems, use the very best scientific knowledge we can, and share that knowledge with partners in agencies and publics in open participation.

So What is Different?

Many people say we have been doing ecosystem management for a long time; that there is nothing new about this concept but it is just a "new handle" for Washington bureaucrats to make policy points. While it is true that we have been following some of the principles of ecosystem management, these principles have not been consistently applied in all actions. More importantly, the ecosystem science is relatively new, and concepts and knowledge about ecosystems has been gradually unfolding over the last few decades.

A recent report from the Society of American Foresters (SAF 1993) included a simplfied comparison of ecosystem management to a more traditional approach to management that I have slightly modified.

What this comparison describes is a shift from focusing on a particular unit of production on a specific piece of land to a broader view. The broader view first identifies the overall condition of the ecosystem at issue, and then attempts to identify the multiple products which are available from that larger landscape, where long-term sustainability of the ecosystem and it's health is a priority. Clearly, there are some management areas which have utilized the ecosystem management model without necessarily describing it in those words. The Forest Service hopes to achieve, through the adoption of an ecosystem management policy, a more consistent application of these ideas on all our lands. We also hope to provide the knowledge and tools needed to achieve long-term ecosystem and forest health through the Forest Service's Research and State and Private Forestry programs.

Implementation

"Ecosystem management" is more then a set of management prescriptions that can be codified in a manual. It is shorthand for a whole array of activities, not the least of which is a behavioral change in how one practices land stewardship. Many of the concepts are not new. What is new is the way the pieces are put together. Is this just rhetoric or is there substance to this change? The implementation of a policy of ecosystem management will need to address all areas of Forest Service activities, from budget to research programs, from the skills of our employees to our customer service. One essential ingredient is that CHANGE and adaptability will be a constant. As our knowledge and abilities increase, we will need to quickly and readily incorporate this knowledge into our actions. Some call this adaptive management,

	Traditional Sustained-yield Management	Ecosystem Management
Objective	Sustained flow of specific products, constrained to minimize adverse effects.	Maintains ecological and desired system condition, within which a sustained yield of products is achieved.
Scale	Stands or aggregates of stands.	Landscapes and aggregates of landscapes/watersheds.
System character	Emphasizes production efficiency but within environmental constraints.	Retains complexity and processes, provides framework for the whole system.

but by any name, the key is to recognize that ecosystem management will not be accomplished overnight and we need to be prepared to adjust with new knowledge.

Using the Guiding Principles as a framework, here are some ideas and examples of how ecosystem management will be implemented within the Forest Service.

Ecological Approach

The science of ecology will be applied to multiple-use management, recognizing that people are part of the ecosystem we manage.

- **Landscape-level Analysis.** Our ability to integrate our knowledge and planning over larger spatial areas is essential. In the Pacific Northwest, planning of projects considers scales well beyond the "project" (often 2,000-3,000 acres) to consider a large enough scale (often 50,000 or more acres), that adequately describes the functioning of ecosystems.

- Ecological Classification System. A hierarchical classification system has been adopted by the Forest Service to serve as a template for describing ecosystems at multiple scales. The Chippewa National Forest, like many national forests around the country, is classifying ecosystems to identify, characterize, and delineate units of land with similar features. This classification system serves as the basis for communication across boundaries, including other Federal agencies and the States (e.g., Wisconsin).

Partnerships

Sharing responsibility for land management is fundamental. Ecosystems cross boundaries, making the need for cooperation, coordination, and partnerships a necessary to achieve mutually agreed-upon goals.

- Interagency Working Groups. The formation of ad hoc groups to bring organizations together to share information and to develop common goals has become the rule rather then the exception, and is consistent with recommendations from the National Performance Review. In the Northeast Region of the Forest Service, 19 Federal and State agencies have joined together to develop coordinated strategies on various aspects of ecosystem management, including large-scale planning.

- BLM/FS Planning Team. At the national level, the Bureau of Land Management and the Forest Service have formed interagency teams to address and formulate needed changes in regulations and directives necessary to implement ecosystem management in a consistent manner across Agency boundaries.

Participation

Grass-roots public involvement, communication, incorporation of public needs and desires into management decisions characterize the changing connection between the Federal government and the people we serve.

- **Local involvement in setting management goals.** Those who have a stake in the outcome of Federal land management and those who want to benefit by the increased understanding of ecosystems to the management of their own lands will be welcomed to the table. In the Applegate Partnership (Oregon), local residents, industry, conservation groups, and public resource management agencies have joined together to proactively manage the Applegate River watershed to achieve sustainable natural resources through the incorporation of ecosystem management principles.

Scientific Knowledge

Management decisions must take into consideration the full range of information available; management actions must be adapted as greater knowledge is acquired from those same management actions. The scientist-manager partnership at all levels of the Forest Service is fundamental to accomplishing the ecosystem management policy.

- **Ecosystem Research.** Ecosystem research does not belong just to ecologists, but it does require an interdisciplinary effort that integrates the pieces of a system into understanding how the whole functions, incorporating social and natural resource scientists. The Forest Service initiated an in-house, competitive process in FY 94 which explicitly called for projects that examined ecosystem structure and functions, utilzing a team approach, and including land managers as part of the team.

- Adaptive Management. Adaptive management may be one of the most effective tools to implementing ecosystem management, especially as a mechanism to incorporate improved knowledge into decision-making systems. Adaptive management illustrates that planning, monitoring, and evaluation (i.e., assessment) are all equal in our management activities. It is an approach that requires a strong scientific basis, and acknowledges up-front that management plans are only as good as our most current knowledge. The Forest Service, along with other natural resource managers, will need to revise our planning regulations, directives, and other tools into a mechanism that works to bring science and new information into the mainstream.

The above list is neither exhaustive nor exclusive. At the local, forest, station, or regional level, there are numerous examples of people incorporating ecosystem management into their daily work activities. There is no "ecosystem management cookbook" that tells all. It is up to each one of us to identify how the principles and concepts which underlie ecosystem management can be incorporated into each of our actions.

Acknowledgment

Numerous individuals from throughout the Forest Service and elsewhere have contributed to the thoughts embodied in this paper. I am especially appreciative of the Ecosystem Management staff (Bill Sexton, Chip Cartwright, Pam Kelty, and Kathy Martinez) and the over 50 detailers who assisted the Forest Service's EM staff in 1993 to accomplish our part of ecosystem management implementation.

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The Role of Silviculture in the Modern Context

David Wm. Smith

Abstract

Silviculture is a biologically based, evolving science impacted by social, political, and economic factors of the past and present. In the future, silviculture will have to respond to yet unknown biotic, abiotic, and human-induced stresses. Tomorrow's silviculturists must react to these stresses in a most innovative manner, using advanced technology to integrate what is already known with predictions of what is not known, and applying this knowledge to solve complex ecosystem-level forest management problems. The goal of silviculture and silviculturists in the modern context is to meet society's needs while ensuring healthy and sustainable forests in perpetuity.

Introduction

It is indeed a privilege for me to be here today and to have the opportunity to participate in this National Silviculture Workshop.

One could use a number of strategies for discussing the "future" and what constitutes "modern" . . . modern being defined by Webster as "of, pertaining to, or characteristic of recent times or the present," or "of, or relating to advance style, technique, or technology."

The definition really leaves things rather wide open, doesn't it? The primary topic of this workshop is silviculture, and silviculture is an evolutionary, ever-changing, and multidisciplinary entity. Silviculture, as we know it today, has been molded by how it evolved, and what happens in the future will be guided, to some degree at least, by what is happening today. The practice of silviculture in the United States has been evolving at a relatively constant rate. The rate of change is directly related to our level of knowledge and technology, and to the values and uses of forest resources as perceived by landowners and managers based on the specific needs and wants of society. In other words, the development of silviculture methods and applications is driven to a significant degree by the market place in an economic context and by the values of forest resources as perceived by society.

While the development of silviculture tends to be more or less steady, the reaction of society tends not to follow a gradient, but to occur as an abrupt change from one way of thinking to a quite different plane or level much the same as teenage fads change rather abruptly and often without much advance notice. It is difficult for us as professionals to address these changes because of the complex nature and the associated interactions that may occur whenever we make alterations in biologic systems. Our knowledge of cause and effect relationships, and our ability to assess and predict the effects and impacts of forest manipulation are certainly incomplete. It is, therefore, imperative that we acknowledge the desire to change, but to proceed with utmost caution when dealing with practices that by their very nature have impacts projecting years and even centuries into the future.

A decision to implement a particular silvicultural technique or system at any point in time is based on whether it is biologically sound, economically attractive, and socially (includes politically and legally) acceptable. If the practice or system is not biologically sound, then the silviculturist is ethically bound to proceed no further without disclosing completely and clearly the implications of the action. Chances are that the long-range economic effects of an unsound biological decision will be a significant loss.

Another key point that must be clearly understood before we proceed: you cannot manage anything until you have a clear understanding of what you are going to manage for. In other words, what are your objectives? Be sure these objectives originate from the appropriate "owner." A preconceived notion or idea of the objective will undoubtedly create a bias and taint the decision-making process, no matter how well meaning it is.

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As I read opening papers in the proceedings of several previous National Silviculture Workshops, I became keenly aware of the text and literature cited and how different each author tried to be. In like manner, I will try to be different and unique in the way I approach the topic of the role of silviculture in the modern context.

Implications of the Past

Looking back, we are just beginning to understand the implications and effects of the forest management as it was implemented in the 1930's. Forest fire suppression is a good example. As a result of that single management practice, the structure and composition of forests across the country have been altered. A long time will pass before a new balance in these altered forest ecosystems will be achieved. Looking back at what some of the early leaders in silviculture wrote provides a great deal of insight into how our thinking and actions have evolved. Tourney (1928) in the preface to his first silviculture text wrote:

> "It is with a measure of hesitation that the author sends the manuscript for this volume to the printer. He realizes the limitations imposed on one who attempts the exposition of forest vegetation in a country as large and as diverse as the United States from the standpoint of the causes which bring it into existence. Although the intensity and duration of the various factors of the site can be known and measured and although the vegetation itself, to a degree, is amenable to instrumentation, we are very far indeed from methods of perfect interpretation of cause and effect."

By 1935, we were just starting to control fire, and one of the most important forest management innovations was just being implemented in Midwest and Lake States: reforestation with pine. Pine plantations were being established on worn-out farmland and on cutover forests in Lake States and in the South, and shelterbelts were being planted all over the Great Plains and in many areas in the Midwest and Lake States.

In the 1920's, our forests were still plentiful in the eyes of the general public, and our objective was solitary. In most areas, we were still mining the existing stands of old-growth timber. It was not until the early 1930's that the general public started to take stock of the great potential of the country's depleted forest lands. The Great Depression had settled in, and work in the Nation's forests was seen as one way for a struggling Nation to put people back to work and gain back economic strength. Thus, forest management in the United States started to evolve, and silviculture became identified as a distinct component of management. These ideas are reflected in the writings of the time.

> "In this present transitional period, when it has begun to dawn upon the logger that even for his business a combination of utilization plus production may be more profitable than destructive utilization alone, the costs of silviculture are receiving close scrutiny."
>
> "The practice of silviculture for the production of wood crops is pointless unless these crops are harvested and utilized." (Hawley 1935)

The profession of forestry was taking shape. Silviculture as a discipline within the profession had been born and was starting to come-of-age. Professional foresters were using their years of experience in observing how, where, and why forests grow to guide them in formulating silvicultural practices that, when implemented, would result in forest stands that would meet the needs of a thriving forest industry, an industry that would ultimately depend on raw material from second-growth, managed forests. In the 1930's, silviculture was mostly an art with just a bit of information from the "young" science of forestry sprinkled in. There was very little known about American silviculture. Hawley (1935) attributed this lack of knowledge to three causes:

> "First, silviculture as yet has been practiced to a limited extent and during a period of only a few years in North America, whereas it requires several decades to build up definite silvicultural practice even for a single species.
>
> Second, silvicultural practice is essentially a local consideration, varying in important details from forest to forest. Generalizations and the intelligent use of knowledge gained by others develop slowly under such a condition.
>
> Third, application of knowledge to treatment of a forest is seriously hampered when such knowledge is fragmentary. Silvics, which in theory affords the

scientific basis for silviculture, is still in its infancy so far as furnishing definite information for use of practitioners on numerous important problems is concerned."

Due to world-wide turmoil, not a lot happened in the forestry profession during the late 1930's and early 1940's. Hawley (1946), in his revised edition, put things in perspective when he made the following statements:

> "The chief concerns of forestry throughout the country during the last half century have been propaganda to obtain support for the forestry movement, the acquisition of public forests, the establishment of an adequate system of forest-fire control, and the organization of such areas as have become available for timber growing ....
>
> It should be evident from what has just been said that up to the present time the forest manager, engrossed with urgent problems of acquisition, organization, protection, and development of timber sales in virgin forests and in previously overcut culled and second-growth forests, has had his hands full without giving much attention to the silvicultural systems (including the methods of obtaining reproduction, of harvesting the mature timber, and of tending the new crops) which will ultimately be introduced."

Hawley (1946) further stated that:

> "When this country actually reaches the point where the decadent growing stock in virgin forests has been removed and the culled and second-growth forests have recovered from their present depleted condition, application will probably be made of all the silvicultural systems described in this text. It is likely that the methods of reproduction producing even-aged stands will be used most often, because of the greater simplicity of management and consequent lesser demands on personnel, and because concentration is more efficient than scattered operations."

In the 1950's, there were individuals, both inside and outside the forestry profession, who were looking ahead at the expansion of forest management objectives to include a full array of uses and values, not just wood as a raw material for traditional construction and paper products industries. The 1960's through the 1980's saw the birth and development of the environmental movement and society's real concern for the health and sustainability of global ecosystems.

Where We Are Today

Silviculture has been allied to timbering and timber harvesting because timber production was the primary objective for the first half of this century; however, that in no way suggests the practice of silviculture is limited to wood production. There is, both active and passive, and conscious and subconscious, resistance to the shifting of objectives to include other values and uses of trees. As has happened in the practice of silviculture, this change has probably been the best and most stimulating professional event that has ever happened to me. Over a relatively short period of time in my career, I have had to draw on things that I learned during my formal education, and many things that I didn't, in order to attempt to solve the problems that have been posed. We are being asked to apply the knowledge of silvics to solve forest management problems. Because of silviculture's reliance on silvical principles and ecological concepts, it has become painfully apparent that our knowledge often falls far short of the need.

I recently completed an evaluation of oak regeneration information in the United States. There are 58 recognized native oak tree species in the United States and Canada, one naturalized tree species, and about 10 native shrub oak species. Oak is the largest tree genus in this country and is the most important hardwood. In terms of the level of knowledge available about oak regeneration, we are at a distinct disadvantage. Of the 31 species reviewed, we have a significant pool of knowledge for only 3 of the 31 species. We have modest regeneration information for an additional 7 species and only limited information on the remaining 21 species. For the 27 native oak species that were not reviewed, there is virtually no information available (Smith 1993). So where are we when it comes to the knowledge of silviculture? Silviculture is still the art and science of establishing, growing, and tending trees and forests to satisfy the owner's or owners' objectives. We have very large gaps in our silvicultural knowledge; however, we certainly have sufficient knowledge to get started with virtually every management objective that we are likely to be asked to achieve. In other words, let's not let a lack of knowledge be an excuse not to manage.

For those of you who grew up in rural America, the forest was most likely perceived as a place to cut firewood, hunt, gather nuts and berries, cut fence posts, enjoy autumn colors, gather maple sap to make sugar, or sell timber to get money for school. For those of you who grew up as an urban dweller, your initial concept of the forest may have been quite different. Instead, what may have come to mind are less product-oriented uses and values-natural beauty, camping, hiking, observing wildlife or wildflowers, quiet and tranquility, old-growth forests, bald eagles, or wilderness. Whatever you used to think, chances are your viewpoint is probably much broader today, and perhaps includes everything just mentioned above. This is the change that I talked about earlier. Think about the rest of society and how their ideas and values are changing.

In the last 50 years, the United States population has shifted from predominantly rural to urban or suburban. And in the past 10 years, we have seen society's awareness of and concern for forests change from one of complacency to one of deep concern for the future. In addition, people are impacting forests of this country far differently than they did 100 years ago when a developing Nation's economic need for forest products dominated how forests were used. Forest management was barely an idea then, and forests were being exploited, not managed.

Today, we know that forests are a limited resource, and because of their high value and many uses, they must be carefully managed to ensure sustainability. Biological, social, political, and economic factors all strongly influence forest management decisions. The relative weight given an individual factor is highly dependent on geographic location, social attitudes, ownership patterns, and the structural and biological characteristics of the forest. To formulate management alternatives and make decisions, forest managers must fully understand these controlling factors. He or she must foster an atmosphere for understanding by all of the forest users that will allow the integration of these complex issues into forest resource management decisions that will ensure sustainable forest ecosystems in perpetuity. The practice of silviculture lies at the very core of the decision-making process, and it is through the implementation of silvicultural practices that the goals of forest management will be achieved.

I am particularly concerned about political intervention in forest resource management decisions. As professional foresters and practicing silviculturists, we must clearly understand biological reality, short-term political gain, and the political power structure. We are working with a vital national resource that will long outlive even the most tenacious political incumbent. I fully accept the fact that politics and politicians are a cornerstone of our government and society; however, our elected officials must be diligent in their acquisition of information and must carry out their legislative responsibilities in a prudent, informed, and competent manner.

We must avoid "political silviculture," and we must develop and defend the concept of "biological correctness" when formulating and evaluating forest management decisions.

The USDA Forest Service, as a governmental agency and an agent for the public, must devise the means of clearly identifying the goals and objectives on national forest land at the Federal, regional, State, watershed, and stand levels. We need to isolate the instances of political meddling for purely political gains. We need to abolish the practice of political silviculture. We need to have a process for sifting out laws and legal language that pre-empts known biological principles and concepts. The legal establishment was never designed, is not in a position, nor does it have the capability to manage the forest base of this country . . . and it certainly will not be inclined to take responsibility for the results of its actions in this area. Responsibility and accountability will always remain on the shoulders of the professional resource managers.

To this end, the USDA Forest Service has embarked on a new process-ecosystem management-to better manage the Nation's Federally owned forests. In June 1992, F. Dale Robertson, then Chief of the USDA Forest Service, described ecosystem management as:

> "an ecological approach that will be used to achieve the multiple-use management of the National Forests and Grasslands. It means that we must blend the needs of people and environmental values in such a way that the National Forests and Grasslands represent diverse, healthy, productive, and sustainable ecosystems. I'm confident that with our knowledge, expertise, and experience along with a stronger public involvement effort, we can bring the American people and their needs together with

the land they own in a better way than it has ever done before by anyone in the world. That's our challenge under this new policy."[1]

I view ecosystem management as a concept to be integrated into the forest resource management process. The intent is to protect the quality of the environment, thereby ensuring sustainability while also producing the commodities and services that people need. It is, therefore, imperative that impacts of any silvicultural activity be understood in time and space. This includes direct effects within the stand being treated, effects at the "edge" of the stand, the indirect effects at a distance from the stand (i.e., the rest of the ecosystem of which the stand is a part). The concept of ecosystem management does not change the practice of silviculture per se. Silvicultural practices will continue to be applied to trees and stands just as they have in the past.

What is changing is how a particular practice will be evaluated and assessed in terms of its impacts in time and space on all the other components of the ecosystem and on associated ecosystems. As we learn more, we have the ability of understanding more, and with modern computer technology comes the capability for comprehending the complex nature of ecosystem functions with much greater speed and over a much wider area.

I don't think that the underlying concept of ecosystem management is new; however, the emphasis being placed on it certainly is. I think that Tourney in 1928 had things pretty much in perspective when he wrote:

"The great advantage of the ecological concept toward biological forest facts, useful in the understanding of the forest and to serve as a foundation for the practice of silviculture, lies in the recognition of forest communities and in the appreciation that they are not fixed units but are in a constant stage of change. Ecology is of fundamental importance to the forester because it brings a true scientific attitude to the multitudinous problems bearing upon the origin and development of forests. The silviculturist studies the forest in order to assemble scientific facts useful in their economic application to the production of timber. The most comprehensive study of environmental factors by the forester lead to nothing useful, unless the forest vegetation itself is interpreted in harmony with them."

In 1935, Hawley alluded to the concept of ecosystem management when he wrote:

"When the forest must be handled with the objective of furnishing protection to other property, silviculture not entirely in harmony with owner's desire may have to be applied, but this is an exceptional case."

The concept of understanding the impacts of forest management in time and space is an essential component of the forest management decision and assessment process. The concept of ecosystem management in the context that it is presently envisioned will certainly enhance the probability of achieving healthy and sustainable forests.

What About Silviculture and the Silviculturist

I consider silviculture to be the pivotal discipline in the forest management decision-making process. Silviculture in the 1990's is going through a period of transition, adjustment, and adaptation as we align our thinking to applying silviculture to achieve forest management objectives that address a much broader spectrum of uses and values than ever before encountered. In the future, we will be faced with the integration and application of an unprecedented amount of knowledge about the biotic and abiotic attributes of forests and forest systems to aid in solving complex environmental problems that will be created by intense population growth and the associated severe pressure on the finite global resources.

A silviculturist is not a very definable entity. He or she generally did not start out with the idea of being a silviculturist. Silviculturists tend to originate from one of an array of more basic disciplines such as forest management, tree physiology, genetics, tree improvement, forest soils, forest ecology, hydrology, and so on. For a number of reasons and with professional field experience, they sought the position/title of silviculturist. A silviculturist must first be an ecologist, and second be a generalist in many aspects of forest management including policy, economics, entomology, pathology,

[1]Excerpts from F. Dale Robertson, Chief, USDA Forest Service, letter dated June 4, 1992.

biometrics, fire management, wildlife management, fisheries management, and outdoor recreation. In addition, skills or experiences in planning, personnel management, arbitration, sociology, and psychology certainly are helpful. Above all, the silviculturist must be a communicator. If your qualifications fit the above description, I have little doubt that you will be a successful contributor to the forest management team as a silviculturist.

One doesn't become a silviculturist by just taking courses and reading the literature. We learn concepts from the literature and learn to understand these concepts by careful and critical observation on the ground and over time. I never have been in two forest stands that are alike. Without a knowledge of basic ecological concepts and functions, it would be very difficult to make consistent and logical recommendations. I think a silviculturist is the result of an evolutionary process that comes after spending a considerable amount of time observing forests at a multitude of locations over time, and thereby developing a keen interest in the processes, functions, and interactions that occur within a forested ecosystem. The process of becoming a silviculturist requires (1) a thorough understanding of ecological concepts and principles across a range of ecosystems; (2) a comprehensive knowledge of the silvical characteristics of all tree species encountered; (3) a mastery of the research that deals with tree and forest responses to disturbance; (4) a history of lengthy discussions and dialogues about silvicultural issues and forest stand dynamics with colleagues and clients from many places; (5) a thorough understanding of the potential values and uses that are, or may be, available within the forest systems in question; and (6) a full awareness of the economic, social, and political implications and constraints that are in force at a particular place and time.

The silviculturist role in the forest management decision-making process today can only increase in importance in the future. We, as silviculturists, are in an era of political and social change, and we face many challenges in managing the Nation's and, for that matter, the world's forest resources. We must take advantage of the opportunity to make a difference in how we foster healthy and sustainably forested ecosystems.

Again, thank you for the opportunity to be part of this very important conference. I would like to close with two quotes that I think should remain indelibly in our minds:

> "Forest vegetation is composed of plant communities or units of vegetation, developed and arranged in accordance with definite biological laws and is not an aggregation of trees and other plants brought together by chance." (Tourney 1928)

> "Silviculture is an art that should base its practices on the proven findings of many sciences. It must be practiced consistently over a long term of years. It should not be managed by considerations of passing expediency or popular appeal. Let foresters keep to their science of silvics. And let us keep research ahead of practice, so that untested innovations will not get ahead and get off the trail of nature's silvicultural laws." (Munger 1950).

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The Role of Silviculturists in Ecosystem Management

John R. Naumann

Abstract

Silviculturists should take au objective approach to define their role in ecosystem management. No discipline, including silviculture, can claim the lead for ecosystem management because it is au integrated effort. Silviculturists can best contribute to ecosystem management by being a team player, and focusing on those things that silviculturists do best. A role for silviculturists in ecosystem management must be the one they earn.

Introduction

It is difficult for silviculturists to be objective about their role in ecosystem management. Perhaps the question is better asked outside the field of silviculture, but then one has the problem of finding someone who knows something about silviculture, much less ecosystem management. We are probably faced with finding an answer to this question ourselves. If that is the case, we should try to be as objective as we can about our own role.

The question is not a matter of being worthy. Silviculturists are dedicated people with a considerable history of success in managing forest stands. They are professionals with a land ethic. And, there are more trees now than there were at the turn of the century. And, growth exceeds harvest. So what is the problem? We talk to ourselves about our role with an assumption that we have one. Maybe starting with that assumption is a barrier to clear thinking about the question.

Much has been written about ecosystem management, or about our role as Federal foresters, or our past failings, or our future challenges, or .... It is good that we have a lot to say about ecosystem management, but we seem to be groping for a role in this blizzard of white papers. Confusion about our role probably started in 1969 with the National Environmental Policy Act. This law forced us to involve others besides foresters in decisions about the forest. This change was as traumatic to foresters then, as ecosystem management may be to some silviculturists today. A "we-they" attitude still lingers in corners of our organization.

One of the stated purposes of this law in 1969 was, "Enrich the understanding of the ecological systems and the natural resources important to the Nation." This sounds like ecosystem management and I think it is time to take seriously this idea of merging ecological systems with forest resources.

Rather than trying to find new words that describe what ecosystem management is, I will just borrow some already written. In his February 2, 1993, white paper, Karl Bergsvik said: "The point is that for the first time the Forest Service has explicitly stated that the sustained yield of values and uses is a function of the health of the ecosystem and that the latter is a major consideration in establishing the level of values and uses to be provided by the National Forests." Note the words, "for the first time." Ecosystem management is truly a new way to look at forestry. Understanding this is critical in identifying how silviculturists should relate to ecosystem management. As silviculturists, we have always been concerned about the ecosystem and sustainability, but ecosystem management is a different way to get there.

If we can accept that ecosystem management is a new basis for silviculture, what can we say about silviculture itself? In a paper to be published in the Journal of Forestry this December, Kevin O'Hara, Robert Seymour, Steven Tesch, and James Guldin (1994) write: "We believe silviculture to be the key discipline in integrating other resource values into stand structure objectives. It will not be the silviculture of the past, but rather a much broader craft, tied to natural ecological patterns and processes in a modern social context. Stand level operations will focus on what is retained rather than what is removed, and will arrange structures on a landscape in a manner that restores and maintains landscape integrity."

These are good words, but lets keep them in perspective as we seek our role in ecosystem management. A role implies more than what we do

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in the forest; more than the trees we retain or cut to achieve different stand structures. A role directs how we think and how we relate to others. We should be open to thinking about silviculture in a different way. Otherwise, we may find ourselves believing that silviculture is a given, and that if we just apply a little more flexibility to our prescriptions, and a new spin to our terminology, we will still be here in the 21st century, certifying each other, and feeling that the rest of the world is abusing what we believe to be silviculturally correct.

Do silviculturists have a role apart from ecosystem management? Given my understanding of ecosystem management, and Karl Bergsvik's vision, and Kevin O'Hara's view, I don't think so.

We can all think of reasons why we should have a key role. Many of these reasons will be biological in nature and will make perfect sense to us as silviculturists. Think about it. What other activity makes such an immediate and enduring impact on the forest ecosystem as does the cutting and planting of trees? Other activities in which we engage often result in a piece of paper, a strategy, a policy, a plan, or some other thing that will not have a direct influence on the forest. Should not these very significant silvicultural actions be prescribed and implemented by the most knowledgeable and sensitive people available? And yet, this critical role we see for ourselves is not always the role in which we are cast by others.

How do others see us? A survey would be revealing. Lacking that, it might be interesting for each one of us to use our own organization as a mirror for how silviculturists are viewed in terms of role. Don't give much credibility to what the organization says about silviculture. The answer is always yes to the question, "should we practice good silviculture?" Rather, think about how silviculturists are used in our organizations. Are silviculturists a member of the leadership team, able to give insight to important decisions? Are silviculturists given some priority in downsizing strategies? Does our role depend on what we think it ought to be-or does our role depend on how we relate to others? In the interest of maintaining an open mind about this question, I would suggest five things to consider as we go about defining a role.

1. Silviculture is not the solution. Before the Monongehela, before the Bitterroot and the Bighorn and 1973, silviculture was something we did, not what we were. Silviculturists, if recognized at all as specialists, were considered people that cleaned up after the timber sale. In 1973, we made a change. We began a program of educating and certifying silviculturists to prepare prescriptions that stood the test of nature and public opinion. As a result of this program, we made a significant step toward better silviculture. But, we are in more trouble now as an agency than we were 20 years ago. Sound silviculture has not been the answer to our problems.

The silviculturist we talk about today is a relatively new entity, at least as measured in terms of rotation lengths. If we have developed a silvicultural practice in the forests of North America, it is a new and developing practice. And, in spite of initiating a lot of good forestry on the ground, the problems of public acceptance for cutting and growing trees, conservation of biodiversity, and sustainability are of foremost concern today. Ecosystem management, not silviculture, is the best hope we have of dealing with these concerns.

2. Silviculturists did not invent ecosystem management. Silviculturists did not conceive of using landscape ecology principles to guide stand level treatments-did not take a leadership role in promoting a hierarchical approach. The new concepts we are now using came from ecologists and geographers, social scientists, and wildlife biologists. In many cases, foresters have been drug backwards into ecosystem management, protesting all the while that they have been doing ecosystem management all along and did not need to change. The message here is that there is nothing that makes silviculture an inherent component of ecosystem management. Ecosystem management will proceed with us, or without us. It may not be the same without us. It may not be as good, but regardless of our involvement, ecosystem management will play an increasingly important role in guiding land management decisions.

3. Ecosystem management is a group effort. A phrase attributed to Frank Engler says something like, nature is not only more complex than we think-it is more complex that we can think. Ecosystem management is too complicated to fall within the realm of one discipline. It is a concept whose application requires integrated skills. Silviculture provides only a piece of the answer. No single discipline, including silviculture, can dominate the entire scope of ecosystem management. Disciplines must work

together to maintain the system rather than champion a single resource with mitigation for others.

4. Ecosystem management will lead to less intensive silviculture. It is a commonly held assumption that silviculture under ecosystem management must be a more detailed and intensive practice. But, it is becoming increasingly apparent that most times what we do at the stand level will turn out to be extensive rather than intensive silviculture, regardless of how detailed or fussy we try to make it.

Old forestry supposed that we would control functions like insects, disease, and fire. Risk from these agents was given little recognition in management strategies. As we gain an appreciation for larger forest systems, we understand that we cannot control natural agents of change. We can only influence them or learn to live with them.

At least in the West, there is no way we can move far enough, fast enough, to manage the forest ecosystem through stand level silviculture. It will do us little good to micromanage at the stand level. For example, on the Deerlodge National Forest in west-central Montana, 1,017,600 of the 1,206,600 total acres are forested. Of these forested acres, 406,800 are suitable for timber production in the Forest Plan. But only 52,007 acres have been treated with a regeneration harvest since 1945! At this rate, it will take another 313 years to influence just the suitable lands on this National Forest through silvicultural treatment. The ecosystem won't wait that long.

Large forested systems cannot be managed by aggregating treatments developed from the stand level perspective. We have learned that treatments that produced great per acre results often created unacceptable conditions at the landscape level. Many hillsides of regenerated clearcuts are now seen as adding up to a fragmented landscape.

Silviculturists as a group are preoccupied with the stand. Forest stands have been emphasized in our classrooms and perpetuated by our tradition of circumscribing our management of the forest with cutting unit boundaries. But, what is done at the stand level must be supportive of the objective for the larger area, and must be prescribed within the context of the risk of natural change. What must be done in a stand may not be the optimum for that stand. If silviculturists do not understand this, disturbance events and other resource disciplines will write the prescriptions that get implemented.

5. Silviculturists need to recognize their strengths and their weaknesses and find the wisdom to act on the difference. We should identify what we can contribute and focus on those things.

For example, timber should not be just a by-product of ecosystem management. People depend on the forest for meeting physical as well as spiritual and social needs. Silviculture is the logical discipline to make the flow of timber products an enduring and predictable part of the system. The silviculturist can specify those alternatives that achieve a level of harvest consistent with requirements of the ecosystem. Within the range of acceptable variability, what stand densities and species compositions will produce the most wood? We have some unique skills and abilities to solve this problem.

Reforestation is another area of expertise that we have. Bernard Fernow (1902) wrote in his textbook on the Economics of Forestry that, "... nothing needs to be more strongly emphasized and impressed upon the American public, and even upon the young professional forester, than that the main business of the forester is expressed in the one word 'reproduction'." Reproduction is still important today as we move into ecosystem management. If we do not ensure a renewal of the forest somewhere in the sequence of cuttings designed to sustain the system, the system will begin to function in a manner inconsistent with our goals. While this may seem obvious as a principle, it is not always clear how regeneration of the appropriate species, free to grow, will evolve from some of the so called nontraditional harvests.

In another example, silviculturists can offer an ability to relate to the forest in real, rather than conceptual terms. Silviculturists are among the few left who have a feel for what can be done in the forest. That is because silviculturists deal with real-time activities rather than abstract plans and ideas. Up to this point in time, we have learned from our practice, but only because we have observed and evaluated our successes and failures in the field. If we stop that evaluation process by taking knowledgeable silviculturists out of the field, we will stop learning. We will not know if the concepts of ecosystem management are finding application in the forest. Silviculturists can be on the front line of the monitoring process for ecosystem management.

We could list other skills and abilities, but the point **is,** silviculturists have something unique to offer ecosystem management.

In summary, it has been said that major advances **are started** by people from outside of a discipline **because they can see things from a more objective point of view. Silviculturists are coming from behind on ecosystem management. They can turn that to an advantage if they take an objective approach and don't get hung up on old ideas. We have focused too narrowly on trees and the stand. We have assumed that if we managed each stand to its potential, it would all add up to a managed forest.**

Because of this myopic vision, ecosystem management can happen without us. On the other hand, we can have a role if we want one. We cannot, however, claim the lead for much of what happens today in the forest. Nor should we, because ecosystem management does not belong to any one discipline.

Silviculturists are implementers. They have the skills and experience to make a strategy happen on the ground. Silviculturists have special insight into how to sustain products from the system, and how to regenerate a new forest that will meet commodity as well as ecosystem goals.

An interesting question for us now is, should silviculture, as a discipline, have a role? That is a hard sell in today's market. Let's not waste time trying to tell others what we think silviculture can do for them. We are more an organization of individuals than people acting out job descriptions and roles. The most significant thing that silviculture can bring to ecosystem management are people, certified and willing to help develop this new basis for forestry.

The role of silviculturists in ecosystem management is one of involvement. This involvement is not defending what forestry has been. It is not assuming we have a role because of some inherent value we think silviculture may have. Rather, it is taking an objective look at forestry as it is today and contributing those things that silviculturists do best. Most importantly, it is understanding that the only role silviculturists really have is the one they earn in the group they work with on a day-to-day basis.

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Defining Objectives of Management

Applying Ecosystem Guidelines on the Ochoco National Forest

Donald C. Wood

Abstract

The Ochoco National Forest approach to ecosystem management describes a mix of vegetation conditions across the landscape. These conditions are based on historical range of variability and the needs of native plants and animals. It is also designed to restore or emulate the natural function of fire, insects, and disease in the ecosystem. The forest lands are classified based on potential plant association and existing condition in terms of stand structure and successional species composition. The existing condition is determined using Landsat mapping with Graphic Information Systems (GIS). This is compared to the desired condition. Differences between existing and desired viable ecosystem condition is the driver for future management activities. For the silviculturist, this means new objectives based on target stand conditions, need for a variety of prescriptions, need for consistent terminology, and a need for creative prescriptions that are based on the basic principles of silviculture.

Introduction

A viable ecosystem team was established on the Ochoco National Forest to provide guidelines for applying ecosystem management on the ground. The team decided to work on forested systems first but recognized that guidelines for riparian and nonforest vegetation systems were also needed. This paper will describe the classification process and discuss new challenges to the silviculturist. This viable ecosystem approach is still in draft form, so it has not been officially adopted but it has had widespread review and the concepts are being applied on the districts. Copies of the document are available from the Ochoco National Forest.[1]

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[1] **The "Viable Ecosystem Management Guide, Ochoco National Forest" is currently in draft form. The final is expected in the spring of 1994. Authors are Andy Eglitis, Susan Johnson, Deb Roy, Mike Simpson, Don Wood, and Dave Zalunardo. All are employees of the Ochoco National Forest except Andy Eglitis who is a Central Oregon Area employee. Copies of the draft or final, when available, can be obtained from the Ochoco National Forest. The mailing address is P.O. Box 490, Prineville, OR 97754. Tables and figures are taken from this draft. Note: This document is about 200 pages in length.**

The Ochoco National Forest is located near the center of the state of Oregon. The major tree species is Ponderosa pine (*Pinus ponderosa,* Laws.). Other tree species are grand fir (*Abis grandis* Dougl.), Douglas-fir (*Pseudotsugo menziesii* Mirb.), lodgepole pine (*Pinus contorta* Dougl.), western larch (*Larix occidentialis* Nutt.), Englemann spruce (*Picea engelmannii* Parry ex Engelm.), and western juniper (*Juniperous occidentalis* Hook). The climate is characterized by hot dry summers and cool moist winters. Lightning fires played a major role in shaping the forest in the past. These fires kept the open parklike conditions that the Ochoco Mountains are noted for.

Landscape Classification

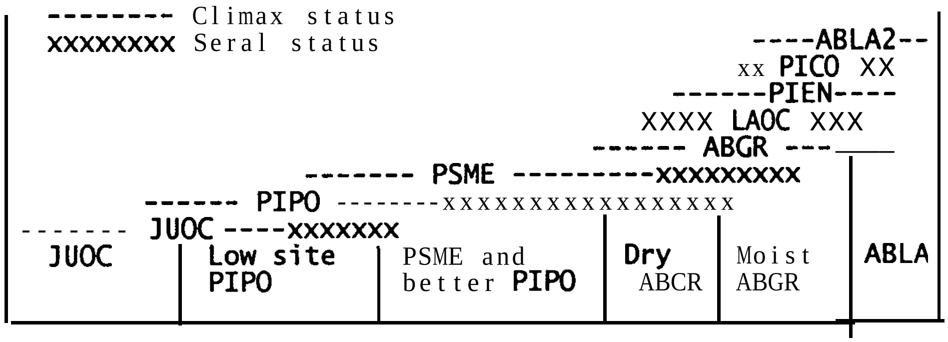
The landscape level that was selected for use in this application was the subwatersheds with a recommended size of 10,000 to 30,000 acres. These boundaries are located in the Forest Geographic Information System (GIS). Lands are also classified based on plant association potential, dominate tree species, and the size of the dominate canopy layer.

Plant Associations

Six major plant association groups (PAG) were identified for the Ochoco National Forest. These are grouped based on climax species and successional trends. These groups and the major tree species found in each are shown in figure 1. The plant associations are based on potential vegetation condition as described by Johnson and Claustinzer (1992). These are in the process of being mapped for the forest and will be entered into GIS.

Structure (Size) Class

There are five structure classes as shown in table 1. These were designed to describe the range of forest structure and to be compatible with the current inventory. Age was not used as it cannot be obtained from the inventory mapping, and size is better related to the stands function in the ecosystem than is age. This does not map "old-growth" but most stands in the medium to large class meet the current old-growth descriptions.



Species codes:

ABLA2 = *Abies lasiocarpa*,
PICO = *Pinus contorta*,
PIEN = *Picea engelmannii*,
LAOC = *Larix occidentialis*,
ABGR = *Abies grandis*,
PSME = *Pseudotsuga mentessii*,
PIP0 = *Pinus ponderosa*, and
JUOC = *Juniperous occidentalis*.

Figure l-Tree species distribution by Plant Association Group.

Table l-Structure (size) classes definitions

Size class	Definition
Grass, forb, shrub	trees not the dominant vegetation
Seedling and saplings	<4.9" d.b.h.
Pole	5.0" - 8.9" d.b.h.
Small	9.0" - 20.9" d.b.h.
Medium and Large	21.0" + d.b.h.

Successional Condition

Three successional conditions are described for each PAG. These are early, mid, and late climax. A description is provided for each PAG that includes both tree and understory vegetation as well as the role of fire, successional trends, and wildlife species associated with a specific PAG. An example of a brief description for the Moist Grand Fir PAG would be:

> Early-75 percent or more of the major canopy layer would be ponderosa pine, lodgepole pine, or western larch.
>
> Mid-25 to 74 percent in ponderosa pine, lodgepole pine, or western larch.
>
> Late-less than 25 percent in ponderosa pine, lodgepole pine, or western larch.

The successional condition and structure class can be used to describe the variety of conditions found in each PAG. This is displayed in table 2. This has 15 potential conditions but the grass, forb, shrub stage was defined to apply only to the early successional stage. There are some other conditions that are not applicable to some PAG's. By using the structure and successional definitions, each acre in a watershed can be classified into one of these conditions. Maps or tables showing acres or locations of these conditions can be produced for any watershed using the vegetation map layers and the plant association layer in GIS.

Guide lnes

Guidelines for management are of two types: the first is PAG specific guidelines to be applied where those plant associations occur; the second included general guidelines that apply to all forest lands. The guidelines are based on the range of historic condition (pre-European), but in some cases this range was modified to promote native plants or animals. An example of specific guidelines for the Moist Grand Fir PAG are shown in table 3. These guidelines provide the land manager with a target and desired range of conditions for this PAG. The application of this will be discussed in the next section. The general guidelines provide direction for managing on the larger scale, i.e., considerations of interactions with

Table 2-Viable ecosystem structure/size and successional matrix with abbreviations

Structure class	Successional condition		
	Early	Mid	Late
Grass, forb, shrub	E1[a]	N/A	N/A
Seed/sapling	E2	M2	L2
Pole	E3	M3	L3
Small	E4	M4	L4
Medium/Large	E5	M5	L5[b]

[a] The grass, forb, shrub class only applies to the early successional stage.
[b] This may be referred to by some as very late climax or potential natural community (PNC).

Table 3-Desired distribution by successional condition and structure. Table shows target percentage in **bo ld** and desired range in parenthesis () for each condition

Structure class	Successional condition Early	Mid	Late	Total
Grass, forb and shrub	**7** (5-12)	N/A	N/A	7
Seed/sapling (<5.0")	(5-k)	**5** (3-10)	**0** (0-2)	13
Pole (5.0"-8.9")	**10** (5-15)	**10** (5-20)	**3** (1-5)	23
Small (9.0"-20.9")	(2-k)	**25** (15-40)	**5** (4-8)	37
Medium/Large	3	12	5	20
Total	35	52	13	100

other watersheds or ownerships. They also identify unique situations such as rock cliffs or aspen stands that need special consideration not provided in the PAG specific guides.

Note: the Viable Ecosystem Guide includes a detailed discussion for each PAG of the role of fire and succession, understory vegetation, wildlife species, historic condition, and insect and disease role.

App lcation

There are seven steps identified in the application process. These are analysis, evaluation, field analysis, project design, NEPA documentation, project implementation, and monitoring. These are different from the traditional project implementation but in many ways it provides clearer direction and allows efforts to be concentrated where they are most needed.

The analysis process consists of comparing the existing condition to the target and desired range of conditions and calculating the differences. This can be done with the GIS data for a given watershed and a computer spreadsheet. An example of this is shown in table 4. Ideally each of the existing and target acres would be within a few acres for every size/structure class for all **PAG's**, but in most cases there are some big differences. The first step is to focus on those classes where the existing condition is below the low range or above the high range of the desired condition. In this case, the E2 through E5 and M2 and M3 are below the low range and the M4, M5, and L5 are above the high range. The silviculturist becomes involved here in helping decide what treatments or combinations of treatments could be used to change the vegetation patterns toward the desired condition. In this case, it is often possible to move a stand from the M4 or M5 condition to an E4 or E5 condition with an improvement cut that removes the climax species and leaves the more seral component. There are usually very few options, except no treatment or regeneration cutting, for stands in the L5 condition. In this case, there is an abundance of the El class so it may be best to wait a few years before regenerating any of the L5 stands. Stands in size class 2 or 3 (saplings or poles) usually need to be grown from El but may need thinning to control species composition and maintain desired growth rates. This is typical of many applications in that it often will take several decades to return a watershed to the desired range of conditions.

The next step for the silviculturist is to verify these assumptions in the field and identify stands and prescriptions that can be applied to change individual stands so the watershed is moved toward the desired mix of conditions. The key part of this process is that the objective is to create a specified mix of stand conditions, and that products such as timber, edible wildlife, etc., are by-products of ecosystem management not the objective.

Table 4-Viable ecosystem subwatershed comparison

Subwatershed: **Bridge Cr.** Total acres: 12,904 Date: 4-9-93

Acres by plant association group:

ABLA	0	Moist ABGR	7098
Dry ABGR	3650	PSME/PIPO	925
Low PIP0	0	JUOC	0
Non Forest	1231		

Existing acres compared to desired and acceptable range:

PAG	S/S class	Existing Condition	Target	Desired Low	High	Difference from: Target	Low	High
Moist	E l	572	497	355	852	75	0	0
ABGR	E2	52	568	355	852	-516	-303	0
	E3	314	710	355	1065	-396	-41	0
	E4	49	497	142	710	-448	-93	0
	E5	0	213	142	355	-213	-142	0
	M2	0	355	213	710	-355	-213	0
	M3	214	710	355	1420	-496	-141	0
	M4	2881	1775	1065	2129	1107	0	752
	M5	1580	852	710	1420	728	0	160
	L2	0	0	0	142	0	0	0
	L3	0	213	71	355	-213	-71	0
	L4	145	355	284	568	-210	-139	0
	L5	1291	355	284	568	936	0	723

Note: In actual application of viable ecosystem, this table would be provided for all plant association groups (PAG), but for illustration purposes in this paper only the Moist ABGR PAG is shown.

Silviculture Application

This change in management strategy provides some new challenges to the silviculturist. Four areas that need to be emphasized in the application of viable ecosystem concepts are discussed in the following sections.

1. Silviculturists must recognize new objectives based on target stand conditions. This may require creating conditions that will grow into late climax old-growth or maintaining parklike ponderosa pine or western larch stands. It will also require regeneration prescriptions that will provide the variety of species mixes needed for the future. Uneven-aged management may be used but it may require "Q" factors of less than or near "1" (Hall 1993) or stands may be started as even-aged stands then converted over time to an uneven or multistoried condition.

2. A variety of prescriptions will be needed to meet the viable ecosystem objectives. In the past, we have been guilty of developing a prescription that works and is accepted by our key publics at that time and applying it across the landscape. Some examples during my career are clearcutting, shelterwood, and now uneven-aged management. Some other mind sets have been region or forest wide spacing guides for planting or thinning. Prescriptions must vary based on existing conditions and the viable ecosystem objective.

3. We need to maintain consistent terminology if we are going to have clear communication between ourselves and the public. We need to use existing terms and definitions as much as possible and add new terms only after regional or national review. We will need to decide on a local basis as to what is adequate stocking for a given site. This is important in distinguishing between regeneration cutting and intermediate cuts.

4. We need creativity but prescriptions must be based on sound silvicultural principles. Even though the management objectives have changed, the silvics of the species has not. So we need to learn and apply things like site stockability, species tolerance to shade, insect and disease susceptibility and risk, etc., in all of our prescriptions. If we cannot achieve an objective, it is better to do nothing than to write prescriptions that have a high probability of failure.

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Assessing Ecosystem Health in the Blue Mountains

David Caraher and Walter H. Knapp

Abstract

An assessment of the Blue Mountains in northeast Oregon and southeast Washington used a framework, Sustaining Ecological Systems, that resulted in a shift from forest health to ecosystem health. The result was an integrated approach that is being used to direct management activities.

Introduction

Last year, when the Forest Service and Bureau of Land Management announced they were shifting to ecosystem management, people had mixed reactions. They applauded the shift, but wondered what ecosystem management meant, and what form it might take in managing public lands.

Their questions have been hard to answer. Ecosystems have invisible and moving boundaries that encompass countless organisms interacting with, and depending on, each other and their environment. Many ecological concepts are well established, but they are used mostly to manage parts of ecosystems (timber, wildlife, fish, and so on); those concepts are only now being assembled into a framework that can be used to manage entire ecosystems. Before the Federal agencies, or anyone else for that matter, can undertake ecosystem management, they will need to have that framework-an assemblage of ecological concepts that they can apply to entire ecosystems on a variety of landscapes, and at a variety of scales.

In a significant coincidence of timing, just as the movement toward ecosystem management was getting underway, the Pacific Northwest Region of the Forest Service began an assessment of forest health in the Blue Mountains of eastern Oregon. Early in the process, the panel conducting the assessment changed its focus from forest health to ecosystem health. The results of their work, "Restoring Ecosystems in the Blue Mountains," exhibits a practical framework of ecological concepts and provides a tangible example of ecosystem management.

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The Blue Mountains

The Blue Mountains cover the northeast quarter of Oregon and southeast tip of Washington. They encompass a number of mountain ranges, give rise to rivers and streams, provide habitat for fish and wildlife, and exhibit a variety of vegetation types. Of the 19 million acres in the Blue Mountains, about a third, 6.2 million acres, are administered by four National Forests; the Umatilla, Wallowa-Whitman, Malheur, and part of the Ochoco. In addition, the Blue Mountains are home to more than 200,000 people, their cities, towns, communities, lumber mills, ranches, and farms.

Symptoms

About 10 years ago, the forests in the Blue Mountains began showing signs of poor health; frequent and widespread insect damage; accumulating forest fuels; large, catastrophic fires; and eroding stream channels (USDA Forest Service 1992a). By 1990, 3 million acres on the National Forests had been affected, and the people who live and work in the Blue Mountains were becoming alarmed.

Scientists and resource managers have pieced together an explanation of declining forest health. Before European settlers arrived, the Blue Mountains were dominated by open, parklike stands of ponderosa pine and larch, with an understory of grass. Mixed conifer stands of Douglas-fir and grand fir were generally confined to moister sites.

Fire was an important part of these ecosystems. In areas dominated by ponderosa pine, frequent, low-intensity fires kept out the shade-tolerant firs and reduced fuel accumulations. In areas where Douglas-fir and true firs dominated the landscape, fires burned less often, but with greater intensity. Yet, everywhere in the Blues, fire performed important ecosystem functions that affected species composition, and stand and landscape structure. Forest insects were active in these ecosystems, but rarely reached epidemic proportions.

When the European settlers and land managers arrived, they controlled fires to protect the timber, harvested the pine and larch for lumber, and encouraged regeneration of fir. The fir began to form dense stands of weak trees, unable to resist insects and drought. And without fire to naturally thin the pine, they too formed dense, weak stands, vulnerable to insects and diseases. After 70 years, the face of the Blue Mountains had changed, and the Forests began showing signs of severe stress.

The Search for Answers

In April 1992, John Lowe, then Deputy Regional Forester of the Pacific Northwest Region of the Forest Service, convened a panel of nine Forest Service resource specialists to conduct a single, comprehensive assessment of forest health in the Blue Mountains. He asked the panel to establish both long-term objectives and immediate priorities for restoration. The priorities were to identify (1) those land areas where restoration work can and should be started immediately, (2) those where more discussion and analysis was needed before restoration work could begin, and (3) those where restoration work would not be undertaken during the next few years.

It might seem that if the symptoms were so obvious, that the objectives and priorities for restoration should also have been obvious. But with so much land affected by so many symptoms, many objectives and priorities were possible. Some interest groups urged for immediate salvage of the dead and dying timber (to help reduce the fire hazard and provide needed employment in local communities). Others argued that salvaging timber had nothing to do with forest health, and would instead make things worse by disturbing even more ground and building more roads. Some urged more use of prescribed fire to reduce fuels and thin the dense stands of weak trees, but others warned that prescribed fires would destroy air quality and should not be used. And, of course, some called for a cessation of all management activity, saying it would be better to just leave the Blue Mountains alone and let them heal themselves. The debates tugged resource managers in different directions, and threatened to create an impasse that would immobilize the Forest Service and prevent it from getting on with essential restoration work. The purpose of the assessment was to sort through this debate enough to get started on the most urgently needed restoration work. There was another significant aspect to the panel's assignment; it had just 6 weeks to complete the assessment, making it clear that answers were needed urgently, and that there would not be time for a lot of detail.

From Symptoms to Systems

The panel began by considering a conventional approach; plotting the insect infestations, stands of dead and dying timber, accumulations of forest fuels, recent catastrophic fires, and stands of dense, weak timber, on a single map. This, at least, would provide a current, comprehensive view of the entire problem, its components and their extent and trends. But several panel members pointed out that this approach would be no more than an assessment of symptoms, a superficial view that could lead only to superficial solutions of limited benefit for the long term. They argued that to get at lasting solutions we would have to go beyond symptoms and address larger and more fundamental questions about the conditions of Blue Mountains ecosystems.

An Ecosystem Approach

This point of view sent the panel into a new direction, and led them to an approach recently developed in the Northern Region of the Forest Service. This approach, called Sustaining Ecological Systems (USDA Forest Service 1992b), assembled several fundamental ecosystem concepts and principles into a practical framework for management: (1) ecosystems occur at a variety of geographic scales, from global and continental down to regional, river basin, and finally to site; (2) ecosystems are collections of natural elements and processes; fire, rain, streams, plants and animals, and so on; (3) natural processes and elements occur within ranges of natural variability;

18 to 40 inches of precipitation annually, 80 to 140 trees per acre, and so on. Within a given ecosystem, an understanding of these ranges of natural variability can help explain how the elements and processes interact with, and depend on, each other; and (4) when an element or process is pushed outside its range of natural variability, that ecosystem cannot long sustain itself naturally.

A useful approach for showing the interrelationships between these concepts and principles is to graphically show the range of natural variability of key ecosystem elements along with their current condition (fig. 1).

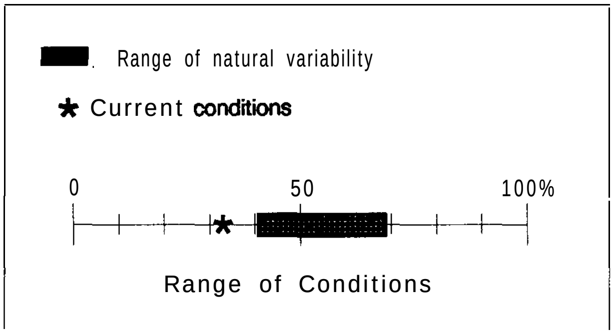

Figure 1-Sample display: the range of natural variability and current conditions for stream channel stability (adapted from USDA Forest Service 1992b).

Assessing Ecosystem Health

Given these ideas, the panel launched into the uncharted territory of an assessment of ecosystem health in the Blue Mountains.

Scale

The panel recognized the Blue Mountains as a distinct physiographic region containing three physiographic zones: (1) the marine zone to the north, with cool, moist climate and wide variations in topography; (2) the mixed zone, influenced by both the cool, wet climate of the north, and the dry, warm climate of the south; and (3) the continental zone in the southern portion, with cold winters, warm summers, and relatively low rainfall.

Elements and Processes

To identify elements and processes that could serve as indicators of ecosystem health-the pulse, respiration rate, and blood pressure of the Blue Mountains ecosystems-the panel considered many possibilities, then settled on nine. For each one of those nine elements, the panel established a unit of measure so that the range of natural variability and current conditions could be expressed on the standard scale as a percent of conditions (USDA Forest Service 1992c):

Early seral: the percent of the climax fir forest that consists of forest openings and stands of young trees with small diameters (less than 2 inches) and has an open canopy.

Late seral parklike: the percent of the climax fir forest that consists mostly of ponderosa pine or western larch, has been maintained by frequent underburns, and has less than 20 percent cover of understory trees.

Late seral tolerant multistory: the percent of the climax fir forest that consists of stands with two or more canopy layers of Douglas-fir and true fir and which have less than 20 percent overstory cover of ponderosa pine or western larch.

Ponderosa pine, high density, low vigor: the percent of the ponderosa pine stands, climax as well as seral, that are dominated by trees larger than 6 inches diameter at breast height and are susceptible to attack by bark beetles.

Lodgepole pine, high density, low vigor: the percent of the lodgepole pine stands, climax as well as seral, that are dominated by trees larger than 6 inches diameter at breast height and which are susceptible to attack by bark beetles.

Available fuels: the percent of the total biomass above the ground that consists of standing dead and down trees.

Juniper grasslands: the percent of the grasslands and shrublands that have been colonized by juniper.

Riparian shrub cover: the percent of stream length that has deciduous shrub cover.

Streambank stability: the percent of stream length that has stable banks.

The panel realized that there are additional elements that could serve as indicators of ecosystem health, but selected these nine just for the purposes of this assessment because they are diagnostic.

Estimating Variability

In the best of worlds, the panel would have had data from the Blue Mountains on which to base the range of natural variability for each element. Lacking such data, the panel relied on the professional judgment of its members to estimate those ranges, and it did so for each element in each of the three physiographic zones (fig. 2). The panel considered these estimates to be first approximations of those ranges of natural variability, adequate for this assessment, but deserving to be revised and refined in the future with practical experience and help from scientists.

Current Condition

To estimate the current conditions for those 9 elements, the panel stepped to the next finer geographic scale and identified 19 river basins within the 3 zones. Again, data for current conditions that would align with the nine elements and their units of measure were not readily available. The panel worked with resource managers from the national forests of the Blue Mountains, to review the ranges of variability for each element, then estimate current conditions, element by element, river basin by river basin where they worked. The panel summarized the current conditions with their ranges of natural variability for each of the 19 river basins on a single chart (fig. 3).

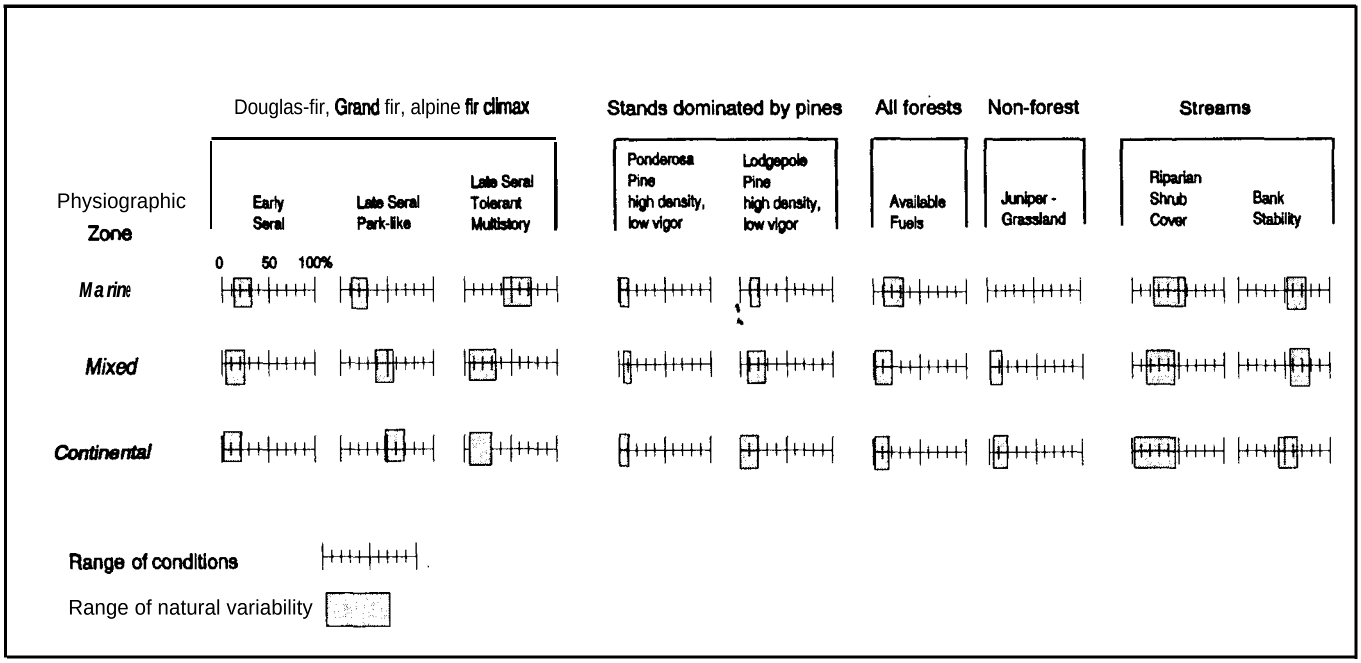

Figure 2-Ranges of natural variability for selected elements in the Blue Mountains (USDA Forest Service 1992c).

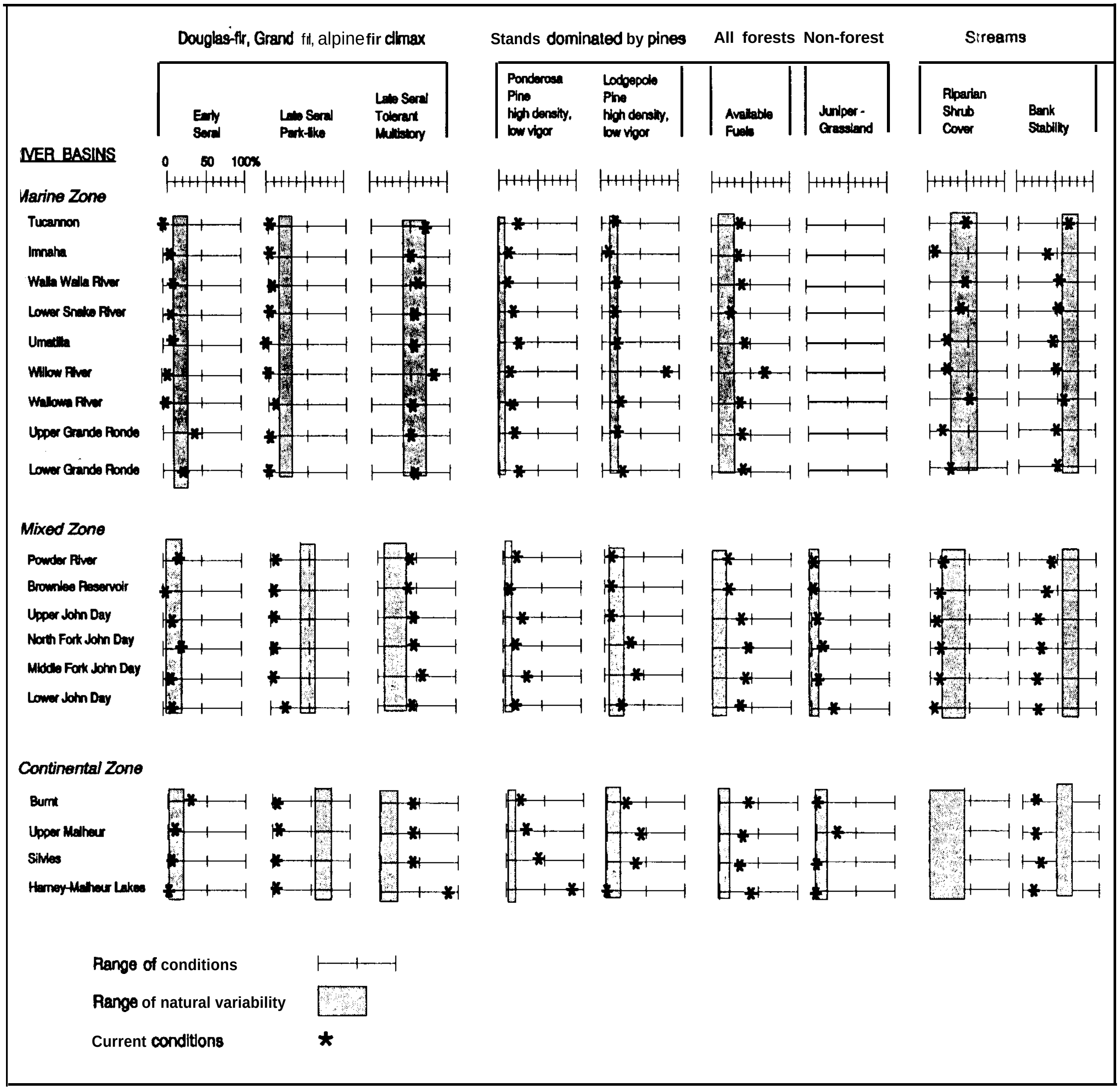

Figure 3—Current conditions and ranges of natural variability for nine elements in the river basins of the Blue Mountains (USDA Forest Service 1992c).

Health Assessment

The summary chart (fig. 4) provides a synoptic view of ecosystem health, not only across the Blue Mountains, but within each of the 19 river basins as well. The comparisons of current conditions with their ranges of natural variability suggest that ecosystems in many of the river basins are suffering from significant health problems:

Within the Douglas-fir-true fir climax forests, the area dominated by ponderosa pine or western larch is below the ranges of natural variability-the historical norms that existed prior to fire suppression and logging-in all 19 river basins.

The percent of ponderosa pine stands in high density-low vigor condition is higher than normal ranges for almost all river basins, and tend to be much higher than normal in the drier, warmer continental zone.

Available fuels are higher than natural ranges in almost all river basins, and much higher than the natural ranges in the mixed and continental zones.

Streambank stability is below natural ranges in almost all river basins, and far below natural ranges in the mixed and continental zones.

In many of the river basins, especially in the mixed and continental zones, several elements are far outside their natural ranges, so that problems with stand structure, for example, are compounded by problems with fuel loading and stream stability as well.

Objectives and Priorities

The final assignment to the panel was to use the assessment to develop objectives and priorities for restoration. This involved the human side of the ecosystem equation, the priorities that people place on those resource values that are at risk.

The panel interviewed more than 30 representatives of agencies, organizations, and groups who have an interest in the health of the Blue Mountains. These representatives appeared eager to shift their focus from symptoms to ecosystems. Their concerns generally fell into four categories:

- Fuel reduction and fire management
- Water quality, including municipal supplies
- Fisheries and riparian areas
- Timber management, including salvage and restoration

The panel used these categories in conjunction with the results of the technical portion of the assessment to establish objectives for restoration.

Final Report

The panel summarized its findings in a report to the Regional Forester and Forest Supervisors of the Blue Mountains. The report includes a map showing river basins: (1) far outside ranges of natural variability, (2) outside ranges of natural variability, and (3) near or within ranges of natural variability (fig. 4). The report identifies seven long-term objectives for restoration: (1) Reduce the risk of catastrophic fire; (2) bring all surface waters to conditions which meet State water quality standards; (3) provide high quality riparian vegetation; (4) emphasize restoration and enhancement of fish habitat, especially for threatened and endangered species; (5) develop conditions which reduced the risk of epidemic insect outbreaks; (6) provide big game cover within the framework of restoration activities; and (7) identify and address community needs when designing ecosystem restoration.

Framework for Ecosystem Management

The Blue Mountains assessment provided a useful tool for resource managers to plan and carry out management activities in an ecosystem context, but what may be more important, it demonstrated a practical framework for assessing and managing ecosystems. This framework, "Sustaining Ecological Systems," is a unique arrangement of at least some of the concepts - geographic scale, ecosystem elements and processes, range of natural variability, and sustainability - that will be essential for managing ecosystems.

The application of the framework in this instance had its necessary weaknesses; results were

BLUE MOUNTAIN ECOSYSTEM RESTORATION

MALHEUR, UMATILLA AND WALLOWA-WHITMAN NATIONAL FORESTS
WITH RIVER BASINS

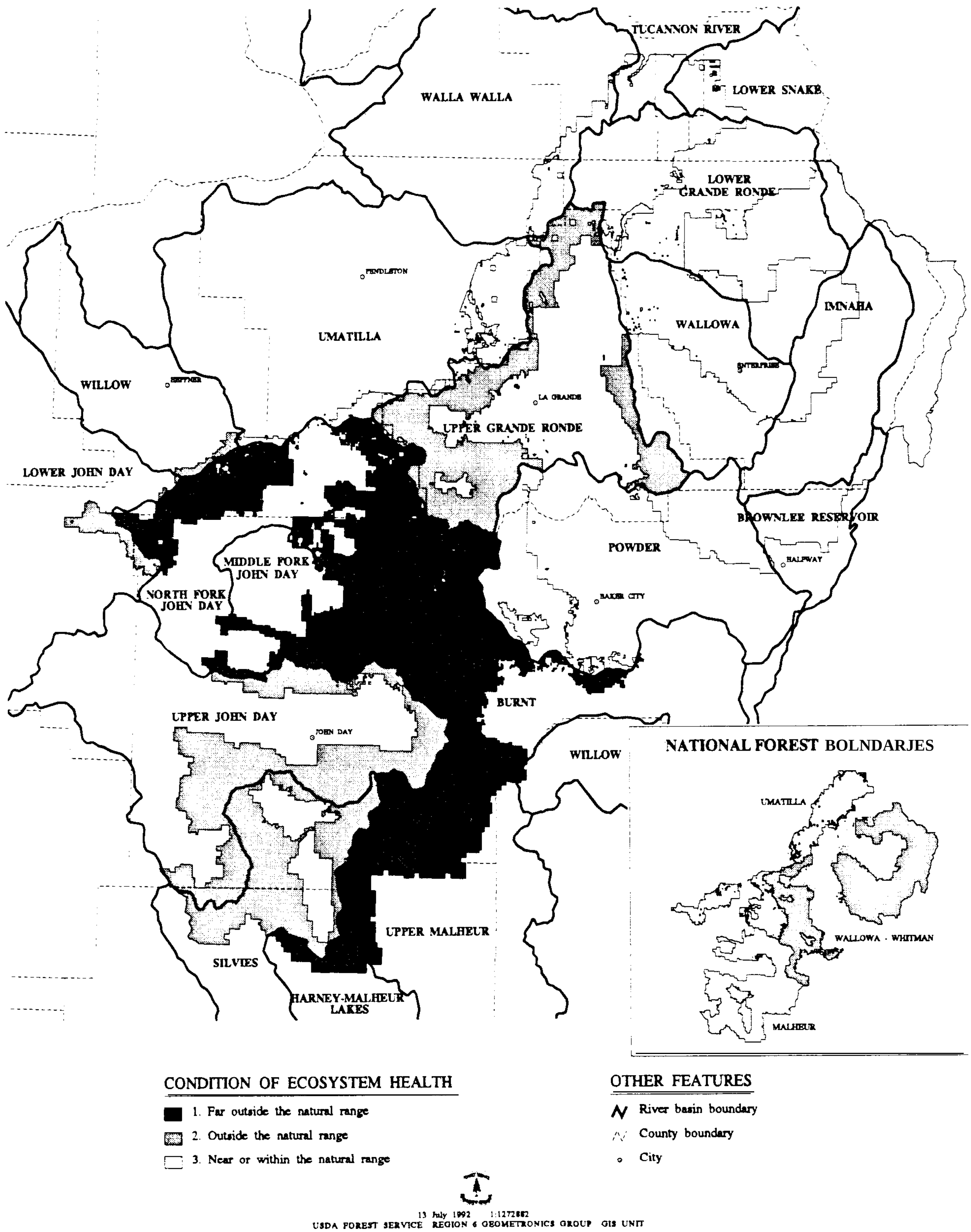

Figure 4-Map of the Blue Mountain ecosystem restoration.

needed urgently to organize triage for ailing ecosystems, so that ranges of natural variability and current conditions had to be estimated. Future assessments, especially those designed to manage ecosystems rather than restore them, should establish ranges of natural variability through historical records, research and data from field inventories, and current conditions should be measured rather than estimated.

Response

People who helped with the assessment or reviewed the results have been enthusiastic about this approach to ecosystem management. They have not been critical, as the panel expected them to be, of the reliance on estimates. However, two philosophical and scientific questions have yet to be resolved: First, how is the term "natural" defined, and what time period is appropriate to use as a reference? Second, the framework implies that the goal for ecosystem management is to return current conditions to the range of natural variability. They point out that we will never be able to return ecosystems to pre-1900 conditions, and to try would be folly.

In the Blue Mountains assessment, the panel used pre-European settlement as a reference point for natural conditions, not as a goal, but as a way to understand how management since then has affected the ecosystems. These points deserve debate, but if we are to manage ecosystems, we must begin somewhere. The framework behind "Sustaining Ecological Systems," and the Blue Mountains assessment offer a landmark, tangible evidence that it may, in fact, be possible to manage ecosystems.

Epilogue

Within a week after receiving this assessment, John Lowe, by then Regional Forester, detailed 250 employees from western Oregon to the Blue Mountains to help identify potential restoration projects as quickly as possible. Their work culminated in a strategy that requires a wide range of activities, including prescribed fire, biomass removal, reforestation, road closures and obliteration, stream improvement, and even natural recovery (USDA Forest Service 1993). The ultimate funding and implementation of these projects should establish new landmarks for ecosystem management.

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Managing Young Douglas-Fir Stands to Foster the Development of Diverse Stand Structure and Species Composition

Thomas C. Turpin and Daniel B. Karnes

Abstract

Innovative silviculture techniques need to be developed to manage for current and future habitat requirements of the northern spotted owl and other late-successional plant and animal species. This conclusion, from a series of high-level task force reports, is challenging silviculturists and other resource specialists to pool their knowledge to treat stands 80 years old or less. Presently, the Siuslaw National Forest has approximately 80,000 hectares (200,000 acres) of young managed stands within its Forest boundaries. Nearly all of these stands are less than 40 years of age. The Siuslaw National Forest has formed a partnership with researchers from the Pacific Northwest Research Station, Oregon State University's Department of Forest Science, and the Coastal Oregon Productivity Enhancement Program (COPE) to test new techniques for forest management. This paper describes a new approach to test the efficacy of commercial thinning and underplanting to accelerate the development of complex stand structure.

Introduction

Harvest activities over the past few decades in the Oregon Coast Range have resulted in thousands of acres of young, densely stocked Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) stands across the landscape. These stands often have much less vertical and horizontal complexity than the natural stands that they replaced. The title of our presentation is "Managing young Douglas-fir stands to foster the development of diverse stand structure and species composition." We would like to share with you an approach that the Siuslaw National Forest is using that integrates the latest science and technology to help answer management questions surrounding the complex issue of diversity.

Forest Silviculturist, USDA Forest Service, Pacific Northwest Region, Siuslaw National Forest, Corvallis, OR; and District Silviculturist, USDA Forest Service, Pacific Northwest Region, Siuslaw National Forest, Mapleton Ranger District, Mapleton, OR, respectively.

Location and Setting

The Siuslaw National Forest is located in the central portion of the Oregon Coast Range. The general crest of the Coast Range is 450 meters (1,500 feet) above sea level; some peaks are higher, with a few over 600 meters (2,000 feet). The topography consists of a complex ridge system characterized by short, steep slopes. The Coast Range is mostly sedimentary rock with some volcanic flows. The soils are well drained and range from loams to clay loams with generally high nutrient levels.

The central Oregon Range has a maritime climate. Average annual precipitation varies from 200 centimeters (80 in) at the coast to 300 centimeters (120 in) at higher elevations. Although some snow falls, it is usually limited to elevations greater than 600 meters (2,000 feet). The combination of fertile soils, low elevation, and mild, wet coastal climate makes the Siuslaw one of the Nation's most productive national forests.

The Forest provides habitat for more than 330 species of wildlife, which includes 17 threatened, endangered, and sensitive species. The northern spotted owl and marbled murrelet are famous members of the "sensitive" list and are used as examples to show how current forest management practices are failing.

The Siuslaw National Forest offers a wide diversity of recreational experiences, with the Oregon Coast attracting local, national, and international visitors. In addition, the Siuslaw National Forest provides something for everyone including three wilderness areas, the Cascade Head Scenic Research Area, and the Oregon Dunes National Recreation Area.

Five of the seven most important fish-producing river systems in coastal Oregon flow from the Siuslaw. The 1900 kilometers (1,200 miles) of stream are key spawning and rearing habitat for three anadromous fish species (salmon, steelhead trout, and sea-run cutthroat). The Forest is one of the few places in the contiguous United States where national forest land fronts the sea.

Natural disturbances and successional paths in the central Oregon Coast Range differ from those of the nearby Cascade Mountain Range. The current pattern of natural vegetation is the result of several major fire events since the 1840's. For example, the Florence fire of 1849 covered 200,000 hectares (500,000 acres). Due to the fire history in the Coast Range, few stands exceed 120 years of age. Except for isolated patches, old-growth stands are rare, yet solitary or clumped remnant trees are scattered across the landscape.

Management Situation

As mentioned, the Coast Range contains some of the most productive lands for conifer production in the world. The average Douglas-fir site index (100-year base) is 160. This site index is generally uniform throughout the Forest. The Siuslaw National Forest falls within the *Tsuga heterophylla* (Raf.) Sarg. (western hemlock) Vegetation Zone as described by Franklin and Dyrness (1973). The dominant tree species is Douglas-fir, with major populations of Sitka spruce (*Picea sitchensis* (Bong.) Carr.), western hemlock, and western redcedar (*Thuja plicata* Donn ex D. Don). The principal hardwood species is red alder (*Alnus rubra* Bong.), with some component of bigleaf maple (*Acer macrophyllum* Pursh.).

Until recently, the silvicultural objective was to prioritize treatment of mature stands mostly through the use of clearcutting. Harvest was followed by aggressively establishing new plantations of 600 to 750 uniformly spaced stems (conifer and/or conifer/hardwoods) per hectare (250 to 300 per acre) at a stand age of 10 years. With proper animal protection, vegetation management, and allowance for seedling mortality, we were able to meet that stocking objective very successfully.

Changing Times

Silvicultural objectives are now changing to meet the spirit of ecosystem management. Short rotation forestry that focuses on intensive silvicultural treatments is now viewed from social, political, and biological contexts as failing to achieve a broad array of objectives. In addition, the Forest Service Chief has directed that the use of clearcutting be minimized. Forest management has become so controversial, resulting in numerous appeals and lawsuits, that gridlock has occurred. This situation prompted the President of the United States to intervene. He commissioned a team to look at an ecosystem management approach in Federal forests comprising the range of the northern spotted owl in Northern California, Oregon, and Washington. It is anticipated that silvicultural treatments will focus on existing plantations and natural stands that are 80 years old or less. Emphasis will be on the development of diverse stand structure and species composition to improve wildlife habitat suitability, while providing for a fully functioning forest ecosystem.

The Partnership

In an effort toward meeting the challenges of changing times, the Siuslaw National Forest has entered into a partnership with researchers to develop and test existing and new technologies.

Creating characteristics of late-successional forests and sustaining productivity in younger, managed stands of Douglas-fir is the focus of a new research and demonstration project on the Forest. Desired stand characteristics are known to include multiple layers, multiaged canopies, a variety of tree and plant species, the presence of large down woody debris, and live/dead wildlife trees. The Siuslaw National Forest, the Pacific Northwest Research Station, Oregon State University, and the Coastal Oregon Productivity Enhancement (COPE) Program are active partners in a project to develop a sound scientific basis for testing new concepts. This partnership will expedite the transfer of current knowledge and enhance its application to on-the-ground management. The project utilizes recent studies of wildlife habitat and plant ecology research. In addition, it incorporates decades of experience from past commercial thinning and previous silviculture studies.

The Project

Installation of one of three replications of the project was completed early in 1993. Plot layout and collection of pre-logging data has been conducted on two other sites, with harvest scheduled to be accomplished this fall/winter.

Interest in the study has been high throughout the region. Three field forums, sponsored by Oregon State University and hosted by the partners, have been conducted during the past year. These have been filled to capacity with participation of more than 300 people from public agencies, private forest industry, and other forest interest groups in Oregon, Washington, and California.

Project Components

Treatments

Each of the site replications are located on fast-growing, 30- to 40-year-old Douglas-fir stands that originated from clearcut harvesting that was followed by burning, hand planting, and pre-commercial thinning. Study treatments will explore the development of stand diversity by commercial thinning to 250 trees per hectare (100 trees per acre) (normal spacing), 150 trees per hectare (60 trees per acre) (wide spacing), 75 trees per hectare (30 trees per acre) (extra wide spacing), and with comparison to a no thin (control) area of 500 to 750 trees per hectare (200 to 300 trees per acre). The treatment blocks are a minimum of 2 hectares (5 acres) each. Within the blocks are smaller plots to study stand development and growth/yield. Some areas will be underplanted with a variety of conifer and hardwood species that include Douglas-fir, western hemlock, grand fir (*Abies grandis* (Dougl. ex D. Don) Lindl.), western redcedar, Sitka spruce, red alder, and bigleaf maple.

Participants

Scientists involved in the project include plant ecologists, silviculturists, wildlife biologists, physiologists, forest engineers, and biometricians.

Project Goal

The goal is to determine if one or more of the treatments will result in managed stands with characteristics and habitats similar to late-successional forests more quickly than if the stands were left to natural processes or traditional management.

Factors to be Measured

- Growth and structure of overstory crop trees.
- Tree crown and stand canopy dynamics (vertical/horizontal).
- Survival and growth of underplanted tree species.
- Composition, abundance, and growth of herb and shrub layers.
- Development of advance and natural tree regeneration.
- Soil productivity.
- Dynamics of downed woody debris.
- Microsite characteristics and quality of plant and wildlife habitat.
- Qualitative differences in wildlife habitat suitability.

The research organizations involved in the study are committed to rapid and thorough technology transfer. In addition to field tours such as those already described, reports are prepared for the COPE quarterly newsletter. Scientists plan to publish interim as well as later results in outlets that reach forest managers and others outside the scientific community who are interested in the findings. Results and concepts from this project should be readily applicable and adaptable to ecosystem management practices specific to the Oregon Coast Range and throughout the Douglas-fir region.

Harvesting of the first replication required a light touch to minimize disturbances to soil and to residual trees. Harvesting restrictions decreased normal logging efficiency and increased the costs of harvest operations. Time and motion studies have been added to the study plan for the other replication sites.

Conclusion

This study relates directly to creating improved habitat for wildlife species that require more structural diversity in forest stands. Under natural conditions or traditional management, it takes many decades before young, managed stands develop forest structure that is typical of mature and old-growth forests. This study focuses on accelerating the structural development of young, managed stands across the landscape. Long-term results should provide valuable information to balance wood production goals with wildlife habitat needs, while utilizing an ecosystem approach to forest management. The project partners intend to continue the collection and analysis of data over time with the goal of developing new management guidelines.

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Ecological Classification and Mapping

National Hierarchical Framework of Ecological Units

Peter E. Avers, David T. Cleland, and W. Henry McNab

Abstract

The National Hierarchical Framework of Ecological Units is a regionalization, classification, and mapping system for stratifying the Earth into progressively smaller areas of increasing uniform ecological potentials. This regionalization, classification, and mapping process uses available resource maps including climate, geology, landform, soils, water, and vegetation. Our goals are to develop an ecological classification and inventory system for all National Forest System lands, and to provide a prototype system acceptable to all agencies. Nationally coordinated ecological unit maps will be developed for Ecoregion and Subregion scales covering all U.S. lands.

Introduction

To implement ecosystem management, we need basic information about the nature and distribution of ecosystems. To develop this information, we need working definitions of ecosystems and supporting inventories of the components that comprise ecosystems. We also need to understand ecological patterns and processes, and the interrelationships of social, physical, and biological systems. To meet these needs, we must obtain better information about the distribution and interaction of organisms and the environments in which they occur, including the demographics of species, the development and succession of communities, and the effects of human activities and land use on species and ecosystems (Urban and others 1987). Research has a critical role in obtaining this information.

This paper presents a brief background of regional land classifications, describes the hierarchical framework for ecological unit design, examines underlying principles, and shows how the framework can be used in resource planning and management. The basic objective of the hierarchical framework is to provide a systematic method for classifying and mapping areas of the Earth based on associations of ecological factors at different geographic scales.

The framework is needed to improve our efforts in national, regional, and forest level planning; to achieve consistency in ecosystem management across national forests and regions; to advance our understanding of the nature and distribution of ecosystems; and to facilitate interagency data sharing and planning. Furthermore, the framework will help us evaluate the inherent capabilities of land and water resources and the effects of management on them.

Ecological units delimit areas of different biological and physical potentials. Ecological unit maps can be coupled with inventories of existing vegetation, air quality, aquatic systems, wildlife, and human elements to characterize complexes of life and environment, or ecosystems. This information on ecosystems can be combined with our knowledge of various processes to facilitate a more ecological approach to resource planning, management, and research.

Note that ecological classification and mapping systems are devised by humans to meet human needs and values. Ecosystems and their various components often change gradually, forming continua on the Earth's surface which cross administrative and political boundaries. Based on their understanding of ecological systems, humans decide on ecosystem boundaries by using physical, biological, and social considerations.

We recognize that the exact boundaries for each level envisioned in this process and developed in map format may not fit every analysis and management need. Developing boundaries of areas for analysis, however, will not change the boundaries of ecological units. In some cases, an ecological unit may be the analysis area. In other cases, watersheds, existing conditions, management emphasis, proximity to special features (e.g., research natural, wilderness, or urban areas) or other conditions may define an analysis area. In these cases, ecological units can be aggregated or divided if needed to focus on relevant issues and concerns.

Soils Program Leader, USDA Forest Service, Washington Office, Washington, DC; Research Liaison, North Central Forest Experiment Station, Rhinelander, WI; Research Forester, Southeastern Forest Experiment Station, Asheville, NC. The paper was presented by Randy Moore, Soil Specialist, USDA Forest Service, Washington Office, Washington, DC, in the absence of the senior author.

Background

Regional Land Classifications

Hierarchical systems using ecological principles for classifying land have been developed for geographical scales ranging from global to local. Using a bioclimatic approach at a global scale, several researchers have developed ecological land classifications: Holdridge (1967), Walter and Box (1976), Udvardy (1975), and Bailey (1989a,b). Wertz and Arnold (1972) developed land stratification concepts for regional and land unit scales. Other ecologically based classifications proposed at regional scales include those of Driscoll and others (1984), Gallant and others (1989), and Omernik (1987) in the United States and those of Wiken (1986) and the Ecoregions Working Group (1989) in Canada. Concepts have also been presented for ecological classification at subregional to local scales in the United States (Barnes and others 1982), Canada (Jones and others 1983, Hills 1952), and Germany (Barnes 1984).

But no single system has the structure and flexibility necessary for developing ecological units at continental to local scales. Each of these systems have strong points that contribute to the strength of the national hierarchy. The concepts and terminology of the national system draws upon this former work to devise a consistent framework for application throughout the United States.

Ecological Unit Design

The primary purpose for delineating ecological units is to identify land and water areas at different levels of resolution that have similar capabilities and potentials for management. Ecological units are designed to exhibit similar patterns in: (1) potential natural communities, (2) soils, (3) hydrologic function, (4) landform and topography, (5) lithology, (6) climate, (7) air quality, and (8) natural processes for cycling plant biomass and nutrients (e.g., succession, productivity, fire regimes).

It should be noted that climatic regime is an important boundary criteria for ecological units, particularly at broad scales. In fact, climate, as modified by topography, is the dominant criteria at upper levels. Other factors, such as geomorphic process, soils, and potential natural communities take on equal or greater importance than climate at lower levels. The discussion under the Classification Framework section and table 1 provide more details on map unit criteria for each hierarchical level.

It follows, then, that ecological map units are differentiated and designed by multiple components including climate, physiography, geology, soils, water, and potential natural communities (FSM 2060, FSH 2090.11). These components may be analyzed individually and then combined, or multiple factors/components may be simultaneously evaluated to classify ecological types which are then used in ecological unit design (FSH 2090.11). The first option may be increasingly used as Geographic Information Systems (GIS) become more available. The interrelationships among independently defined components, however, will need to be carefully evaluated, and the results of layering component maps may need to be adjusted to identify units that are both ecologically significant and meaningful to management. When various disciplines cooperate in devising integrated ecological units, products from existing resource component maps can be modified and integrated interpretations can be developed (Avers and Schlatterer 1991).

Ecological unit inventories are generally designed and conducted in cooperation with the Soil Conservation Service, agricultural experiment stations of land grant universities, Bureau of Land Management, and other appropriate State and Federal agencies. Mapping conventions and soil classification meet standards of the National Cooperative Soil Survey.

Classification Framework

The National Ecological Unit Hierarchy is presented in Tables 1, 2, and 3. The hierarchy is based on concepts and terminology developed by numerous scientists and resource managers (Hills 1952, Crowley 1967, Wertz and Arnold 1972, Rowe 1980, Allen and Starr 1982, Barnes and others 1982, Forman and Godron 1986, Bailey 1987, Meentemeyer and Box 1987, Gallant and others 1989, Cleland and others 1992). The following is an overview of the differentiating criteria used in the development of the ecological units. Table 1 summarizes the principal criteria used at each level in the hierarchy.

Table l-Principal map unit design criteria of ecological units

Ecological unit	Principal map unit design criteria[1]
Domain	Broad climatic zones or groups (e .g. , dry, humid, tropical)
Division	Regional climatic types (Koppen 1931, Trewartha 1968). Vegetational affinities (e.g. , prairie or forest). Soil order.
Province	Dominant potential natural vegetation (Kuchler 1964). Highlands or mountains with complex vertical climate-vegetation-soil zonation.
Section	Geomorphic province, geologic age, stratigraphy , lithology. Regional climatic data. Phases of soil orders, suborders, or great groups. Potential natural vegetation. Potential natural communities (PNC) (FSH 2090).
Subsection	Geomorphic process, surficial geology, lithology . Phases of soil orders, suborders or great groups. Subregional climatic data. PNC--formation or series.
Landtype Association	Geomorphic process , geologic formation, surficial geology, and elevation. Phases of soil subgroups, families, or series. Local climate. PNC--series , subseries, plant associations.
Landtype	Landform and topography (elevation, aspect, slope gradient, and position). Phases of soil subgroups, families, or series. Rock type, geomorphic process. PNC--plant associations.
Landtype Phase	Phases of soil families or series. Landform and slope position. PNC--plant associations or phases.

[1] It should be noted that the criteria listed are broad categories of environmental and landscape components. The actual classes of components chosen for designing map units depend on the objectives for the map.

Table 2-National hierarchy of ecological units

Planning and analysis scale	Ecological units[1]	Purpose, objectives, and general use
Ecoregion	Domain	Broad applicability for modeling and sampling.
	Division	Strategic planning and assessment. International planning.
	Province	
Subregion	Section	Strategic, multiforest, statewide and multiagency analysis and assessment.
	Subsection	
Landscape	Landtype Association	Forest or area-wide planning, and watershed analysis.
Land Unit	Landtype	Project and management area planning and analysis.
	Landtype Phase	

[1] Hierarchy can be expanded by user to smaller geographical areas and more detailed ecological units if needed.

Table 3-Map scale and polygon size of ecological units

Ecological unit	Map scale range	General polygon size
Domain	1:30,000,000 or smaller	1,000,000's of square miles
Division	1:30,000,000 to 1:7,500,000	100,000's of square miles
Province	1:15,000,000 to 1:5,000,000	10,000's of square miles
Section	1:7,500,000 to 1:3,500,000	1,000's of square miles
Subsection	1:3,500,000 to 1:250,000	10's to low 1,000's of square miles
Landtype Association	1:250,000 to 1:60,000	100's to 1,000's of acres
Landtype	1:60,000 to 1:24,000	10's to 100's of acres
Landtype Phase	1:24,000 or larger	<100 acres

Ecoregion Scale

At the Ecoregion scale, ecological units are recognized by differences in global, continental, and regional climatic regimes and gross physiography. The basic assumption is that climate governs energy and moisture gradients, thereby acting as the primary control over more localized ecosystems. Three levels of ecoregions, adapted from Bailey (1980), are identified in the hierarchy:

Domains-Domains are subcontinental divisions of broad climatic similarity, such as lands that have the dry climates of Koppen (1931), which are affected by latitude and global atmospheric conditions. For example, climate of the Polar Domain is controlled by arctic air masses, which create cold, dry environments where summers are short. In contrast, the climate of the Humid Tropical Domain is influenced by equatorial air masses and there is no winter season. Domains are also characterized by broad differences in annual precipitation, evapotranspiration, potential natural communities, and biologically significant drainage systems. The four Domains are named according to the principal climatic descriptive features: Polar, Dry, Humid Temperate, and Humid Tropical.

Divisions-Divisions are subdivisions of a Domain determined by isolating areas of definite vegetational affinities (prairie or forest) that fall within the same regional climate, generally at the level of the basic types of Koppen (1931) as modified by Trewartha (1968). Divisions are delineated according to: (a) the amount of water deficit (which subdivides the Dry Domain into semi-arid, steppe, or arid desert; and (b) the winter temperatures, which have an important influence on biological and physical processes and the duration of any snow cover. This temperature factor is the basis of distinction between temperate and tropical/subtropical dry regions. Divisions are named for the main climatic regions they delineate, such as Steppe, Savannah, Desert, Mediterranean, Marine, and Tundra.

Provinces-Provinces are subdivisions of a Division that correspond to broad vegetation regions, which conform to climatic subzones controlled primarily by continental weather patterns such as length of dry season and duration of cold temperatures. Provinces are also characterized by similar soil orders. The climatic subzones are evident as extensive areas of similar potential natural vegetation as mapped by Kuchler (1964). Provinces are named typically using a binomial system consisting of a geographic location and vegetative type such as Bering Tundra, California Dry-Steppe, and Eastern Broadleaf Forests.

Highland areas that exhibit altitudinal vegetational zonation and that have the climatic regime (seasonality of energy and moisture) of adjacent lowlands are classified as Provinces (Bailey and others 1985). The climatic regime of the surrounding lowlands can be used to infer the climate of the highlands. For example, in the Mediterranean Division along the Pacific Coast, the seasonal pattern of precipitation is the same for the lowlands and highlands except that the mountains receive about twice the quantity. These Provinces are named for the lower elevation and upper elevation (subnival) belts, e.g., Rocky Mountain Forest-Alpine Meadows.

Subregion Scale

Subregions are characterized by combinations of climate, geomorphic process, topography, and stratigraphy that influence moisture availability and exposure to radiant solar energy, which in turn directly control hydrologic function, soil-forming processes, and potential plant community distributions. Sections and Subsections are the two ecological units mapped at this scale.

Section-Sections are broad areas of similar geomorphic process, stratigraphy, geologic origin, drainage networks, topography, and regional climate. Such areas are often inferred by relating geologic maps to potential natural vegetation "series" groupings as mapped by Kuchler (1964). Boundaries of some Sections approximate geomorphic provinces (for example Blue Ridge) as recognized by geologists. Section names generally describe the predominant physiographic feature upon which the ecological unit delineation is based, such as Flint Hills, Great Lakes Morainal, Bluegrass Hills, Appalachian Piedmont.

Subsections-Subsections are smaller areas of Sections with similar surficial geology, lithology, geomorphic process, soil groups, subregional climate, and potential natural communities. Names of Subsections are usually derived from geologic features, such as Plainfield Sand Dune, Tipton Till Plain, and Granite Hills.

Landscape Scale

At the Landscape scale, ecological units are defined by general topography, geomorphic process, surficial geology, soil and potential natural community patterns, and local climate (Forman and Godron 1986). These factors affect biotic distributions, hydrologic function, natural disturbance regimes, and general land use. Local landform patterns become apparent at this level in the hierarchy, and differences among units are usually obvious to on-the-ground observers. At this level, terrestrial features and processes may also have a strong influence on ecological characteristics of aquatic habitats (Platts 1979, Ebert and others 1991). Landtype Association ecological units represent this scale in the hierarchy.

Landtype Associations-Landtype Associations *are* groupings of Landtypes or subdivisions of Subsections baaed upon similarities in geomorphic process, geologic rock types, soil complexes, stream types, lakes, wetlands, and series, subseries, or plant association vegetation communities. Repeatable patterns of soil complexes and plant communities are useful in delineating map units at this level. Names of Landtype Associations are often derived from geomorphic history and vegetation community.

Land Unit Scale

At the basic Land Unit scale, ecological units are designed and mapped in the field based on properties of local topography, rock types, soils, and vegetation. These factors influence the structure and composition of plant communities, hydrologic function, and basic land capability. Landtypes and Landtype Phases are the ecological units mapped at this scale.

Landtypes-Landtypes are subdivisions of Landtype Associations or groupings of Landtype Phases based on similarities in soils, landform, rock type, geomorphic process, and plant associations. Land surface form that influences hydrologic function (e.g., drainage density, dissection relief) is often used to delineate different Landtypes in mountainous terrain. Valley bottom characteristics (e.g., confinement) are commonly used in establishing riparian Landtype map units. Names of Landtypes are to include an abiotic and biotic component (FSH 2090.11).

Landtype Phase-Landtype Phase more narrowly defined Landtypes based on topographic criteria (e.g., slope-shape, steepness, aspect, position, hydrologic characteristics, associations and consociations of soil taxa, and plant associations and phases. These factors influence or reflect the microclimate and productivity of a site. Landtype Phases are often established based on interrelationships between soil characteristics and potential natural communities. In riparian mapping, Landtype Phases may be established to delineate different stream type environments (Herrington and Dunham 1967). Naming is similar to Landtypes (FSH 2090.11).

The Landtype Phase is the smallest ecological unit recognized in the hierarchy. However, even smaller units may need to be delineated for very detailed project planning at large scales (table 2). Map design criteria depend on project objectives.

Plot Data

Point or plot sampling units are used to gather ecological data for inventory, monitoring, quality control, and for developing classifications of vegetation, soils, or ecological types. This plot data feeds into data bases for analysis, description, and interpretation of ecological units (Keane and others 1990). Broad policy for data administration and standardization is in FSM 1390 and FSM 6600. Specific standards to be followed are in the Standards for Data and Data Structures Handbook (FSH 6609.15). Other directives may also apply such as the Timber Permanent Plot Handbook (FSH 2409.13a). The plots can serve as reference sites for ecological types. Plots, while not mappable, can be shown on maps as point data.

In summary, the national framework has an extensive scientific basis, and provides a hierarchical system for mapping ecological units ranging in size from global to local. At each level, abiotic and biotic components are integrated to classify and delineate geographical areas with similar ecological potentials. These ecological units, combined with information on existing conditions and ecological processes, provide a basis for managing ecosystems.

Underlying Principles

Ecosystem Concept

Ecosystems are places where life forms and environment interact; they are three dimensional segments of the Earth (Rowe 1980). Tansley introduced the term “ecosystem” in 1935, and the explicit idea of ecological systems composed of multiple abiotic and biotic factors was formally expressed in our language (Major 1969). The ecosystem concept brings the biological and physical worlds together into a holistic framework within which ecological systems can be described, evaluated, and managed (Rowe 1992).

The structure and function of ecosystems are largely regulated along energy, moisture, nutrient, and disturbance gradients. These gradients are affected by climate, physiography, soils, hydrology, flora, and fauna (Barnes and others 1982, Jordan 1982, Spies and Barnes 1985); and these factors change at different spatial and temporal scales. Ecological systems therefore exist at many spatial scales, from the global ecosphere down to regions of microbial activity.

At global, continental, and regional scales, ecosystem patterns correspond with climatic regions, which change mainly due to latitudinal, orographic, and maritime influences (Bailey 1987, Denton and Barnes 1988). Within climatic regions, physiography or landforms modify macroclimate (Rowe 1984, Smalley 1986, Bailey 1987), and affect the movement of organisms, the flow and orientation of watersheds, and the frequency and spatial pattern of disturbance by fire and wind (Swanson and others 1988). Within climatic-physiographic regions, water, plants, animals, soils, and topography interact to form ecosystems at Land Unit scales (Pregitzer and Barnes 1984). The challenge of ecosystem classification and mapping is to distinguish natural associations of ecological factors at different spatial scales, and to define ecological types and map ecological units that reflect these different levels of organization.

While the association of multiple biotic and abiotic factors is all important in defining ecosystems, all factors are not equally important at all spatial scales. At coarse scales, the important factors are largely abiotic, while at finer scales both biotic and abiotic factors are important. Furthermore, the level of discernible detail, the number of factors comprising ecosystems, and the number of variables used to characterize these factors progressively increase at finer scales. Hence, the data and analysis requirements and investments for ecosystem classification and mapping also increase for finer scaled activities.

The conditions and processes occurring across larger ecosystems affect and often override those of smaller ecosystems, and the properties of smaller ecosystems emerge in the context of larger systems (Rowe 1984). Moreover, environmental gradients change due to climatic, physiographic, and edaphic variations that affect ecological patterns and processes at different spatial scales. Thus, it is useful to conceive of ecosystems as occurring in a nested geographic arrangement, with smaller ecosystems embedded in larger ones (Allen and Starr 1982, O’Neill and others 1986, Albert and others 1986). This spatial hierarchy is organized in decreasing orders of scale by the dominant factors affecting ecological systems. Ecosystems become networked, however, when non-adjacent systems exhibit similar structure and function with respect to specific biota (e.g., sedentary plants as opposed to wide ranging animals) and various processes; hence, the networking of ecological systems is scale dependent (Allen and Hoekstra 1992). Networking of ecosystems occurs most often at lower levels of the hierarchy and depends upon requirements, environmental tolerances, and dispersion mechanisms of biota, as well as other factors that affect biotic-abiotic interactions occurring within and across local, landscape, and regional ecosystems.

Life and Environmental Interactions

Life forms and environment have interacted and codeveloped at all spatial and temporal scales, one modifying the other through feedback. Appreciating these interactions is integral to understanding ecosystems.

At a global scale, scientists have theorized that the evolution of cyanobacteria, followed by terrestrial plants capable of photosynthesis, carbon fixation, and oxygen production converted the Earth’s atmosphere from a hydrogen to an oxygen base and still sustain it today. At a continental scale, the migration of species in response to climate change, and the interaction of their environmental tolerances and dispersal mechanisms with landform-controlled migration routes formed today's patterns in species' distributions. At a Landscape scale, life forms, environment, and disturbance regimes have interacted to form patterns and processes. For example, pyrophilic communities tend to occupy droughty soils in fire-prone landscape positions, produce volatile foliar substances, and accumulate litter, thereby increasing their susceptibility to burning. At yet finer scales, vegetation has induced soil development over time through carbon and nutrient cycling, enabling succession to proceed to communities with higher fertility requirements.

In each of these examples, life forms and environment have modified one another through feedback to form ecological patterns and processes. These types of relationships underscore the need to consider both biotic and environmental factors while classifying, mapping, and managing ecological systems.

Spatial and Temporal Variability

The structure and function of ecosystems change through space and time. Consequently, we need to address both spatial and temporal sources of variability while evaluating, classifying, mapping, or managing ecosystems (Delcourt and others 1983, Forman and Godron 1986). At a Land Unit scale, for example, the fertility of particular locations changes through space because of differences in soil properties or hydrology, and at Ecoregion scales, conditions vary from colder to warmer because of changes in macroclimate. These relatively stable conditions favor certain assemblages of plants and animals while excluding others because of biotic tolerances, and processes such as competition. These environmental conditions are classified as ecological types and mapped as ecological units.

Within ecological units, ecosystems may support vegetation that is young, mature, or old, and they may be composed of communities that are early, mid, or late successional. These relatively dynamic conditions also benefit certain plant and animal species and assemblages. Conditions that vary temporally are classified and mapped as existing vegetation, wildlife, water quality, and so forth.

These examples illustrate that ecological units do not contain all the information needed to classify, map, and manage ecosystems. Ecological units address the spatial distributions of relatively stable associations of ecological factors that affect ecosystems. When combined with information on existing conditions, the National Hierarchy of Ecological Units provides a means of addressing spatial and temporal variations that affect the structure and function of ecosystems. Adding our knowledge of processes to this information will enable us to better evolve into ecosystem management.

Use of Ecological Units

Ecological units provide basic information for natural resource planning and management. Ecological unit maps may be used for activities such as delineating ecosystems, assessing resources, conducting environmental analyses, establishing desired future conditions, and managing and monitoring natural resources.

Ecosystem Mapping

To map ecosystems, or places where life and environment interact, we need to combine two types of maps: maps of existing conditions that change readily through time, and maps of potential conditions that are relatively stable. Existing conditions change due to particular processes that operate within the bounds of biotic and environmental, or ecological, potentials. Existing conditions are inventoried as current vegetation, wildlife,' water quality, and so forth. Potential conditions are inventoried as ecological units. When these maps are combined, biotic distributions and ecological processes can be evaluated and results can be extrapolated to similar ecosystems. The integration of multiple biotic and abiotic factors, then, provides the basis for defining and mapping ecosystems.

Fundamental base maps are key to mapping ecosystems and integrating resource inventories. These maps include the Primary Base Map series showing topography, streams, lakes, ownership, political boundaries, cultural features, and other layers in the Cartographic Features File. On this base, the next set of layers could include ecological units, watersheds, and inventories of aquatic systems at appropriate spatial scales. Next would be layers of information on existing vegetation, wildlife populations, fish distribution, demographics, cultural resources, economic data, and other information needed to delineate ecosystems to meet planning and analysis needs.

GIS will provide a tool for combining these separate themes of information, and representing the physical, biological, and social dimensions to define and map ecosystems. But scientists and managers using this technology must actually integrate information themes, comprehend processes, and formulate management strategies. These tasks will not be accomplished mechanically.

Resource Assessments

The hierarchical framework of ecological units can provide a basis for assessing resource conditions at multiple scales. Broadly defined ecological units (e.g., Ecoregions) can be used for general planning assessments of resource capability. Intermediate scale units (e.g., Landtype Associations) can be used to identify areas with similar natural disturbance regimes (e.g., mass wasting, flooding, fire potential). Narrowly defined Land Units can be used to assess site specific conditions including distributions of terrestrial and aquatic biota; forest growth, succession, and health; and various physical conditions (e.g., soil compaction and erosion potential, water quality).

High resolution information obtained for fine scale ecological units can be aggregated for some types of broader scale resource assessments. Resource production capability, for example, can be estimated based on potentials measured for Landtype Phases, and estimates can be aggregated to assess ranger district, national forest, regional, and national capabilities.

Environmental Analyses

Ecological units provide a means of analyzing the feasibility and effects of management alternatives. To discern the effects of management on ecosystems, we often need to examine conditions and processes occurring above and below the level under consideration (Rowe 1980). For example, the effects of timber harvesting are manifest not only at a Land Unit scale, but also at microsite and Landscape scales. Although the direct effects of management are assessed at the Land Unit scale, indirect and cumulative effects take place at different points in space or time, often at higher spatial scales. Ecological units defined at different hierarchical levels will be useful in conducting multiscaled analyses for managing ecosystems and documenting environmental effects (Jensen and others 1991).

Watershed Analysis

The national hierarchy provides a basis for evaluating the linkages between terrestrial and aquatic systems. Because of the interdependence of geographical components, aquatic systems are linked or integrated with surrounding terrestrial systems through the processes of runoff, sedimentation, and migration of biotic and chemical elements. Furthermore, the context of water bodies affects their ecological significance. A lake embedded within a landscape containing few lakes, for example, functions differently than one embedded within a landscape composed of many lakes for wildlife, recreation, and other ecosystem values. Aquatic systems delineated in this indirect way have many characteristics in common, including hydrology and biota (Frissell and others 1986). Overlays of hierarchical watershed boundaries on ecological mapping units are useful for most watershed analysis efforts. In this case, the watershed becomes the analysis area which is both superposed by and composed of a number of ecological units which affect hydrologic processes such as water runoff and percolation, water chemistry, and ecological function due to context.

Desired Future Conditions

Desired future conditions (DFC's) portray the land or resource conditions expected if goals and objectives are met. Ecological units will be useful in establishing goals and methods to meet DFC's. When combined with information on existing conditions, ecological units will help us project responses to various treatments.

Ecological units can be related to past, present, and future conditions. Past conditions serve as a model of functioning ecosystems, and provide insight into natural processes. It is unreasonable, for example, to attempt to restore systems like oak savannas or old-growth forests in areas where they did not occur naturally. Moreover, natural processes like disturbance or hydrologic regimes are often beyond human control. Ecological units will be helpful in understanding these processes and in devising DFC's that can be attained and perpetuated.

Desired future conditions can be portrayed at several spatial scales. We can minimize conflicting resource uses (e.g., remote recreational experiences versus developed motorized recreation, habitat management for area sensitive species versus edge species) if we consider the effects of projects at several scales of analysis. Ecological units will be useful in delineating land units at relevant analysis scales for planning DFC's (Brenner and Jordan 1991).

Resource Management

Information on ecological units will help establish management objectives and will support management activities such as the protection of habitats of sensitive, threatened, and endangered species, or the improvement of forest and rangeland health to meet conservation, restoration, and human needs. Information on current productivity can be compared to potentials determined for Landtype Phases, and areas producing less than their potential can be identified (Host and others 1988). Furthermore, long-term sustained yield capability can be estimated based on productivity potentials measured for fine scale ecological units.

Monitoring

Monitoring the effects of management requires baseline information on the condition of ecosystems at different spatial scales. Through the ecological unit hierarchy, managers can obtain information about the geographic patterns in ecosystems. They are, thus, in a position to design stratified sampling networks for inventory and monitoring. Representative ecological units can be sampled and information can then be extended to analogous unsampled ecological units, thereby reducing cost and time in inventory and monitoring.

By establishing baselines for ecological units and monitoring changes, we can protect landscape-, community-, and species-level biological diversity; and other resource values such as forest productivity, and air and water quality. The results of effectiveness and validation monitoring can be extrapolated to estimate effects and set standards in similar ecological units.

Evaluation of air quality is an example of how the National Hierarchical Framework of Ecological Units can be used for baseline data collection and monitoring. The Forest Service is developing a National Visibility Monitoring Strategy that addresses protection of air quality standards as mandated by the Clean Air Act, along with other concerns (USDA Forest Service 1993). Key to this plan is stratification of the United States at the subregion level of the national hierarchy into areas that have similar climatic, physiographic, cultural, and vegetational characteristics. Other questions dealing with effects of specific air-borne pollutants on forest health, such as correlation of ozone with decline of ponderosa pine and other trees in mixed conifer forest ecosystems in the San Bernardino Mountains of southern California, will require establishment of sampling networks in smaller ecological units at landscape or lower levels.

Contemporary and Emerging Issues

The National Hierarchical Framework of Ecological Units is based on natural associations of ecological factors. These associations will be useful in responding to contemporary and emerging issues, particularly those that cross administrative and jurisdictional boundaries. Concerns regarding biological diversity, for example, can be addressed using the ecological unit hierarchy (Probst and Crow 1991). Conservation strategies can be developed using landscape level units as coarse filters, followed by detailed evaluations and monitoring conducted to verify or adjust landscape designs. We can rehabilitate ecosystems and dependent species that have been adversely affected through fire exclusion, fragmentation, or other results of human activities if we grow to understand the natural processes that species and ecosystems codeveloped with, and then mimic those processes through ecosystem management.

Species may become rare, threatened, or endangered because their habitat is being lost or degraded, because they are endemic to a particular area, or because they are at the edge of their natural range. In the first two instances, protection or recovery efforts are warranted. In the latter case, however, it may be futile to try to maintain biota in environments where they are predisposed to decline. At a minimum, populations at the edge of their range can be evaluated for genetic diversity, and recovery programs can be administered accordingly. Species and community distributions can often be related to ecological units, which can be useful in their inventory and protection.

The new emphasis on sustaining and restoring the integrity of ecosystems may aid in arresting the decline of biological diversity, and pre-empt the need for many future protection and recovery efforts. Developing basic information on the nature and distribution of ecosystems and their elements will enable us to better respond to issues like global warming, forest health, and biological diversity.

Conclusion

The hierarchical framework of ecological units was developed to improve our ability to implement ecosystem management. This framework, in combination with other information sources, is playing an important role in national, regional, and forest planning efforts; the sharing of information between forests, stations, and regions; and interregional assessments of ecosystem conditions.

Regions and stations, with national guidance, are coordinating their design of ecological units at higher levels of the national hierarchy. Development of landscape and land unit maps is being coordinated by appropriate regional, station, forest, and ranger district level staff. As appropriate, new technologies (e.g., remote sensing, GIS, expert systems) should be used in both the design, testing, and refinement of ecological unit maps.

The classification of ecological types and mapping of ecological units pose a challenge to integrate not only information, but also the concepts and tools traditionally used by various disciplines. The effort brings together the biological and physical sciences that have too often operated independently. Specialists like foresters, fishery and wildlife biologists, geologists, hydrologists, community ecologists, and soil scientists will need to work together to develop and implement this new classification and mapping system. The results of these concerted efforts will then need to be applied in collaboration with planners, social scientists, economists, archaeologists, and the many other specialties needed to achieve a truly ecological approach to the management of our nation's national forests and grasslands.

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Ecogeographic Analysis

A Guide to the Ecological Division of Land for Resource Management

Robert G. Bailey

Abstract

Ecological units of different sizes for predictive modeling of resource productivity and ecological response to management need to be identified and mapped. A set of criteria is presented for subdividing a landscape into ecosystem units of different sizes, based on differences in factors important in differentiating ecosystems at varying scales in a hierarchy. Practical applications of such units are discussed.

Ecogeographic Analysis, A Guide to the Ecological Division of Land for Resource Management, was presented at the 1993 National Silviculture Workshop but was previously published in 1988 as Miscellaneous Publication 1465 by the USDA Forest Service, Washington, DC.

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Ecological Classification, Mapping, and Inventory in the Southern Region and Its Potential Application Using Geographic Information Systems

W. Henry McNab and Steve McCorquodale

Abstract

The Southern Region is developing an integrated ecological classification, mapping, and inventory system, patterned after the Forest Service national framework of ecological units, for use in terrestrial and aquatic environments. Research results suggest that geographic information systems can be used to preclassify (predict) ecological types in mountainous terrain in advance of field examination.

Introduction

The Forest Service recently adopted a policy of ecosystem management, which has created a nationwide need for ecological classification, mapping, and inventory (ECM&I) from landscape to local scales. Based on more than a single forest product or environmental factor, ecological classifications integrate relationships among multiple components, including climate, landform, soil, and vegetation (Barnes and others 1982). This paper provides a brief overview of the Southern Region's approach to developing an ecologically based system of ECM&I. A case study of an experimental method developed by the Southeastern Forest Experiment Station to apply ecological classifications using a geographic information system (GIS) is also presented.

Ecological Classification and Inventory

During the summer of 1992, the Southern Region devised a strategy for implementing ecosystem management (USDA Forest Service 1992). As part of the strategy, an interdisciplinary ECM&I team of resource specialists from the Regional headquarters, Forest Supervisor's offices, and Research was formed. The ECM&I team was mandated to develop an ECM&I system that could be used initially in forest-level planning, and then in project-level ecosystem management activities. Developing a standard regional approach to ECM&I was a fundamental objective. This approach would ensure scientific validity and compatibility across political and administrative boundaries. Consistent methods are important in the Southern Appalachian Mountains where many national forests meet at State boundaries, and throughout the Southern Region where cooperation with other agencies and interested partners is fostered.

The Southern Region's emerging ECM&I is based on the Forest Service national hierarchy (Ecomap 1993), at and below the Subregion scale (table 1). The team is developing a single hierarchy for classifying terrestrial and aquatic ecological units. Applying the hierarchy in terrestrial environments has been relatively simple because a considerable amount of work has been done and examples are available. The aquatic classification has evolved during the past year and draws heavily on the concepts advanced by Cowardin and others (1979). Described in an administrative paper, integration of the aquatic environment into the hierarchy is well under way.[1] Similar papers have been prepared to describe how the human dimension and wildlife components will be integrated into the Southern Region's ECM&I.[2]

Closely following the logic and structure of the national system, ECM&I in the Southern Region is based on integration of climate, geology, landform, water, soils, and vegetation at all hierarchical levels. By using two approaches, "top-down" and "bottom-up," at the same time, the team expedites development of the classification. The top-down method is based on regionalizing large ecological units at the Subregion scale. The bottom-up approach involves collecting field data and grouping small ecological units at the Land Unit scale into

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[1]Personal communication. 1993. Keith McLaughlin, USDA Forest Service, Southern Region.

[2]Personal communication. 1993. Teri Raml, USDA Forest Service, George Washington National Forest.

Table l-Hierarchical structure of the Southern Region's ecological classification, mapping, and inventory system

Planning scale	Ecological units	Purpose, objectives, and use
Ecoregion	Domain Division Province	National planning and assessment.
Subregion	Section Subsection	Regional planning and assessment.
Landscape	Landtype Assn.	Forest planning and assessment.
Land Unit	Landtype Landtype Phase	Project and management area planning and analysis.

larger units. To achieve uniformity across forest boundaries, the Regional Office is classifying and mapping ecological units at the Subregion scale. Meanwhile, each national forest is responsible for developing ecological units at the Landscape and Land Unit scales of the ECM&I. The Southern Region's ECM&I is directed only to Federal lands, however, the principles are widely applicable.

The team is also developing a guidebook that covers all phases of ECM&I in the Southern Region. The guidebook serves three purposes. It will: (1) provide information on standard procedures for ecological classification and mapping with chapters on methods of field plot location, field data collection, data analysis, and construction of field keys for distinguishing classification criteria. When local classifications are developed using standardized methods, the databases can be combined and used for refinement of Subregion scales in the hierarchy. (2) Provide a reference source based on ECM&I within the Southern Region and specific information pertaining to its application on each forest; and (3) ensure compatibility among national forests for application of ECM&I.

Management interpretations for the ecological units, an important part of the ECM&I guidebook, will be used to evaluate effects of management activities on ecosystems over a range of scales. Valid ecological classification will allow delineation of map units that will respond to management activities in a predictable manner. Because a large amount of information will be needed to implement ecosystem management on national forests, the Forest Service expects to work with many partners, including universities, conservation groups, industry, and individuals. Established cooperative efforts include working on a classification of arborescent vegetative communities by The Nature Conservancy for over 5 years. Other cooperative efforts or partnerships will be needed, especially for management interpretations.

The Southern Region must quickly apply ecological classifications for use in forest planning and resource management. Extensive areas must be mapped for ECM&I, ideally by an interdisciplinary team, which will require considerable time, money, and training. Preclassification, the process using general knowledge of an area to develop a preliminary ecological classification in advance of intensive field examination, is an alternative method of applying an ECM&I to meet a range of objectives.

Geographic Information Systems

Using GIS is one way to apply ecological classifications over extensive areas. When the relationships between physical and biological components are accurately quantified into mathematical models, GIS can quickly apply the models on a landscape basis. Research in the Southern Appalachian Mountains has shown that distribution of vegetative communities is associated mainly with the environmental gradients of temperature and moisture, and slightly with fertility (McLeod 1988). These gradients are correlated with the following environmental variables: elevation, aspect, slope gradient, landform, and soils. Using digital elevation models, GIS can automatically calculate all the variables except soils. Raster-type GIS is especially well-suited to applying biological models (Congalton and Green 1992), and it can be easily integrated with remote sensing (Lachowski and others 1992).

A preliminary ecological classification was developed for a 10,000-acre tract in the Wine Spring Creek area of the Nantahala National Forest, in western North Carolina to illustrate preclassification using GIS. The classification model is described in more detail by McNab and Browning (1993). Briefly, the area was stratified for sample plot location using a recent 1:12,000-scale soil map. All vegetation on 0.25-acre plots in old, recently undisturbed stands was measured by species. Topographic and soil variables were also measured. Vegetative data were analyzed using standard ecological techniques to classify plots into groups of similar species composition and dominance. Ordination analysis identified tentative ecological types, which are categories of land having unique combinations of vegetation, soil, landscape features, and climate. The procedures used to develop an ecological classification for the Wine Spring Creek study area generally followed guidelines that will be presented in the Southern Region's field guidebook.

Results of the analysis indicated that at least five ecological types occur on the Wine Spring Creek study area, each of which is associated with characteristic topographic and soil variables (table 2), and vegetation (table 3). Ecological type names were based on elevation and apparent moisture

Table 2-Environmental characteristics associated with ecological types in Wine Spring Creek study area of the Nantahala National Forest

Ecological type[a]	Topographic and soil variables				
	Elevation	Landform	Aspect	Gradient	Solum
	(ft)				(in)
High-Dry	>4,500	Side slope	Southerly	Variable	25-40
High-Mesic	>4,500	Side slope	Northerly	Moderate	>45
Middle-Xeric	<4,500	Ridge	Variable	Steep	<25
Middle-Dry	<4,500	Side slope	Southerly	Moderate	25-40
Middle-Mesic	<4,500	Valley	Variable	Gentle	>45

[a]A sixth ecological type was highly correlated with soil, but was not used in this test because a digitized soil map was not available for use with GIS.

Table 3-Dominant overstory and understory vegetative species associated with ecological types in the Wine Spring Creek study area of the Nantahala National Forest

Ecological type	Predominant overstory species	Predominant understory shrub
High-Dry	Northern red oak	Flame azalea
High-Mesic	Sugar maple	Herbs and ferns
Middle-Xeric	Scarlet oak	Mountain laurel
Middle-Dry	Chestnut oak	Blueberries
Middle-Mesic	Yellow-poplar	Rhododendron

regime. We developed discriminant functions for the ecological types and applied them to the study area using a raster-based GIS. Using topographic variables, each 0.25-acre sample "site" (actually a cell of the DEM) was classified by the discriminant models into one of five ecological types (fig. 1).

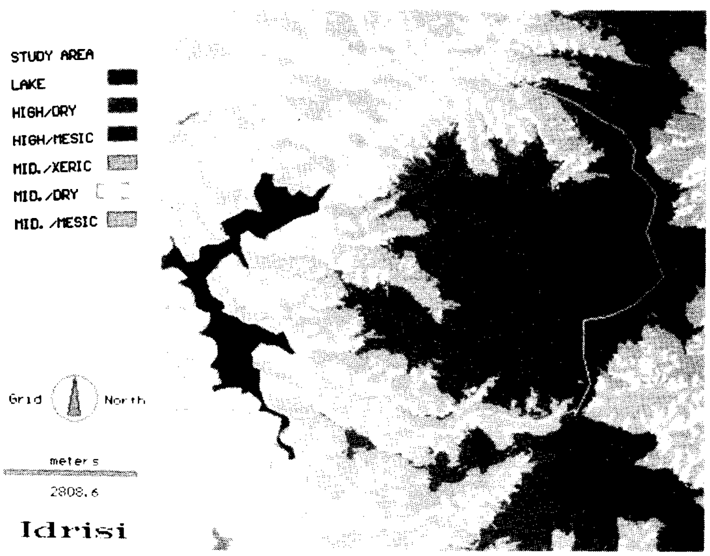

Figure 1Output from geographic information system (GIS) showing the Wine Spring Creek study area and vicinity classified into five ecological types (see tables 2, 3).

Several more steps in the ECM&I process are required before this preclassification can be used for management purposes. First, the preclassification must be field validated to determine its accuracy and area of applicability. The area of application could probably include much of the Landtype Association[3] where the study was conducted. Also, ecological types must be grouped into ecological units, using criteria related to management considerations such as minimum unit size and within-unit variability, and displayed on a map of the proper scale.

Summary

The Southern Region is developing an ECM&I patterned after the Forest Service national framework of ecological units and applicable to terrestrial and aquatic ecological units on national forest lands over a range of map scales. As part of this project, the Region will publish a guidebook that provides information on application of the ECM&I at the project level, and on management interpretation of ecological units. Prior to actual field classification of ecological types and mapping of ecological units, GIS will provide a means of applying the ECM&I over extensive areas.

Acknowledgment

Other members of the Southern Region and Southeastern Forest Experiment Station who indirectly contributed to this paper through their participation on the Southern Region's Ecological Classification Team are T. Collins, J. Herrig, S. Hooks, J. Keys, K. McLaughlin, W. Pistrang, T. Raml, K. Stoneking, J. Walker, S. Weaver, and C. Williams.

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[3]The Wine Spring Creek study area was initially reported to consist of two Landtype Associations. However, further evaluation suggests that only one Landtype Association is appropriate (Personal Communication. 1991. Robert G. Bailey, USDA Forest Service).

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Management Data Needs

Information from the Past is a Resource for the Present and Future

Ronald M. Dippold and Barry D. Webb

Abstract

Resource management requires considering the long-term consideration. Ecosystem management put increased emphasis on broader spatial and temporal aspects. This has increased the need to manage information in a more efficient manner. R10-DataLib is presented as a tool to help with this task.

Introduction

Those that ignore the past are destined to repeat the same, or greater, mistakes in the future.

Land management and stewardship, especially of public lands, is a long-term proposition. What management actions have been accomplished, or not accomplished, in the past must be reviewed and considered when evaluating current conditions and deciding future actions. Knowledge of past: levels of scientific knowledge, public expectations, administrative decisions, contractual commitments, and political mandates in effect at various times all need to be considered.

Ecosystem management, and the related adaptive management, dictate maintenance of easily accessed records of past actions and monitoring of the results of those actions. The resource manager must consider and evaluate past activities over a mix of geographic areas and long time frames. This increases the need to access and evaluate a large spectrum of information in order to make decisions. The manager has an obligation to leave a legacy for successors that documents decisions and monitoring of activities that implemented the decisions.

Correspondence management needs in Region 10 in the 1970's illustrated the necessity to develop an efficient index and retrieval system for a large amount of correspondence. To meet this need, Region 10 implemented a library bibliographic computer program called DataLib on the Region's Data General. The program as implemented is referred to as RlO-DataLib. Its use has greatly expanded beyond the original correspondence management task for which it was purchased. It is helping manage many long-term planning and resource management records.

The following will be discussed: (1) Region 10's need for an index and retrieval system, (2) other options used and/or considered, (3) how DataLib is now being used, (4) operational advantages, (5) introduction to the technical aspects of the DataLib program, and (6) the availability of the Forest Service FSJNFO Database on DataLib.

While no computer program will solve all our record keeping, record indexing, record recall, and decision documentation needs, it can, as part of an integrated procedure, help to make these tasks achievable and manageable.

Need for an Index and Retrieval System

Region 10 administers two long-term (50-year) timber sale contracts for which the files have correspondence dating from the mid-1940's. To date, there are over 65,000 pages in the correspondence files. There are also additional filing cabinets and boxes containing related documents, such as appeals, contract dispute claims, NEPA documents, litigation, and other special studies.

By the early 1980's, many hours had been spent researching these files. Often very short response time was required, and it was very time consuming to visually search for documents. Despite efforts to be careful and thorough, documents were overlooked. A better way that would take much less time and assure retrieval of pertinent documents needed to be found. In 1985, litigation associated with the two long-term sales emphasized a pressing need to establish an "instant recall database" for all the potential references and exhibits.

Again, in 1986, while compiling large certified records for two NEPA documents, the Region was confronted with the urgent need for a document index and retrieval system in order to operate with any degree of efficiency. In addition, Interdisciplinary Team's (IDT's) were in various stages of completion on additional NEPA documents. There was an

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immediate need to find a way to create an index for these planning records that would serve as (1) a useful in-house reference for the current and future needs, (2) an administrative record as required by NEPA, and (3) a certified record as required by the courts when there is litigation.

As a stop-gap measure, two methods, both using software on the Region's Data General MV, were used to create the required Certified Records Index. While meeting the court's requirements, these processes were very time consuming and had little reference capability beyond the "hard copy" index. A review in 1986 did not surface any software operational on the Data General MV system at that time that would provide a better index and retrieval system.

Other Options Used or Considered

Early in 1985, the Region considered numerous PC software programs. None met all the needs identified, most would require a considerable investment in hardware, software, and time in order to become useful. Also, this approach was counter to the Forest Service policy of having, to the extent possible, Data General MV-based software usable to more than one computer station.

An Introduction to DataLib and Its Use by Region 10

In 1987, the Region became aware of DataLib, a bibliographic software package operational on the Data General MV Series computers. In June 1987, the Chief granted technical approval for a pilot test and stipulated the Region to evaluate the software and report findings to the Washington Office after 6 months of use.

Introduction to DataLib

DataLib is an automated bibliographic system developed by Sigma Data Services Corporation, now Cordant Inc., for special libraries and document management in summary form. It runs on Data General Eclipse minicomputers and VAX. DataLib has been installed on customer sites since 1978, first as an acquisition system for a group of Federal libraries. In 1982, Sigma Data began development of a more powerful and more flexible version. Other new features included interactive updating, improved security, more sophisticated searching and an interactive updating, and an interface with shared catalogs.

While covering all the features of R10-DataLib is beyond the scope of this paper, some of the basic features need to be covered to help illustrate the structure and use of the database.

Cordant Inc. tailors DataLib software to meet different bibliographic needs by use of a Data Definition File (DDF). This file defines record layouts, field definitions, print formats, etc. Region 10 has used this ability to allow identification of numerous databases (vis Group Codes) and various Record Types.

Group Codes-Although Region 10 purchased one license to use DataLib, and therefore only has one program running in the Region, we currently have provisions for eleven separate databases. Figure 1 illustrates the current databases. Other databases can be easily added.

Access to each of these databases is controlled by each user's DataLib profile. An individual can be granted specific privileges for each of the databases. For example, a person with Read and Edit capabilities to the TM Group database may only have Read access to the TLMP database and no access to the LMW database.

Within the database group, distinct subgroups of records are identified and searched separately by use of a Function Code. Figure 2 lists some of the subdatabases within the TM Group. Our current policy is to assign a new code to each sale project area Environmental Impact Statement (EIS). All databases within DataLib can be searched at one time or searches can be limited to subgroups or smaller.

Record Types-The Region 10 database defines 20 different Record Types, or types of documents within the DDF. Figure 3 contains a complete list and short explanation of the 20 Record Types. There are unique Record Types for such documents as letters, agency studies, books/publications, maps, meetings, telephone conversations, etc. This facilitates limiting the size of the record to what is needed to identify, describe, and locate the individual record. For example, there is no need for a Letter Record Type to have an element for Scale as would be needed for a Map Record Type. Figure 4 illustrates the DDF's for the Letter and Map Record Types.

CNF	CHUGACH NATIONAL FOREST Used by the Chugach NF for EIS and other document files.
APC-AA	APC AREA ANALYSIS OPERATING PLAN Used to manage operating plans under the Alaska Pulp Co. 50-year contract.
KPC-AA	KPC AREA ANALYSIS OPERATING PLAN Used to manage operating plans under the Ketchikan Pulp Co. 50-year contract.
LMW	LANDS/MINERALS/WATER USER Used by the Land, Minerals, and Watershed Staff to manage the mining claims and associated documents.
OTHER	REGIONAL FORESTER ASSIGNED Reserved for assignment by the Regional Forester to satisfy one-time urgent needs.
RO-PLAN	REGIONAL OFFICE PLANNING EFFORTS Used to manage planning documents and associated other papers for any Regional planning effort.
SHARED	COMMON INFORMATION Used to store 100+ training record and information of a general nature, not specific to a project.
SO	SPOTTED OWL Used to support the Spotted Owl Team located in Portland, OR.
TLMP	TONGASS LAND MANAGEMENT PLAN Used to manage the revised Tongass Land Management Plan and associated documents.
TM	TIMBER MANAGEMENT Used to manage the APC and KPC long-term sale contracts and associated documents.
WDL	WORKING DOCUMENT LIBRARY Used to manage reference documents of importance to the planning processes and operation of the Region.

Codes can be added to or removed from this list by changing the data dictionary file (DDF).

Figure 1-Group Codes for R10-DataLib.

APC	Records and correspondence relating to Alaska Pulp Company.
KPC	Records and correspondence relating to Ketchikan Pulp Company.
1987 CORRESPONDENCE	
	Used to identify material in the APC and APC permanent files.
1994 CORRESPONDENCE	
SEIS	Administrative of Court direct Supplemental Environmental Impact Statement for APC. First Planning Record where documents were entered into R10-DataLib at the start of the planning process.
81-86	Planning Record for 5-Year EIS for APC.
86-90	Planning Record for 5-Year EIS for APC.
84-89	Planning Record for 5-Year EIS for APC.
B	Planning Record for Bohemia Mountain Timber Sale EIS.
CPOW	Planning Record KPC Project Area EIS at Central Prince of Wales.
KB	Planning Record APC Project Area EIS at Kelp Bay.
TTRA	Document dealing with the Tongass Timber Reform Act.
QUARTZ HILL	Planning Record for the U.S. Borax Mine EIS.
EM	Documents on file in RO dealing with New Perspectives or ecosystem management.

Figure 2—Subdatabases within the TM Group.

AGENCY-STUDY	Summarizes any study or planning documents (non NEPA) prepared by the Forest Service or any Federal, State, or local government agency. Unpublished research papers (generally) Informal research Site-specific studies Habitat Capability Models Task force studies
AGREEMENT	Used to summarize any agreements between Region 10 and any other government office or private business.
ANNOTATION	A linked record to the MAP record. Used to summarize any annotation made on a map. The MAP record has to be entered on the database before entering the annotation.
BOOKPUBLICATION	Summarizes any book or formal publication. Entire books Entire publications Published research studies USDA Forest Service publications Brochures Leaflets
CASE	Used to summarize any court case. A DOCUMENT record type is a linked record to this record.
CLIPPING	Summarizes any type of media clipping, press releases, copies of parts of larger publications. Clippings of information from other publications, i.e., newspapers or magazines. Include copies of parts of books or other formal publications. Press releases Speeches
CONTRACT	Used to summarize any contract: THE CONTRACT FORM ITSELF.
DOCUMENT	A linked record to the CASE record. Used to summarize any affidavits that are connected to the court case.
FIELD	Used to summarize any field prepared documents: FIELD NOTES, FIELD MANAGEMENT NOTES.
FS_DECISION	Used to summarize internal Forest Service decisions. Do not confuse with Records of Decision which go in **NEPA_Study_Pub.**
LAW_POLICY_DIRECT	Summarizes any law, policy, or government direction. Forest Service Directives Legal notices Hearing notices Federal Register

Figure 3—**Record** types for **R10-DataLib** (continued to next page).

LETTER	Used to summarize any letter: EXTERNAL CORRESPONDENCE OUTGOING OR INCOMING.
MAP	Summarizes any of the following: Aerial photos; orthophotos GIS maps Topographic maps Overlays Quadrangles Sketch ANNOTATION is a linked record to this record.
MEETING	Summarizes verbal communications between parties when communication is NOT over the phone. Public meetings Presentations to groups Interdisciplinary team meetings Task group meetings Leadership team meetings Scoping meetings
MEMO	Used to summarize any memorandum: INTERNAL CORRESPONDENCE OUTGOING OR INCOMING.
NEPA_STUDY_PUB	Summarizes any NEPA document. Notices of Intent; Records of Decision Environmental Assessments Environmental Impact Statements Land Use Designation Prescriptions Standards and Guidelines Forest Plan
NOTE	Summarizes any written communication that follows no specific format. DG (electronic) messages Hand written messages Flyers Presentation Materials
NUMERIC-DATA	Summarizes information that is numeric. Data tables — Diskettes FORPLAN — Flowcharts Graphs — Index Inventories — Printouts Queries — Spreadsheets Tables
PHONE	Used to summarize any telephone records kept of appropriate telephone conversations. Phone calls Teleconferences
STRATREC	Used to save search strategies for future use in retrieving documents. Will m-execute the same search strategy when called using $FIND/U. Search results may be different because of records added.

Figure 3—Record types for R10-DataLib (continued from previous page).

LETTER RECORD

(Elements)

GROUP:
FUNCTION:
DESIGNATOR:
DOC-DATE:
FILE-DESIGNATION
SUBJECT:
AUTHOR:
** RECIPIENT:
PAGES:
RESPONSE TO:
PUBLIC INVOLVEMENT:
ENCLOSURE:
KEYWORD:
SHORT-SUMMARY:
PRIVILEGED-SUMMARY:
FOIA-PRIVILEGE:
** POSTMARK:
CABINET:
DRAWER:
FOLDER:
LOCATION:
BARCODE:
RECID:
CREATED:
LASTMOD:
OPID:
RECTYPE:
HISTORY:

MAP RECORD

(Elements)

GROUP:
FUNCTION:
DESIGNATOR:
SUBJECT:
** TITLE:
** PUBLISHER:
DOC-DATE:
** PHYSICAL-DESCRIPTION
** MEDIA:
** SCALE:
** SERIES:
PAGES:
TYPE-OF-MAP:
FILE-DESIGNATION:
AUTHOR:
RESPONSE-TO:
PUBLIC-INVOLVEMENT:
ENCLOSURES:
KEYWORDS:
SHORT-SUMMARY:
PRIVILEGED-SUMMARY:
FOIA-PRIVILEGE:
CABINET:
DRAWER:
FOLDER:
LOCATION:
BARCODE:
RECID:
CREATED:
LASTMOD:
OPID:
RECTYPE:
HISTORY:

Elements for each record are in the order they are prompted for data entry.
** Indicates elements in one record type, but not the other.

Figure 4—Data Definition Files for the Letter and Map Record Types.

The Record Types in the R10 version of DataLib were identified and defined by Region 10 personnel with the help of expert technical guidance from a DataLib systems person. At this same week-long work session, the Group codes and the definitions and characteristics of all the data elements were established. To date, there have been only a few minor adjustments to the original DDF.

Current Status of Implementation

1. The Tongass Land Management Plan Revision is using DataLib to identify and index the planning record. To date, this planning record consists of 4,493 documents, all entered in DataLib.

2. The Ketchikan Area, Tongass National Forest, has indexed their massive planning and implementation record for the Borax Molybdenum Mine, some 6,998. The Borax Mine has a projected life of over 50 years. The records for this project will, in all probability, be much larger than those of the 50-year timber sales.

3. Timber Management (TM) has entered all the Alaska Pulp Company (APC) and Ketchikan Pulp Company (KPC) contract correspondence records back to 1977. The Director, TM, has provided direction for handling new documents.

4. Starting with the Supplemental EIS for APC, 1987, all planning teams working on EIS's for the two long-term sales are using DataLib for document storage and retrieval. Currently there are five EIS's for project sale areas that are being completed by contractors and six EIS's being completed by Forest Service IDT's. This has allowed the EIS IDT teams to have access to previously used reference material, public input, and Forest Service decision documents.

None of contractors doing EIS's or any of the Forest Service IDT's for timber project areas are located in Juneau, AK; where the DataLib software is housed on the Regional Office (RO) Data General MV. Entry and searches are accomplished using remote access to the RO's Data General MV.

5. The National Spotted Owl Team, stationed in Portland, OR, used RlO-DataLib to store and retrieve their planning record. This allowed fast and accurate searching for documents and rapid creation of numerous indexes of the planning record, including an index for the certified record.

Using DataLib Database

Following are some of the more common uses of the RlO-DataLib databases:

1. Find specific information and cites needed while writing a document.

The DataLib records can be referenced while writing letters, memos, technical reports, EA's, EIS's and/or Records of Decision (ROD's). Searches can be done without exiting from the document being worked on. The needed information from the DataLib record(s) can be printed out to hard copy or just copied off the screen.

The exact location of the original is identified on the DataLib record. This hard copy location indicator is saving countless hours of searching through the files looking for needed information or supporting documentation.

2. Search for documents meeting a specific set of criteria.

This involves entering DataLib and performing the desired search. DataLib tells you how many records met each search criteria, and how many met all the defined criteria.

3. Save a search strategy for record and future use.

DataLib has a provision to save search strategies for future use. This allows repeating the same search strategies when necessary. This facilitates keeping track of what documents were found in response to requests by Congress, the Washington Office, OMB, an FOIA, and others.

4. Create Index of records in a format suitable for certification to the courts.

DataLib has wide carriage (132 characters) capability that facilitates this need.

A listing of databases, sorted by date and author, can be used as a check against duplication of entries.

DataLib reports can be exported to CEO and the desired changes made. This also facilitates putting page headers on each page as required for specific specialized uses. With the Index Report in CEO, it can easily be shared and/or mailed anywhere within the Forest Service.

Operational Advantages

The use of DataLib has helped get some tasks done faster and more efficiently, and has also helped to take a close look at our existing filing systems and those we design for special situations such as NEPA documentation. RlO-DataLib has enabled us to create a corporate database that will be available for many years. As senior personnel retire, much of their knowledge is contained in the database, making it retrievable by almost everyone. Our dependence on personal memories has been greatly lessened with implementation of RlO-DataLib.

Use of RlO-DataLib has:

1. Through the use of “deflected drawers,” provided fully supported software to the forests, ranger districts, research stations, and contractors, without their having to train and fund their own software manager.

2. Resulted in less duplication of documents in the records.

3. Resulted in better documentation for new writing and consistency with previous documents and decisions.

4. Resulted in forests being able to access the RO’s database on the long-term sales.

5. Provided faster and more thorough searches for documents requested by Congressmen, FOIA, managers, specialists, publics, and others.

6. Provided documentation of the planning record that is easily accessed for reference and use during implementation of the ROD and monitoring the results. Monitoring and tracking of activities promised by the ROD are essential not only for compliance with NEPA, but also to meet the spirit and intent of ecosystem management.

7. Provided an efficient method to record, track, and recall public comment. This allows long-term tracking of public comment and facilitates analysis of both short- and long-term public views, demands, and desires.

Other Considerations

RlO-DataLib is not a magic “black box” that will solve all data index and retrieval problems just by being on line. It requires up-front work and commitment to provide timely and quality input of data records. This has proven to be a very important factor. For example, documents should be filed and recorded in DataLib from the very beginning of a project. This allows use of the very powerful search capabilities of DataLib during the planning process from the initial drafts to the final implementation and monitoring.

New IDT’s, or any research project or study, have access to the records used by previous and ongoing projects. Not only is a great deal of start-up time saved, but this reference capability facilitates consideration of cumulative effects and connectivity in relation to past and ongoing projects.

The quality of the data summaries is, of course, very important. This is a one-time entry that may be used for many purposes and for many years. Entry of data into DataLib is a rather straight forward process that is easily learned in less than half a day. There are, however, certain rules and conventions that must be followed. Most of these are needed in order to later take advantage of the powerful search capabilities of DataLib. Quality control of data entry must be maintained.

Outline of the Technical Aspects of the DataLib Program

General Overview

- DataLib was developed to handle “special” libraries.
- Run on Data General and VAX.
- Software is designed to be tailored to meet user needs and be meaningful to users.
- Data records are defined to meet user needs.
- Software supports multiple users during input and search processes.
- Prompts rather than screens are used.
- Authorities file, good for maintaining input consistency and input edits.

- Cordant operates a hotline, provides training and software maintenance and enhancements.

- Users are profiled giving or denying functions/privileges, providing database security.

Search/Retrieve Capabilities

- Most searches take 1 to 2 seconds.

- Searches may be performed on selected elements of a record or the entire record.

- Software supports full Boolean string searches.

- Retrieved records may be displayed on the screen, printed, or stored in a separate file.

- Retrieved records may be displayed in multiple formats.

- Software logs all search strategies, these may be saved, reused, and/or printed.

Security

- Through user profile, access is given or denied to databases, record classes, individual records, and element(s) within records.

- Each record added to the database contains the name of the person and date of the action.

FS-INFO on DataLib

In 1991, the USDA established FS_INFO on DataLib as its library management tool. As a result, any person with access to the Forest Service Data General system at the most remote ranger station or via telephone, is able to research documents available in Forest Service libraries throughout the country. This has provided the field resource manager and researcher access to a vast storehouse of knowledge. It has also set the stage for a more efficient technology transfer. For example, there is no longer a need for the library staff to summarize the new publications and then send a hard copy of the summary to all offices. The library staff can more efficiently spend their time entering the new documents into FSJNFO DataLib.

Since R10-DataLib has records for a large number of references, the librarians search it for documents that are not yet in the general library. This emphasizes an important point. If field managers and researchers find an important reference document that is used to influence our decisions, they have an obligation to make the library aware of it. This will make it available to anyone else that is searching for information.

Conclusion

DataLib software has proven to be very useful in our daily work. It has aided in the accuracy and consistency of our written documents. With each use, new and more discoveries are made about the software and its capabilities. It has had little to no impact on computer resources or other system users. The software is user-friendly by evidence of the amount of training needed for people to be productive in the use of the software. The software and information loaded into the databases are a very valuable asset to the Region that will increase in value in the future.

Applying What We Know

Developing and Managing Sustainable Forest Ecosystems for Spotted Owls in the Sierra Nevada

Jared Verner and Kevin S. McKelvey

Abstract

Studies of the California spotted owl have revealed significant selection for habitats with large. old trees; relatively high basal areas of snags; and relatively high biomass in large, downed logs. Based on planning documents for national forests in the Sierra Nevada. we projected declining amounts of older-forest attributes. Region 5 has adopted measures to retain these attributes, generally distributed throughout the conifer zone, for an interim period. We believe that a long-term strategy for the owls, and for other species associated with older forests, must retain some level of these attributes that otherwise can take over a century to develop after regeneration harvests.

Introduction

A recent assessment of the status of the California spotted owl (scientific names are given in the Appendix) demonstrated the importance of retaining sorne levels of older-forest attributes in conifer forests of the Sierra Nevada to maintain a viable population of the owls there (Verner and others 1992b). Based on this information, guidelines are presently in place for national forests (NF's) in the Sierra Nevada to maintain future options for the owl for an interim period. The intent during this interim is to focus research on obtaining a more detailed characterization of suitable habitat, for the owls and to obtain more certain estimates of population trends. Our objectives in this paper are to summarize those aspects of the owl's ecology that relate to older-forest attributes, to discuss those attributes in terms of past and present forest management, and to provide some thoughts about future directions for managing NF's in the Sierra Nevada.

Chief Research Wildlife Biologist and Project Leader, USDA Forest Service, Pacific Southwest Research Station, Fresno, **CA; and Research Forester, USDA Forest Service, Pacific Southwest Research Station,** Arcata, **CA (respectively).**

The California Spotted Owl

General Biology

Spotted owls in Sierran conifer forests use home **ranges on** the order of thousands of acres. For example, home ranges of eight pairs during the breeding period in mixed-conifer forests in the southern Sierra Nevada averaged 3,420 acres (SD = 858) (Zabel and others 1992a). Above about 4,000 feet elevation in the northern and 4,500 feet in the southern Sierra Nevada, northern flying squirrels are the owl's predominant) prey. Gophers are also important, with a variety of other small mammals, a few bird species, and even some insects being taken (Vernrr and others 1992a). Dusky-footed woodrats dominate the diets of the owls at lower elevations, with a cutoff probably between 4,000 and 4,500 feet, in elevation, depending on latitude. Courtship and nest-site selection generally begin in late February or early March and many pairs are still feeding fledglings by mid- to late September. Clutch size ranges from one to three eggs, but nearly all clutches contain two. In a given year, almost none to almost all territorial pairs may nest; owl biologists consider it. a "good year" when at least half of the pairs nest. Studies of radio-tagged spotted owls in the Sierra Nevada indicate that about 45 percent of the birds with summer home ranges in conifer forests migrate to lower-elevation oak-pine woodlands for the winter (Verner and others 1992a).

Habitat Relations

This section surnmarizes available evidence on the structure and composition of suitable habitat for spotted owls in Sierran conifer forests. Ninety-one percent of all known sites of California spotted owls are in the Sierra Nevada, and 81.5 percent of those are in mixed-conifer forests. The remainder occur in red fir (9.7 percent), ponderosa pine/hardwood (6.7 percent), foothill riparian/hardwood (1.6 percent), and eastside pine forests (0.5 percent). (An "owl site" is defined as an area with unspecified dimensions where a single owl or a pair of owls has been located. usually repeatedly.)

Major studies have investigated habitat relations of the owls in four general areas from throughout the length of the Sierra Nevada. From north to south, study areas were in (1) the Lassen NF (Zabel and others 1992a): This study area was primarily at high elevations (5,500 to 7,200 feet) in forests of red and white fir, and secondarily in some lower-elevation habitats dominated by pines and mixed-conifer forests. The area was a mosaic of partial retention cuts. clearcuts, and uncut stands (old-growth). (2) the Tahoe NF (Call 1990): This study area was primarily in mid-elevation mixed-conifer forest at 2,200-5,200 feet. The past history of logging there created a diverse mosaic of different stand ages, types, and densities. (3) the Eldorado NF (Laymon 1988, Bias 1989, Lutz 1992): This extended from low- and mid-elevation mixed-conifer forest to higher-elevation fir forest (1 ,OOO-7,400 feet). Logging activity there was strongly influenced by ownership patterns. About 44 percent of the land was in private industrial forests occupying alternate sections in a "checkerboard" pattern with Federal lands (Bias and Gutiérrez 1992). (4) the Sierra NF (Verner and others 1991): This study area included two distinct habitat types-one dominated by mixed-conifer forest at elevations from about 4,500 to 7,500 feet, the other dominated by hardwoods in oak-pine woodlands and relatively dense riparian/hardwood forests at elevations from about 1,000 to 3,500 feet. Results from only the conifer portion of the study area are included in this report.

Extensive and intensive analyses of results from these studies revealed consistent, and often statistically significant, selection in relation to several habitat attributes (Gutidrrez and others 1992; Verner and others 1992c; Zabel and others 1992a, 199213). Most nest sites were selected in dense stands (at least 70 percent canopy cover) of mixed-conifer forest, and more than half were in stands with average quadratic-mean diameters of canopy trees >24 inches in diameter at breast height (d.b.h.). Results of identical analyses in roost stands produced parallel results. Nest and roost stands showed consistent, often significant differences from random locations in the forest in having higher canopy cover, greater snag basal area, greater total basal area of live trees, and greater softwood basal area. Mean values for canopy cover ranged from about 75 to 96 percent in the different studies, and 80 percent of all nest trees were in stands with at least 70 percent canopy cover. The studies in nesting and roosting stands suggested a range for total basal area of live trees frorn 185 to 350 square feet per acre, and basal area of large snags (>15 inches in d.b.h. and >20 feet tall) from 19 to 31 square feet per acre, and a range of 10 to 30 tons per acre of relatively large downed woody material (at least 11 inches in diameter).

Many of these parameters varied considerably, and not all measures of habitat used by spotted owls and at random locations differed significantly within a given study. The data were, however, consistent and mutually supportive among all studies. California spotted owls in these several studies selected nest and roost stands that were denser than average, that contained a large-tree component, that included more large snags than random sites, and that had considerable biomass of relatively large downed wood. We know of no studies that contradict these findings.

Results of sirnilar analyses at foraging locations indicated that the owls foraged in stands characteristic of nest and roost sites. as well as in a wide variety of other habitats having lower canopy cover and a greater range of tree sizes and ages. Nonetheless, in comparison with random locations within the forest, owls tended to forage in sites with higher canopy closure: greater basal areas of live softwoods and of live softwoods and hardwoods combined; greater basal area of snags: and more dead-and-downed wood. In general, they foraged in forests of intermediate to old age, typically with >40 percent, canopy closure.

Data from 124 nests in Sierran conifer forests provided the most conclusive evidence of selection for very large, old trees by the owls. Nest trees averaged about 96 feet in height and 45 inches in d.b.h.; canopy cover in the nest stands averaged about 75 percent (table 1). The diameters of nest trees were significantly greater than the average tree in today's conifer forest (fig. 1). Only 2.3 percent of trees ≥10 inches in d.b.h. in the Tahoe NF's M4G stands were ≥40 inches in d.b.h., compared to 64.5 percent of the nest trees in Sierran conifer forests that were that, large. Similarly, 89.5 percent of trees in the M4G stands that were ≥10 inches in d.b.h. were <30 inches in d.b.h., but only 13.1 percent of the nest trees were that small. It is important to note that this comparison should reduce the likelihood of detecting spurious patterns of selection

Table 1-Nest stand and nest tree characteristics of California spotted owls in Sierran conifer forests (based on Gutiérrez and others 1992)

	Northern Sierra Nevada	Southern Sierra Nevada
Number of nests	83	41
Nest trees:		
Number in conifers	79	29
Number in hardwoods	4	12
Number living	61	29
Number dead	22	12
Mean elevation (in feet, ± SD)	5,284 ± 922 n = 65	5,750 ± 1,355 n = 41
Mean canopy cover of nest stand (percent ± SD)	75.4 ± 17.2 n = 28	75.5 ± 27.4 n = 17
Mean diameter at breast breast height (inches ± SD)	43.5 ± 14.7 n = 81	46.7 ± 19.6 n = 41
Mean height (feet ± SD)	96.8 ± 36.7 n = 75	95.0 ± 52.7 n = 40
Nest types:		
Cavities	55	27
Broken-tops	9	4
Mistletoe platforms[a]	4	2
Other platforms[b]	15	2
Unknown	0	4

[a] Platforrn developed on top of a dwarf mistletoe broom.
[b] For example. a platform atop an old hawk nest, or one created by accumulated debris in the fork of a tree with two or more leaders.

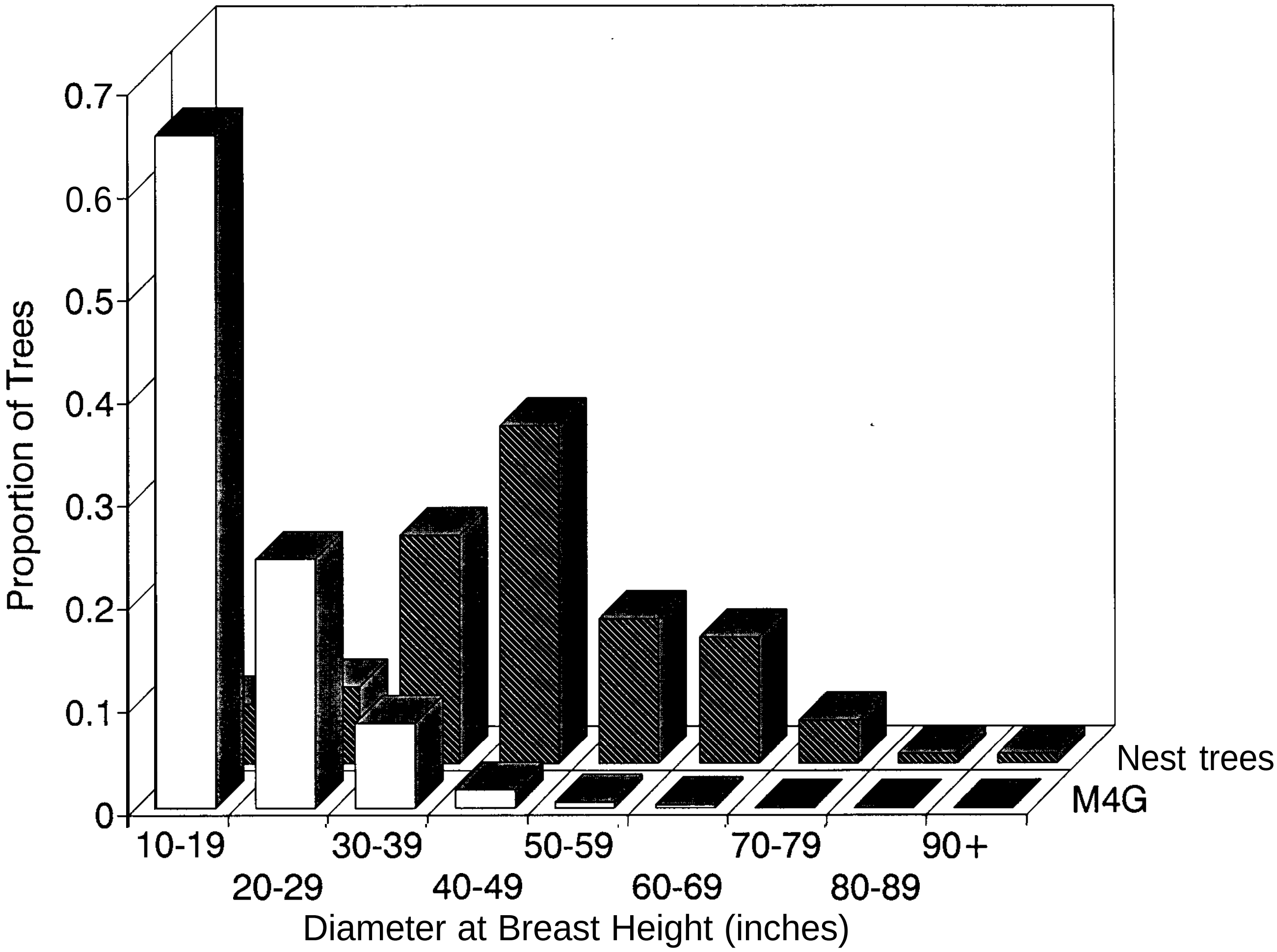

Figure 1-A comparison of the diameter distributions of nest trees used by California spotted owls in conifer forests of the Sierra Nevada and of all trees ≥10 inches in d.b.h. as measured in M4G stands (mixed-conifer, overstory canopy dominated by trees ≥24 inches in d.b.h., and canopy cover ≥70 percent) on the Tahoe National Forest.

for large trees, because the comparison is based on tree sizes only in M4G stands. These are stands of mixed-conifer forest with the canopy dominated by stems ≥24 inches in d.b.h., and canopy cover ≥70 percent-they have a higher density of large trees than most other timber strata. Data from industrial timberlands are consistent with these findings (unpublished document by Robert J. Taylor, 1992, entitled "California spotted owls on industrial forests," California Forestry Association, Sacramento, CA). No data from any study support a contradictory view for conifer forests in the Sierra Nevada.

A prevalence in these forests of cavity nests (66 percent), nests on broken-topped trees (10 percent), and nests on mistletoe brooms (5 percent) (Gutie'rrez and others 1992, table 51) showed that most nest trees were not only large but also old and decadent. Age data presented in Gutie'rrez and others (1992, table 5M), collected in the San Bernardino 'Mountains in southern California, suggested nest tree ages generally ranging upward from 200 years. We lack data to directly age nest trees used by spotted owls in the Sierra Nevada. To obtain age estimates for these trees on the seven westside NF's in the Sierra Nevada, we analyzed the inventory data that provide the basis for size, age, and growth rates of the various timber strata. Timber strata were included in the analysis if they were westside types. The large-tree grouping in the inventory data included trees ≥39 inches in d.b.h.; we used these data to compare with nest trees ≥40 inches in d.b.h. Any negative bias in age estimates that may have resulted from this is probably too small to be of consequence.

Data from 86 strata were available from the Lassen, Plumas, Tahoe, Eldorado, Stanislaus, Sierra, and Sequoia NFs. Based on inventory protocols, ages of

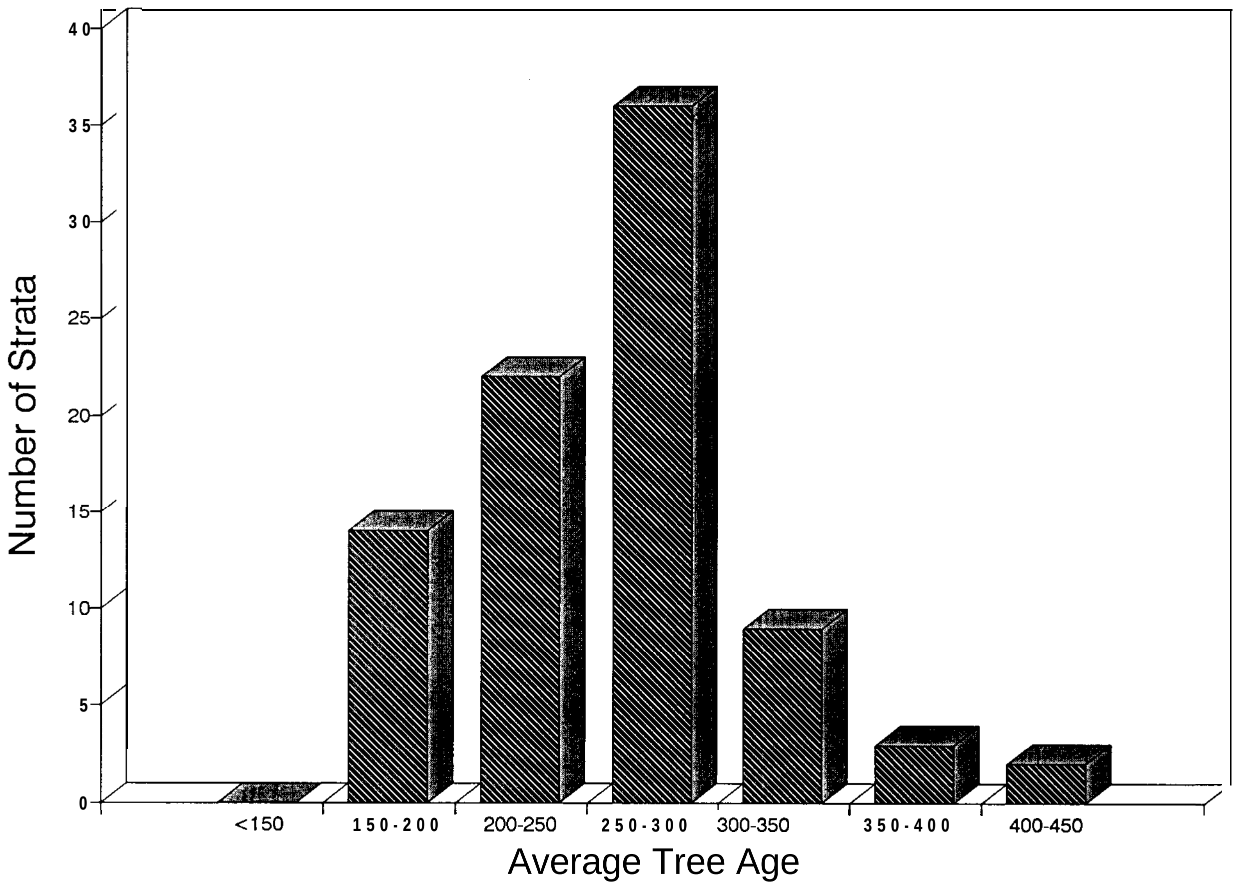

Figure 2—Distribution of the mean ages of trees ≥ 39 inches in d.b.h. in a sample of timber strata from westside national forests in the Sierra Nevada ($n = 86$).

relatively few trees were measured in each stratum. Because trees in this diameter class are relatively rare, much of the variability in sample estimates may be due to small sample sizes. Nevertheless, only 16 percent, of the strata sampled had average ages of <200 years for trees ≥ 39 inches in d.b.h. The mean ages of trees in this size class in these strata ranged from 156.8 to 438.0 years, with an overall average age of 258.1 years. Most strata-level age estimates averaged between 250 and 300 years (fig. 2). Age estimates for the strata important for nesting by spotted owls were consistent with this finding. We believe the data justify a conservative assessment that the majority of nest trees used by spotted owls in Sierran conifer forests were at least 200 years old.

Results of this and the several other studies of habitat attributes important to the owl consistently highlight the importance of very large, decadent trees. These trees are important not only in providing nest sites. but also in providing the snags that later fall, to become decaying logs that enrich the forest floor. From a silvicultural standpoint, to reliably maintain a supply of these trees in the landscape requires either maintaining older trees or more quickly producing trees that have old-tree attributes. This means more than just quickly generating large-diameter trees (although this is a starting point). The trees must have structural characteristics similar to current nest trees. Most of the cavities used by spotted owls are created naturally, where large branches pull out as a result of heart rot, leaving large-diameter holes. Clearly, then, important features of these trees include flattened crowns (broken tops and platforms) and large limbs, as well as the presence of rot in the upper stem.

Physiologically, we are looking at manipulating the shift from excurrent (obvious central stem, single leader) to decurrent (multiple leaders without an obvious central stem) growth-a shift in conifers that is linked to tree age and site quality (Daniel and others 1979, p. 121). We also need to explore the dynamics of rot and determine whether heart-rot

Figure 3-Nest tree with adult and two fledglings; the cavity above the birds, in the main stem to the right, may have housed the nest, at least 60 feet above the ground. The tree was a sugar pine at an elevation of 7,000 feet on the Tahoe National Forest (photo by John S. Senser, 26 June 1991).

patterns generally associated with older trees can be encouraged through cultural techniques. An approach would be to consider attributes of current nest trees (e.g., fig. 3) and test various options that might generate trees with the same appearance and rot characteristics more quickly through silvicultural manipulation. For example, Hall and Thomas (1979, p. 139) suggested that old-growth conditions in the Blue Mountains of Oregon and Washington could be produced through stand manipulation if the rotation were extended to 240 years. Their silvicultural prescription included thinning during early stages of stand development, and counted on logging damage to encourage the formation of heart rot in the stand. Until tested, however, the possible outcomes of this prescription remain uncertain. Logging damage, for instance, may produce root rot rather than the desired heart rot.

If we cannot generate old-tree structures in younger trees, we will be left with the only other possibility-to retain significant, old-tree components within the stands. In any case, this is the only reasonable approach in the near-term. This logic is at the heart of the recommendations in the "CASPO Report" (Verner and others 1992c), summarized below in the section entitled "Interim Guidelines "

In spite of the extensive amount of information available on the habitats selected by the owl for nesting, roosting, and foraging, we still lack the needed information to characterize the structure and composition of habitats that will assure persistence of spotted owl populations in the Sierra Nevada. This is the case for at least three reasons: (1) the habitats used by the owls are structurally and floristically very heterogeneous, and they have been degraded by human activities over the past century; (2) the studies have not been underway long enough; and (3) nearly all data on owl habitats in Sierran forests were obtained during a prolonged and severe drought in California. Nesting by the owls tended to be sporadic during the study period, and fewer than 20 percent of pairs under study nested in some years. Because not all pairs nest in all years, they need to be studied over relatively long periods to determine whether their reproductive output is sufficient to sustain a regional population. Existing demographic studies have not been underway long enough to make this determination with any degree of certainty.

Status of the California Spotted Owl Population in the Sierra Nevada

The most recent assessment of the status of the owl's population in the Sierra Nevada (Noon and others 1992) failed to reject the null hypothesis that the population was stable or increasing. Demographic studies had been underway in four locations-Lassen NF (2 years), Eldorado NF (6 years), Sierra NF (2 years), and Sequoia/Kings Canyon National Parks (NP's) (4 years). Based on detailed knowledge of the histories of color-banded owls, researchers estimated age-specific rates of reproduction and mortality, and identified all cases in which owls disappeared from territories and were replaced (or not) by other owls.

Owl banding had been underway long enough to estimate population trends in only two study areas-Eldorado NF and Sequoia/Kings Canyon NP's. The estimates suggested about a 5 percent annual rate of population decline (alpha = 0.05; $P = 0.1271$) from 1986 through 1991 in the Eldorado NF population, and about a 3 percent annual rate of population decline (alpha = 0.05. $P = 0.2709$) in the Sequoia/Kings Canyon NP's population from 1988 through 1991. These estimates were not significantly <1.0, so we cannot conclude that the populations were declining. Each test, however, had a power of only 0.30 to detect a real decline of 5 percent per year. This means that, even if the populations actually had that rate of decline, it would not be detected 70 times in every 100 studies of equivalent size. The low power resulted from a relatively small number of marked birds, and the large standard errors of parameter estimates (Noon and others 1992). The correct inferences to draw from these results are that we cannot be certain about the true trends of these populations during the periods of study.

If the quality of owl habitat has undergone a gradual decline in the Sierra Nevada, the effects may be subtle and difficult to detect. Because we lack adequate, historical inventories of Sierran owls, we have nothing to compare with present inventories. The current distribution and abundance of the owls, however. suggest no decline in their overall distribution in the Sierra Nevada, but it is less clear whether any decline in abundance has occurred within any forest type. Relatively few large areas exist that have sufficiently low densities of owls to engender some concern. The observed (nonsignificant) declines in the Eldorado and Sequoia/Kings Canyon populations may have reflected the fact that both studies were done coincident with the severe and prolonged drought in California. These studies are continuing in an effort to determine the true trends of the populations.

Sierran Forests-Past, Present, and Future

The Past

Sierran forests prior to European settlement of the west were characterized by extensive canopies dominated by large trees, relatively open understories with only occasional fuel ladders, and probably relatively little surface fuel (figs. 4 and 5). This condition has been markedly changed

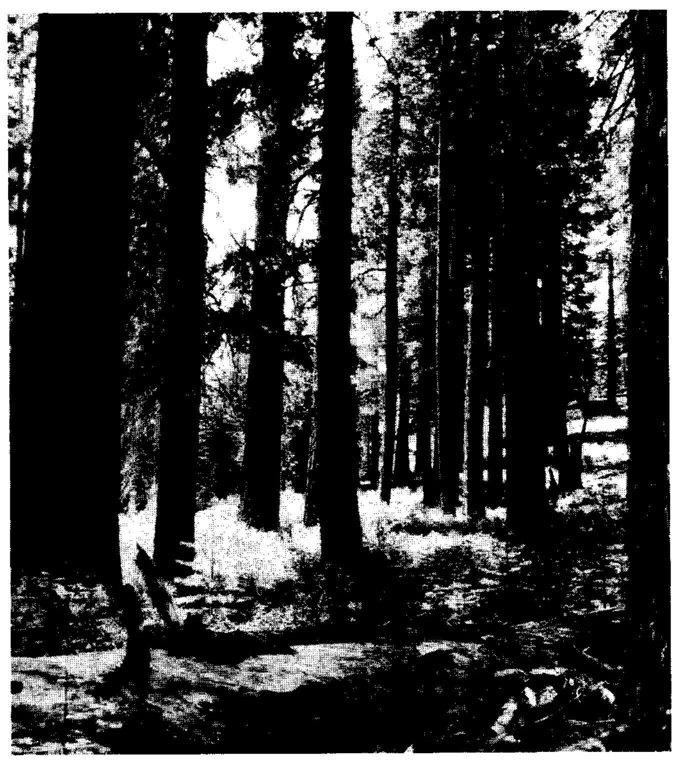

Figure 4-A virgin forest near Strawberry, on the Stanislaus National Forest. Conifers in this stand included sugar pine, ponderosa pine, true fir, and incense-cedar (USDA Forest Service file photo, 1920).

Figure 5-A stand of old-growth Jeffrey pines on the Lassen National Forest (USDA Forest Service file photo, about 1920).

in various ways by human activities, however, especially during the past 150 years (McKelvey and Johnston 1992). Major impacts resulted from grazing by a million or more sheep from the early 1860's through the first decade or so of this century; peak numbers occurred in the 1870's. Extensive early logging took place coincident with sheep grazing, primarily at low elevations near towns, mines, and along transportation corridors. Timber production reached a peak about 1950 (McKelvey and Johnston 1992, figure 11T), dropping some from that level but remaining relatively high in most years since. Fire suppression began in the early part of this century and became increasingly aggressive as time passed.

The coincidence of at least four factors, early in this century, resulted in a major pulse of regeneration (fig. 6). These were (1) "churning" of the soil by sheep. and later removal of the sheep from the land during the first decade of the century; (2) onset of a wetter-than-normal climatic cycle during most of the century; (3) removal of dominant, overstory trees by logging; and (4) development of increasingly aggressive fire suppression. As a result, forests in the Sierra Nevada were subject to extensive development of fuel ladders, accumulation of surface fuels, and ingrowth of shade-tolerant conifers such as white fir and incense-cedar (e.g., figs. 7 and 8) (McKelvey and Johnston 1992, Weatherspoon and others 1992). A decline in the number of large, old trees resulted from logging and natural attrition of the old forest. Past logging activities that concentrated on removal of the largest, most valuable trees broke up the patchy mosaic of the natural forest, further enabling the development of dense conifer regeneration. These events, especially in ponderosa pine and mixed-conifer forests, reduced large-diameter trees in many areas to small remnant populations. These changes have not occurred to the same degree in the red fir type, where fires were less frequent historically, and where logging was generally uncommon until recent decades.

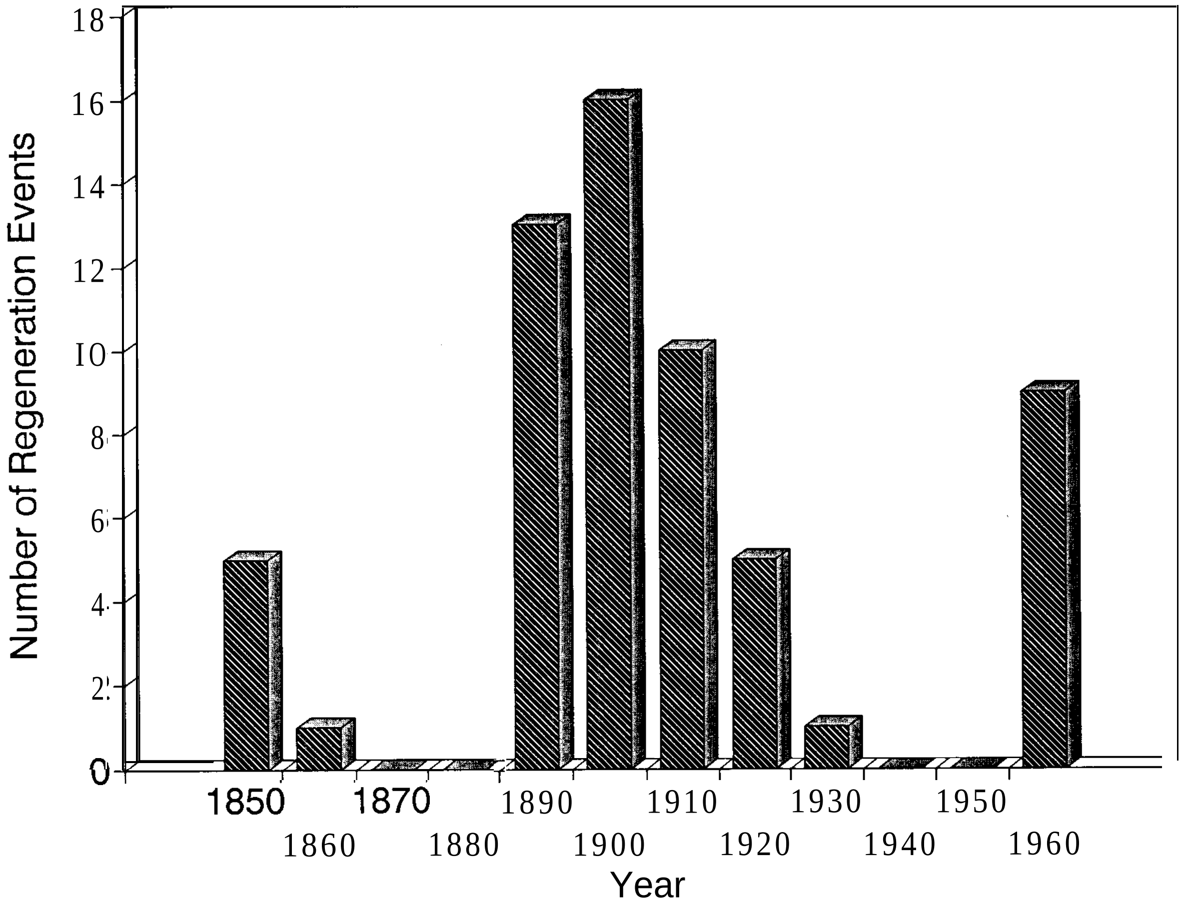

Figure B-Periods of significant regeneration on sites within Sequoia National Park. This figure was developed by combining data from tables in appendices of Vankat (1970).

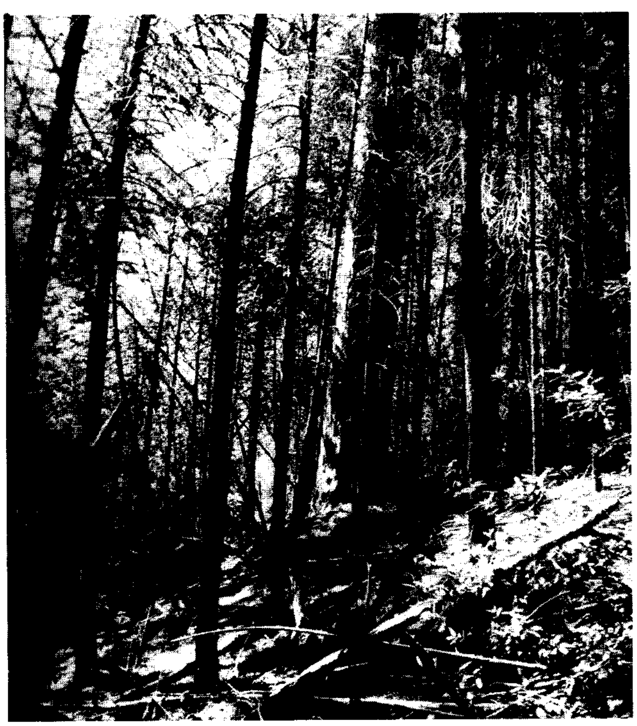

Figure 7-Mixed-conifer forest at an elevation of 2,800 feet on the Eldorado National Forest; note the extensive surface and ladder fuels (photo by John S. Senser, 24 June 1991).

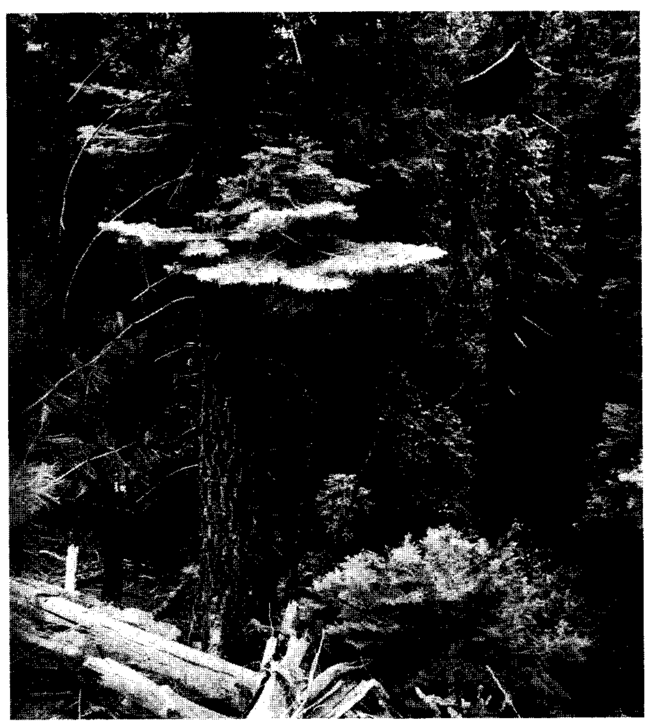

Figure 8-Mixed-conifer forest at an elevation of 4,400 feet on industrial forestland within boundaries of the Tahoe National Forest: note the surface and ladder fuels.

The Present

Because of current stand structures and excessive fuel loadings in much of the Sierran mixed-conifer type, fires that escape initial attack-usually fires occurring during extreme weather conditions-tend to become catastrophic. Fire trends in the Sierra Nevada can be expected to continue along their current trajectories, with more frequent catastrophic fires. As the human population increases in Sierran forests and woodlands, the presence of numerous houses within the forest will shift further the emphasis of suppression from saving forests to saving property. Fuels also continue to accumulate, with the recent drought-induced bark beetle infestations contributing a major pulse of new fuels over the next few decades. We expect the net result to be a much higher incidence of stand-destroying fires in the future than was the case prior to this century. Those fires will continue to destroy remnant. individual old trees, stands of old trees, and other old-growth attributes.

The Future

Logging trends based on Land Management Plans (LMP's) of NF's in the Sierra Nevada also pointed to a continuing decline in the number of old trees and remnant stands of old-growth forest. Sixty-five percent of the forested lands on Sierran NF's were classified as suitable for timber production (McKelvey and Weatherspoon 1992). Discounting forested acres that could not produce timber commercially because they were too poor in quality, they could not be successfully regenerated, or they had unstable soils, 74 percent of the lands that could potentially produce timber would have been harvested in some manner. Seventy-two percent of the timber volume would have been taken through even-aged systems-mostly clearcuts. Of the 528,474 acres of suitable timberlands on the Tahoe NF, for example, 68 percent were slated for even-aged silviculture (24 percent long rotation, 44 percent short rotation) (McKelvey and Weatherspoon 1992). On the Plumas NF, 52,000 acres were scheduled for even-aged cutting per decade, with 8,000 acres in selection cutting methods.

Clearcut, seed-tree, and shelterwood cutting techniques all have the same goal: produce even-aged stands. In this regard, seed-tree and shelterwood systems usually can be thought of as two-stage (sometimes three-stage) clearcuts. Few stands were scheduled to retain the seed trees. In terrns of owl biology, the primary impact of traditional, even-aged silviculture lies in the creation of simple stand structures and, probably more importantly, the removal of all large trees from vast areas of the forest. Even if prescriptions were modified to leave snags and live culls at the first cutting, no provision was made for a predictable recruitment of replacement trees for these relics when they fell. This, in turn, would have led to a loss of large-diameter downed logs important in the production of fungi that, are a primary food source for flying squirrels-the main prey of spotted owls in Sierran mixed-conifer forests (Verner and others 1992a). Log slash can create much small-diameter woody debris, but it cannot replace the large logs. In an even-aged system, these old-growth features can be created only by an extreme extension of the rotation interval. Even if the rotation were extended to 150 years, for instance, no trees would match the average age of the forest at the beginning of this century in the Sierra Nevada (McKelvey and Johnston 1992). Decadent tree features (e.g., cavities, broken-tops, snags) in stands are functions of age, not just d.b.h. Without those features, animals that depend on them, or the large woody debris they create, would simply drop out of the forest ecosystems.

Even on lands planned for selection harvest, (about 80,000 acres/decade), harvest prescriptions did not guarantee retention of any large, old trees. Ideally, stands managed for individual-tree selection are logged in a manner that, brings the diameter distribution in the stand into conformity with an idealized distribution, characterized by a declining exponential function (the inverse "J" curve). The number of large trees in a stand is dictated by the slope of this curve and the designated diameter of the largest tree. In selection harvests. timber is taken from all diameter classes as needed to maintain this diameter distribution. Little evidence exists. however, that historical patterns of partial cutting have followed the classic single-tree theory. "Selection" harvest in the Sierra Nevada has, in the past, primarily targeted the large trees. This system, sometimes called "pick and pluck," does not produce the simple, even-aged structures that characterize clearcutting techniques, but its effect on the presence of large, old trees is similar. If the large trees are removed and no stocking control is done on the smaller stems, replacement trees in these diameter classes will be produced very slowly, if at. all, and they will consist primarily of the more shade-tolerant species. Even with classical single-tree selection, a gradual loss of shade-intolerant, species would be likely.

The future forests of the Sierra Nevada, as projected by the LMP's, would have been split between areas of even-aged plantations and areas of dense and increasingly small-diameter stands. Given these projections, it seems most likely that the forest to be generated by adherence to the LMP's would have been susceptible to severe fire disturbance, nearly devoid of large, old trees, and depauperate in terms both of plant, and animal species that depend on attributes of the older forests that were common last century. The key elements of spotted owl nest and roost stands definitely would have declined sharply over most of the Sierra Nevada in the next few decades. Without them, a hiatus of well over 100 years would pass before more would grow to take their place. In the process, the spotted owl would probably be markedly reduced in numbers over most, of the Sierra Nevada, possibly with viable subpopulations surviving in Yosemite and Sequoia/Kings Canyon NP's.

What Does it All Mean?

We are uncertain whether the Sierran populations of spotted owls are in decline. Continued adherence to the LMP's in effect in 1992, however, would have continued to erode the abundance and distribution of those kry habitat attributes consistently associated with occupancy and nesting by the owls. Unchecked, we believe this trend would have led to significant declines in the abundance and distribution of the owls in the Sierra Nevada. Of greatest concern to us at this time is the possibility of the rapid disappearance of large, old, and generally decadent trees selected for nesting by the owls. These same trees eventually become the large snags, and finally the large fallen logs, that we believe are important for maintaining suitable owl habitat. Once gone, they could not be replaced quickly.

In addition to our concern about the loss of key "old-forest" attributes. we believe that the extensive accumulation of surface and ladder fuels in the relatively dry, ponderosa pine and mixed-conifer forests on the western slopes of the Sierra Nevada will foster major stand-destroying fires. Recent Sierran fire history teaches us that these fires can engulf tens of thousands of acres in a matter of a few days. In such events, essentially all resource values are eliminated or seriously degraded, not just vast acreages of suitable owl habitat.

Dealing with the Current Situation

Interim Guidelines

Uncertainties about (1) the real status of owl populations in the Sierra Nevada and (2) the specific details of habitat structure and composition that, would assure self-sustaining populations of owls precluded recommendations for long-term management of the owl. Instead, the Technical Assessment Team recommended an interim approach to allow more time for research to eliminate some of the uncertainties (Verner and others 1992c).

The Team identified eight major factors of concern in habitats of California spotted owls in the Sierra Nevada (table 2). These involved projected declines in the older attributes of forests believed to be important to the owl, the long recovery time for owl habitat after regeneration harvests, and the excessive accumulation of surface and ladder fuels. Recommendations in the CASPO Report were later adopted as the preferred alternative in an Environmental Assessment (EA) of the owl in the Sierra Nevada (USDA Forest Service 1992). The Decision Notice (Stewart 1993) set March 1, 1993 as the start date for a 'L-year interim period to implement the spotted owl guidelines, during which time a full Environmental Impact Statement dealing with this matter is to be completed.

Interim guidelines (summarized in table 3) stress protection of nest and roost areas; retention of large, old trees, large snags, and large downed logs; and efforts to begin dealing with the excessive surface and ladder fuels that have developed in Sierran conifer forests since the first decade or so of this century. Specifically, the guidelines require delineation of a 300-acre "Protected Activity Center" (PAC) around known owl sites. Commercial logging is excluded in PAC's, but light underburning is allowed in certain circumstances to deal with fuels problems. Within "Selected Timber Strata" (those shown to be significantly selected for nesting by the owls), guidelines suggest removal of no live

Table z---Summary of major factors of concern in habitats of California spotted owls in the Sierra Nevada, reasons for those factors, and their impacts on the owls (taken from Verner and others 1992c)

Factor	Reason(s) for the factor	Impact on spotted owls
Declne in abundance of very large! old trees	Selective logging of the largest trees from stands	Loss of the owl's preferred nest sites
Long recovery period for spotted owl habitat after logging	Selective logging of the largest trees from stands	Less of total landscape in suitable owl habitat at any given time
Ingrowth of shade-tolerant tree species, creating unnaturally dense stands with ground-to-crown fuel ladders	Selection harvest; aggressive fire suppression; sheep grazing, which created ideal seedbeds for conifer germination late last century	Increased threat of stand-destroying fires
Excessive build-up of surface fuels	Aggressive fire suppression over the last 90 years, leading to higher densities of trees, more competition for space and water. so a higher death rate of trees	Increased threat of stand-destroying fires
Loss of large-diameter logs from the decaying wood source on the ground	Intentional fires by sheepherders; selective logging of largest trees; pilng and burning logs after logging; domestic fuelwood removal	Potential declne in flying squirrel densities via loss of fungi that are a dietary staple for the squirrels
Declne in snag density	Selective logging of the largest trees from stands; salvage logging; fuelwood removal	Loss of potential nest sites for owls; loss of den sites for flying squirrels; loss of a source of large logs for decay needs on the ground
Disturbance and/or removal of duff and topsoil layers	Sheep grazing; mechanical disturbance from logging equipment, skid trails, and so on; increased surface fuels that burn hot enough to destroy duff layer	Potential decline in flying squirrel densities via loss of fungi that are a dietary staple for the squirrels
Change in composition of tree species (fewer pines and black oaks, more firs and incense-cedar)	Selective logging of the largest trees, particularly pine species, from stands; aggressive fire suppression	Some loss of nest sites; other effects unknown

trees ≥ 30 inches in d.b.h.; retention of at least 40 percent of the basal area, starting with the largest tree and working down toward the 40-percent basal area limit: and maintenance of 40 percent canopy cover. Within "Other Timber Strata" (those known to be used for nesting but not significantly selected by the owls), guidelines suggest removal of no live trees ≥ 30 inches in d.b.h., and retention of at least 30 percent of the basal area, starting with the largest tree and working down toward the 30-percent basal area limit. The guidelines also specify targets for retention of snags and large downed logs in owl habitat. Finally, one of the strongest recommendations in the CASPO Report was to undertake activities, such as biomass sales, that would begin to lessen the threats of catastrophic fires in Sierran conifer forests.

The primary intent of all these guidelines is to retain key attributes for owls throughout Sierran conifer forests in a way that will maintain options for later implementation of a long-term strategy. In addition, by retaining very old trees! large snags, and large downed logs, the guidelines shorten the recovery time after logging in suitable owl habitat. Indeed, because guidelines for "Selected Timber Strata" require retention of at least 40 percent canopy cover. we suspect that these stands will

Table 3-Summary of primary recommendations for stand retention and special stand treatments to maintain options for spotted owls on public timberlands in the Sierra Nevada during an interim period (taken from Verner and others 1992c)

Attributes	Protected[a] activity centers	Selected[b] timber strata	Other[c] timber strata	Salvage sales
Large, old trees				
Basal area	No logging	Keep 40 percent) from largest healthy trees and culls	Keep 30 percent. from largest healthy trees and culls Retain at least 50 square feet per acre	Does not apply
D.b.h.	No logging	Retain all live trees ≥30 inches	Retain all live trees ≥30 inches	Does not apply
Percent canopy cover	No reduction	≥40 percent	No restriction	No restriction
Snags	No reduction	Retain largest down to a total of 20 square feet per acre	Retain largest down to a total of 20 square feet per acre	Retain largest down to a total of 20 square feet per acre; take no snag ≥30 inches in d.b.h.
Dead-and-downed woody material	Retain at least 3-5 percent of ground cover; at least three logs 20 inches in diameter by 20 feet long	Retain at least 3-5 percent of ground cover; at least three logs 20 inches in diameter by 20 feet long	Retain at least 3-5 percent of ground cover; at least three logs 20 inches in diameter by 20 feet long	Retain at least 3-5 percent of ground cover; at least three logs 20 inches in diameter by 20 feet long
Fire threats	Light under-burning	Positive fuels management	Positive fuels management	Positive fuels management

[a] Block of 300 acres of suitable nesting/roosting habitat delineated around nest site or primary roost site in all known spotted owl sites in the Sierra Nevada.
[b] Timber strata significantly selected for nesting by spotted owls in the Sierra Nevada.
[c] Other timber strata used for nesting by spotted owls in the Sierra Nevada, but not significantly selected.

be used for foraging by the owls within 5 years of logging. Without retention of the older stand elements, recovery to suitable foraging habitat after logging would likely take at least 60-80 years, and recovery to suitable nesting habitat could take as long as 150-200 years.

Implementing the guidelines also has the inherent potential to deal aggressively with the fuels problem. Most timber sales following the guidelines could be classified as commercial thinning operations or biomass sales. Their effect would be to remove significant amounts of the fuel ladders. If properly done in terms of fuels treatments, surface fuels would also be reduced to acceptable levels.

We have encountered essentially no opposition to our conclusions about the seriousness of the present fuels conditions in Sierran conifer forests. This is a problem clearly visible to all who care to look. But adoption of the CASPO guidelines in the EA has created a storm of protest from the timber industry in California and from some timber staffs on NF's in the Sierra Nevada. A primary concern has been the lack of availability of trees larger than 30 inches in d.b.h. Estimates indicate that about 50 percent of the potential timber volume is in these large trees, so projections suggest a marked drop in timber volume from sales in the Sierra Nevada. At least some mills are not equipped to handle smaller logs efficiently, and owners of others that are so equipped assert that they cannot sustain their operations if they lack access to at least some larger logs. We do not know how valid these assertions are, but we know that rnills in the southeastern United States maintain viable operations without large logs.

A point that we believe has been overlooked so far is reflected in the concern about potential volumes under the EA guidelines. At least from an ecological standpoint, or the standpoint of the spotted owl in the Srerra Nevada, timber volumes under CASPO guidelines need not be reduced from past years. Indeed, it would be preferable if they were Increased, because that would result in many more acres being treated and the fuels problem being further reduced. Large, stand-replacing fires, such as those in the Stanislaus-Complex Burn of 1987 (145,000 acres) or the Cleveland Burn of 1992 on the Eldorado NF (25,000 acres), can remove as much owl habitat as decades of clearcutting.

Perhaps the most significant challenge in this arena is the lack of funding now available (1) for the extra planning needed to implement the EA and (2) to deal aggressively with the fuels situation. Even if a timber sale can be offered, it may generate insufficient revenues to pay for the needed fuels reduction. This is a real problem, but it is not a reason to discard our responsibility to deal effectively with an escalating fuels situation. We need to educate the public, the Congress, and the Administration about the seriousness of this situation. Undoubtedly its solution lies in spending much more money than has been the case historically. If we fail to do this, we will continue to experience catastrophic fires in the Sierra Nevada, and we will most likely lose more in the long run than it would cost now to assure adequate protection for these resources.

A View to the Future

Several lines of research and development need to be explored. For example, we still lack a full understanding of the many linkages in forest ecosystems that directly or indirectly influence the ability of spotted owls to reproduce at rates sufficient to balance their death rates. We need to develop silvicultural methods and logging systems that retain specified levels of key elements of older forests that are important for ecosystem integrity. The relatively new "cut-to-length" and "forwarding" systems developed by the Scandinavians are promising examples. We also need silvicultural research on ways to create stand attributes that are generally associated with species that are highly adapted to older forests. We also need to understand better the nature of old-growth forests prior to European settlement) (as opposed to current old-growth forests, which have been strongly affected by fire exclusion, past sheep grazing, and other anthropogenic factors), because the presettlement forests should provide conservative models of sustainable forest ecosystems.

In recent years, the spotted owl has been a beacon for contentious issues in forest management in all of the far-western States. Millions of dollars have been spent in research and management, singularly directed at this species. We cannot, know how history will evaluate these expenditures, but at least the owl is a reasonably effective "umbrella" for many other species-both animals and plants-that are best adapted to older forests. This is the case primarily because individual owl pairs have extraordinarily large home ranges. so maintenance of enough habitat to assure a viable population of the owls provides for the needs of numerous other species with lesser area requirements.

Attitudes are changing now about how to deal with the challenges posed by threatened and endangered (T&E) species. The Forest Service is shifting its emphasis toward more integrated managernent of multiple resources—so-called ecosystem management. What this means. how we will do the managing, and how researchers will evaluate results still remain to be seen. But this is a promising shift, one that should have been made many years ago. Maintaining the integrity of ecosystems should markedly reduce the likelihood of adding to the current list of T&E species. We contend, however, that lessons learned from intensive studies of individual species like the spotted owl and fisher will serve us well, at least initially. For example. whatever long-term strategy may be adopted for California spotted owls, we believe it will include measures to retain some level of very large, old trees, large snags, and large downed logs. We also hope that it will reduce the need to set aside areas managed exclusively for one or a limited number of uses or resources. Numerous species of plants and animals will benefit from management changes implemented at a landscape scale.

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Appendix

Common and Scientific Names Used in Text

Plants

Dwarf mistletoe	*Arceuthobium* spp. Bieberstein
Sugar pine	*Pinus lambertiana* Douglas
Ponderosa pine	*Pinus ponderosa* Douglas ex Lawson
Jeffrey pine	*Pinus jeffreyi* Greville and Balfour
White fir	*Abies concolor* Gordon and Glendinning
Red fir	*Abies magnifica* A. Murray
True fir	*Abies* spp. Miller
Incense-cedar	*Libocedrus decurrens* Torrey
Oak	*Quercus* spp. Linnaeus

Animals

California spotted owl	*Strix occidentalis occidentalis* Xántus de Vesey
Northern flying squirrel	*Glaucomys sabrinus* Shaw
Dusky-footed woodrat	*Neotoma fuscipes* Baird
Gophers	*Thomomys* spp. Wied-Neuwied
Fisher	*Martes penanti* Erxleben

Combining Ecological Classification and Silviculture Prescriptions to Achieve Desired Future Forest Conditions

Thomas M. Jimerson and David W. Jones

Abstract

Ecological classification combined with silviculture can be used to achieve desired stand structure attributes, to accelerate stands toward old-growth structure, and together with vegetation mapping and GIS, identify stands for treatment and future stand development in order to maintain forest health and achieve desired landscape patterns.

Introduction

Increased controversy over use and allocation of national forest resources and concerns for the loss of biological diversity and the health of forest ecosystems has caused the USDA Forest Service to review its approach to management of the national forests. This change in strategy, labeled ecosystem management, provides a new approach to management based on ecological principles. This is particularly important now since the worldwide demand for goods, services, and amenities from forests continues to increase (Graham 1991). The goal of ecosystem management is to conduct management and research with emphasis on maintenance of ecosystem processes and functions, while still providing goods and services (USDA 1992).

To begin understanding ecosystem processes and functions requires an ecological classification system based on potential natural vegetation units in combination with soils, physiography, and response to disturbance (Hall 1970, 1980, 1983; Pfister 1976). These potential natural vegetation (PNV) units then are used to analyze ecosystems (coarse filter analysis). It is thought that maintaining a representative array of various PNV types and their seral stages will ensure viable populations of most species (85-90 percent) and maintain biological diversity (Noss 1983, 1987; Hunter 1991).

In 1984, the Forest Service in the Pacific Southwest Region began a long-term project to develop an ecological classification system for the 20 million acres it manages in California. These ecological classifications provide a common language for better communications between specialists, an ecological database to help understand plant-environment interactions, and a tool for land and resource management (Wenger 1984). The long-term objective is to describe vegetation/soil/physiographic/management units called ecological types. These units are distinguished from each other by differences in species composition, soils, productivity, physiography, and expected response to management (Allen 1987).

In the past few years, silviculture has undergone a change from primarily wood production to a broader perspective of maintaining wildlife habitat, stand structure, and ecosystem function, while still providing wood products. This creates the need for very different stand management prescriptions, some of which are aimed at developing and maintaining old-growth habitat. Ecological classification of potential natural vegetation types, observation of natural disturbance, and past silvicultural treatments, provide the silviculturist with a picture of stand development over time. The assumption is that silvicultural prescriptions can be applied that will reduce the time needed to achieve late seral conditions and produce wildlife habitat features, while producing commodity outputs. The practice of silviculture should be focused on the maintenance of complex forest ecosystems with diverse structure and composition well into the future (Graham 1991) and should take the lead in providing strategies for long-term ecologically based systems, while producing wood and other products (Hann 1989). In areas where ecological classifications are described and include silvicultural and mensurational information, the reliability of predicting management prescriptions results should increase (Layser 1974; Jimerson 1986, 1990, 1993).

Project Area

The Pilot Creek project area is a complete watershed composed of 15,207 acres located in the northern tip of the Mad River Ranger District, Six Rivers

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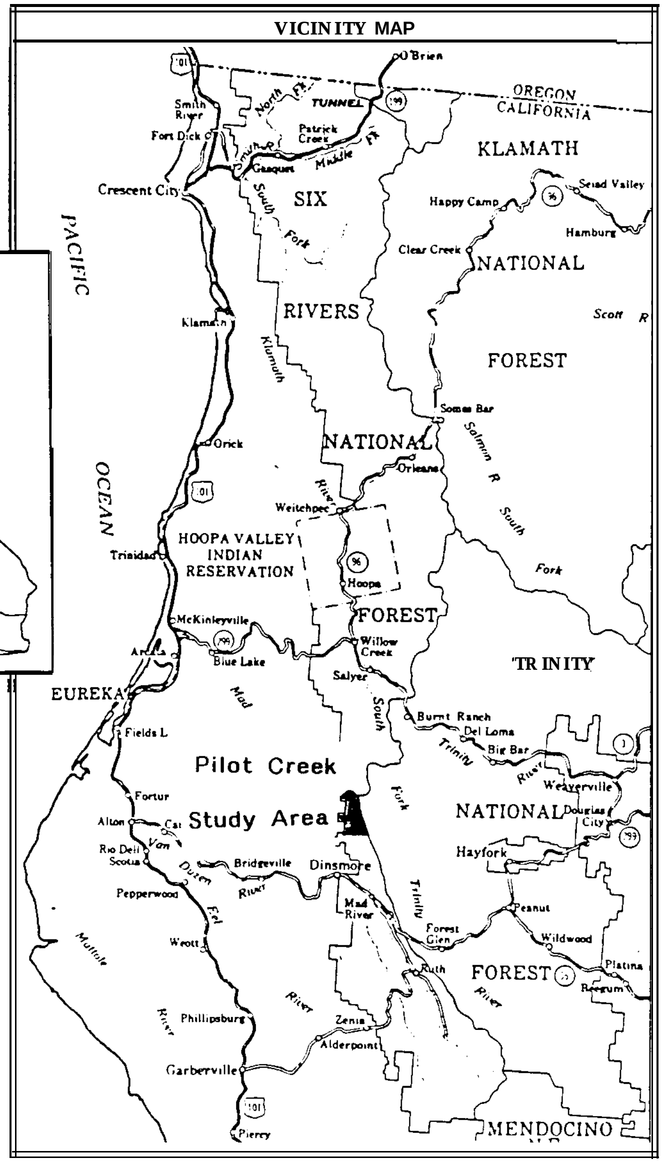

Figure 1—Map of the Six Rivers National Forest, northwest California, with the Pilot Creek Study Area highlighted.

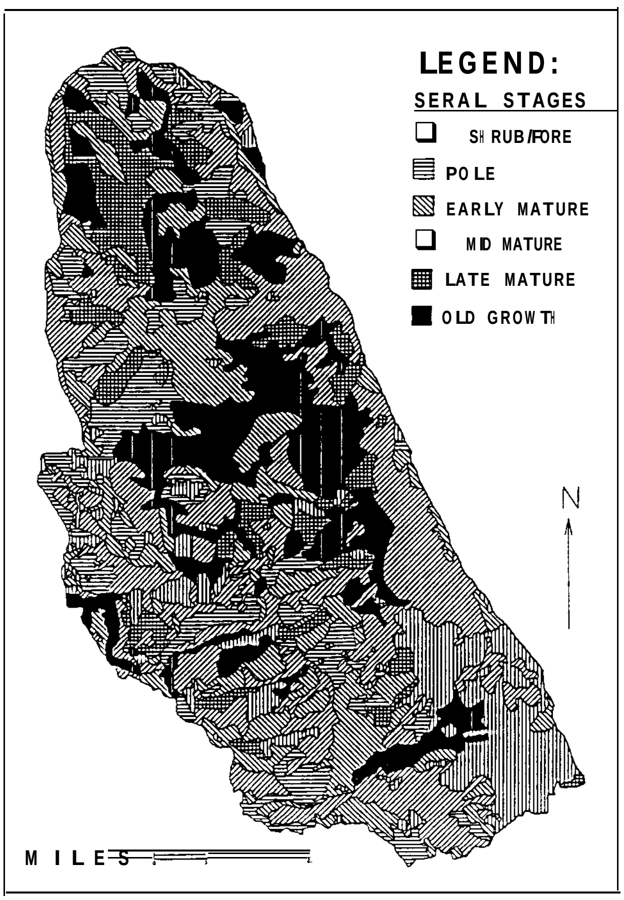

Figure 2—Current seral stage map of the Pilot Creek project area.

National Forest, northwest California (fig. 1). Due to the orientation of transverse ridges and the distance from the Pacific Ocean, climate here becomes drier than stands located to the north (Albert 1979; Parsons and Knox 1984). The closed canopy conifer stands to the north give way to a mosaic of conifer forests and their seral stages, intermixed with oak woodlands and grasslands in Pilot Creek. This mixing of unlike vegetation types is the result of the change in climate and an increased level of stand replacing fires. In addition, physiographic factors such as soil depth and coarse fragment content, along with geomorphic processes such as mass soil movement, also contribute to a mosaic of vegetation types. The increased level of natural disturbance contributes to a moderate level of natural fragmentation and a low to moderate frequency of old-growth forest stands (table 1). The active fire history of Pilot Creek is displayed in the dispersal of vegetation seral stages (fig. 2) and the

Table l-Current description of the vegetation seral stages in the Pilot Creek project area, including number of acres, percent of area, and mean patch size

Seral stage	Number of polygons	Acres	Percent of area	Mean patch size (acres)
Shrub/forb	60	1,777	11	30
Pole	44	1,854	12	42
Early-mature	63	2,825	19	45
Mid-mature	47	4,184	28	89
Late-mature	26	1,486	10	57
Old-growth	23	3,079	20	134
All stages	263	15,207	100	58

Table 2-Number of acres by tree size class in the Pilot Creek project area

Size	Description	Acres
O-5.9”	Plantations/grassland	2,593
6-10.9"	Poles	1,039
11-20.9"	Small sawtimber	2,825
21-35.9”	Medium sawtimber	5,133
>36"	Large sawtimber	3,617
Total	(All sizes)	15,207

size classes of the trees (table 2). The medium sawtimber category, size class 4 (21-35.9 inches d.b.h.) dominates the project area and includes 33 percent (5,133 acres) of the watershed. It is followed by the large sawtimber category, size class 5 (>36 inches d.b.h.) with 24 percent of the area (3,617 acres). Pole size trees, class 2 (6-10.9 inches d.b.h.) have the lowest frequency of occurrence 7 percent (1,039 acres) (table 2).

The 1987 California fire siege left its mark on the Pilot Creek watershed Blake Mountain, where most of the area was converted to the shrub/forb seral stage by stand replacing wildfires. Human disturbance within the project area and its effect on vegetation is relatively low and related to past Native American use, recent timber harvests, firewood gathering, and livestock grazing.

History

Pilot Creek was studied by the Forest Service for designation as a wilderness area during the Roadless Area Review Process (Rare II) (USDA 1979). It was not selected for designation as wilderness and hence has a very high public sensitivity. After its release from Rare II status, several timber sales were planned in the watershed. These projects proposed to convert most of the remaining old-growth stands to younger thrifty stands moving toward regulated harvest on a 100-year rotation. Because of high public sentiments against these projects and the designation of portions of the Pilot Creek watershed as a fisher management area and an important territorial link, they were withdrawn and a proposal to do an Environmental Impact Statement (EIS) for the watershed was made. Based on preliminary analysis of the past project proposal, and high public sentiment against the project, it was determined that the harvesting of most of the remaining acres of old-growth forests would be an unacceptable impact on wildlife habitat (Jimerson and Hoover 1992). Therefore, the project objectives were changed from converting old-growth to maintaining fisher habitat. This paper is a result of this sequence of events.

Fisher Habitat

Fisher (*Martes pennanti*) habitat has been described by Buck (1979), Raine (1981), Powell (1982), Allen (1983), Buck and others (1983), and Arthur and others (1989). The specific fisher habitat structure and components are defined in the Region 5 Furbearer Guidelines (Free1 1991). In California, fisher most often occur at somewhat lower elevations than marten, between 2,000-5,000 feet in the North Coast region (Grinell and others 1937, Ingles 1965).

An early study of fisher in California (Buck and others 1983) found a general selection of mature/old-growth stands within home range boundaries. Preferred habitat was characterized by dense, multistoried, late seral stage coniferous forests with large (>30 inch d.b.h.) snags and downed logs. These areas are found in close proximity to riparian corridors and saddles between major drainages. Minimum optimum stand size was identified as 120 acres in the Region 5 Furbearer Management Guidelines (Free1 1991). A component of foraging habitat was described by Zielinski[1] as interlacing crowns that permit tree to tree movement in pursuit of prey.

Vegetation

The vegetation of the project area falls along an elevation and moisture gradient. Douglas-fir stands (*Pseudotsuga menziesii* [Mirb.] Franco.) dominate the lower and mid elevation moist sites in the Pilot Creek project area, where they make up 64 percent of the area. These stands are composed of plant communities dominated by Douglas-fir, Douglas-fir with white fir (*Abies concolor* [Gord. & Glendl.] Lindl.), and Douglas-fir with black oak (*Quercus ke lbggii* Newb). The white fir series is the second highest contributor; it is found in mid-slope positions and makes up 17 percent of the study area. White fir communities are dominated by white fir, white fir with incense cedar (*Libocedrus decurrens* Torr.), and white fir with Douglas-fir. Oak woodlands are the next highest contributor making up 12 percent of the study area. They are dominated by white oak (*Quercus garryana* Dougl.), and found at lower elevations along dry spur ridges intermixed with the Douglas-fir series. The red fir series (*Abies magnifica* A.Murr.var. *shastensis* Lemmon) dominates the highest elevation sites on South Fork Mountain, making up 5 percent of the area. These communities are dominated by mixed stands of red fir with white fir and nearly pure stands of red fir. Grasslands make up 2 percent of the area and occur in small patches at lower elevations dispersed throughout the study area on dry sites. They are dominated by the annual grass, dogtail (*Cynosorus echinatus* L.).

Disturbance within the Pilot Creek project is related to clearcut timber harvesting and a moderate frequency of stand replacing wildfires. The result of this is a moderate level of fragmentation and the dominance of small patches <200 acres in size (55 percent) throughout the project area (table 3). Stands in the early- and mid-mature seral stages account for 46 percent of the project area and are found in patches <200 acres 28 percent of the time and in patches >200 acres 18 percent of the time. It is these smaller patches that have been selected for treatment. The expectation is that their seral development can be accelerated and they can be merged into adjacent late seral stands and thereby increase patch size.

In general, patch size increases with increasing seral stage development (table 1). The notable exception to this is in the Blake Mountain area where a stand replacing wildfire resulted in 7 percent of the project area being included in a >1,000-acre shrub/forb patch.

The objectives of this paper are to describe how ecological classification combined with silviculture can be used to apply ecosystem management principles to the Pilot Creek watershed while:

1. Achieving desired stand structure attributes,

2. Accelerating stand development toward old-growth structure,

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[1] **Personal communication. 1992. Willam Zielnski, USDA Forest Service, Pacific Southwest Forest and Range Experiment Station, Forestry Sciences Laboratory, Arcata, CA.**

Table 3-Number of acres and percent of the Pilot Creek project area by patch size and seral stage

	Total acres (%)					
Seral stage	<50	50-100	100-200	200-500	500-1000	>1000
Shrub/forb	556 (4)	111 (1)				1,110 (7)
Pole	448 (3)	742 (5)	390 (3)	274 (2)		
Early-mature	875 (6)	719 (5)	387 (3)	319 (2)	526 (3)	
Mid-mature	392 (3)	729 (5)	1,142 (8)	1,067 (7)	854 (6)	
Late-mature	460 (3)	571 (4)		455 (3)		
Old-growth	231 (2)	181 (1)	477 (3)	731 (5)		1,358 (9)
All stages	2,962(21)	3,053(21)	2,396(17)	2,846(19)	1,380 (9)	2,468(16)

3. Maintaining or enhancing fisher habitat,

4. Providing commodity outputs,

5. Together with vegetation mapping and GIS, identifying stands for treatment to achieve desired future landscape patterns.

Methods

The methods are described below by section according to subject heading.

Ecological Classification

The ecological classification and mapping methods follow those described in detail in Jimerson and others (1989). Field sampling and mapping was conducted during the 1991 field season. Field verification was used in conjunction with aerial photo analysis to describe and map the potential natural vegetation types, vegetation seral stages, tree size classes, and canopy closure.

Potential natural vegetation types were field verified using the vegetation classification of Jimerson (1993). This classification includes species composition by layer, stand structure, a description of environment and soils, as well as the expected site response to management.

Seral stages were identified and recorded as follows: shrub/forb; pole; early-mature, mid-mature, late-mature; and old-growth, using the descriptions outlined in Jimerson and Fites (1989) (fig. 3). The

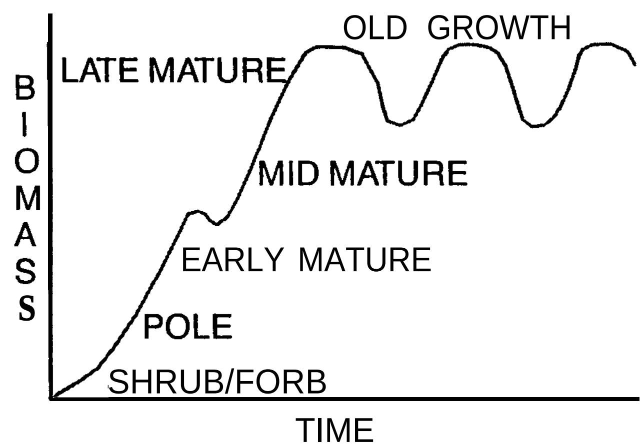

Figure 3—Seral stage development as a function of biomass accumulation and time.

mature seral stage was divided into three classes to aid in the analysis of wildlife habitat structure. Types of criteria used in identification of seral stages were stand age, overstory tree diameter, the presence or absence of snags and down woody material, horizontal and vertical diversity (fig. 4), high or low shrub/forb cover, dense or open groupings of trees, and uniformity of age and sizes.

Tree size classes were recorded as average diameter breast height (d.b.h.) of the overstory trees over 10 feet, size classes were 1 (O-5.9 inches d.b.h.), 2 (6-10.9 inches d.b.h.), 3 (11-20.9 inches d.b.h.), 4 (21-35.9 inches d.b.h.), and 5 (36 inches d.b.h. or greater). Canopy closure was recorded as a vertical projection of overstory cover; percent canopy closure was recorded as 0 <10 percent, S 10 to 19 percent,

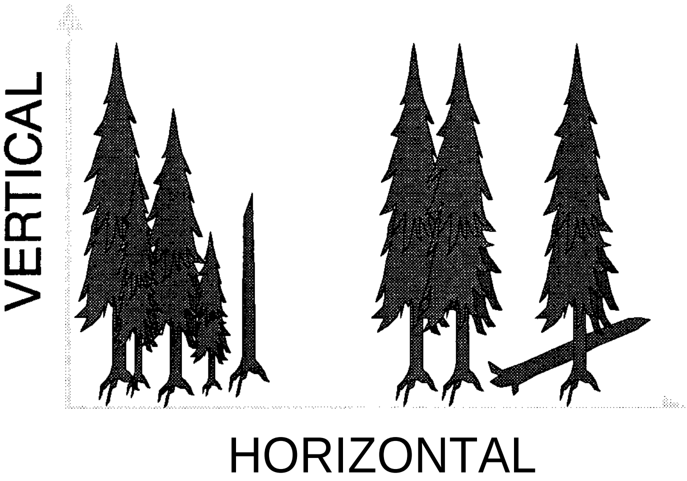

Figure 4-Graphic representation of in-stand vertical and horizontal structural diversity.

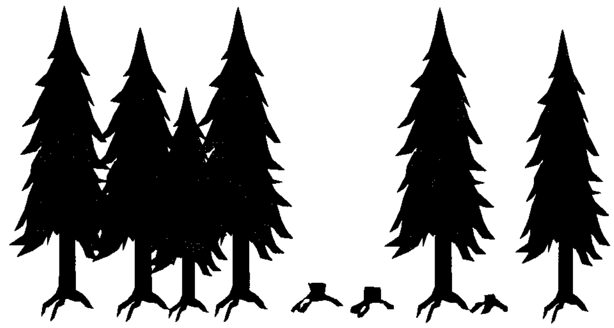

Figure 5—Post-harvest early-mature seral stage stand structure.

P 20 to 39 percent, N 40 to 69 percent, and G 70 to 100 percent). The attributes described above were manuscripted and scanned into the GIS and Distributed Wildland Resource Information System (DWRIS) (USDA 1987). DWRIS was used to make the potential natural vegetation type, seral stage, and size class/canopy closure maps, to select the sites for treatment, and to make projections of future landscape configuration. It also reports the number of acres for each of these maps by category, patch, and the perimeter in feet of each patch (edge). This information, together with each polygon label, was used to create a database in the Statistical Package for the Social Sciences (SPSS) (Norusis 1988).

Stand Examination

Classification of the vegetation within the project area allowed the concentration of the field work on those plant associations and seral stages where the best opportunity exists to achieve the desired future habitat conditions. Stand examinations were conducted using the methods described in the Region 5 Timber Management Inventory Handbook FSH 2409.211, (USDA 1986). Data was analyzed using the Forest Inventory and Analysis computer program. The summary information obtained by species (trees/acre by diameter class, basal area, cubic volume, site class, and coarse woody debris) were used to develop the silvicultural prescriptions for these stands. Stands classified as early- to mid-mature (fig. 5), ranging in age from 70 to 110 years, were selected for treatment based on their vigor, health and ability to achieve and maintain rapid diameter, and height and crown growth (Schumacher 1930).

Silvicultural Prescriptions

The objectives of the silvicultural prescriptions developed for this project were to:

A. Create fisher habitat using variable density marking to produce:

1. Large diameter trees,
2. Vertical and horizontal diversity,
3. Snags and logs,
4. An increased uniform patch size, and
5. Replacement habitat.

B. Provide timber sale volume sufficient to make a viable offering; and

C. Maintain forest health.

Currently, early- and mid-mature stands (fig. 6) are even-aged and lacking in the horizontal and vertical diversity components of fisher habitat (fig. 4). Using variable density marking prescriptions, gaps will be created (horizontal diversity) (fig. 5) and clumps of trees with vertical diversity will be

Figure 6-Existing early-mature seral stage stand structure.

maintained. Individual trees with high potential for rapid growth will be widely spaced to accelerate diameter and height growth with the expectation of achieving vertical diversity (fig. 7). These trees are also expected to develop large diameters, wide crowns with large limbs, and could become future fisher denning and resting sites.

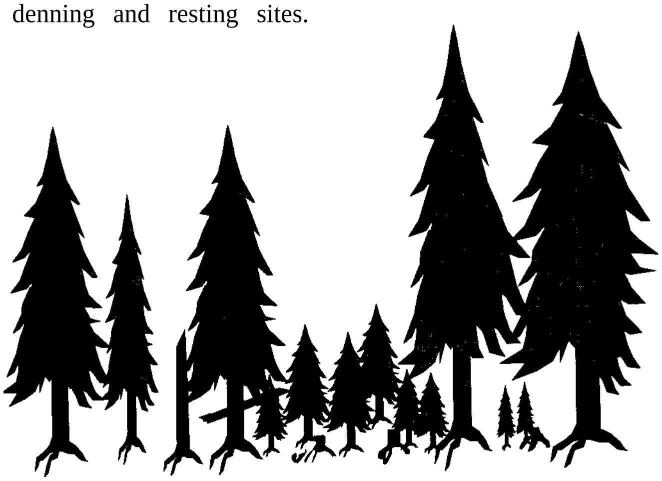

Figure 7-Projection of early-mature seral stage stand structure four decades after treatment.

In addition to providing stand level habitat characteristics for fisher, the prescriptions will foster an increased patch size of late seral stands. This will provide replacement habitat for stands that are harvested, diseased, or lost to natural disturbance.

It is thought that these structural components and attributes will be attained in less time through the use of variable density marking guides than if stands are left to develop without treatment.

Modeling of stand development in a representative number of Pilot Creek stands was carried out for the purpose of predicting changes in stand structure and composition over time for both treatment and no treatment options. The Klamath variant (NC6) of the Forest Vegetation Simulator (FVS) (Stage 1973) was used to predict a number of parameters considered significant to habitat quality for late successional associated species. These parameters include mortality, stand density, quadratic mean diameter, percent crown cover, cubic foot volume of down woody material, and live trees per acre.

Results

Using the GIS of mapped vegetation attributes, approximately 1,400 acres were selected for treatment within the Pilot Creek project area. These acres will be commercially thinned with the objective of improving stand health and vigor, accelerating the rate of tree diameter growth, precluding build-up of fuels, enhancing vertical layering, decreasing fragmentation of late successional habitat, improving species composition, retaining trees with special wildlife characteristics, and promoting the development of patches of understory vegetation. Stands selected for treatment amount to 9 percent of the project area and 17 percent of the suitable vegetation in the early- and mid-mature seral stages (table 1). They were selected for treatment based on their expected ability to provide future late seral habitat structure and increased patch sizes. Treatment units were included in the early- (406 acres) and mid-mature (466 acres) seral stages within the Douglas-fir series; mid-mature (268 acres) seral stage in the white fir series; and the early-mature (12 acres) and mid-mature (179 acres) seral stages in the red fir vegetation series. Of the stands selected, 31 percent and 67 percent were included in the early-mature and mid-mature seral stages, respectively. Stands classified as early- to mid-mature ranged in age from 70 to 110 years, with basal areas ranging from 200-350 ft^2. An additional 30 acres within the late-mature seral stage of the red fir series was proposed for regeneration treatment due to heavy infestation of dwarf mistletoe ***(Arceuthobium abietinum)*** and true fir canker ***(Cytospora abietis).*** Vegetation communities not selected such as white oak-Douglas-fir and black oak-Douglas-fir did not have the potential to reach late-seral conditions under a natural disturbance regime and were also determined to be incapable of developing denning and resting characteristics for fisher.

Silvicultural Prescriptions

Described below are marking guidelines developed from the prescriptions for 70- to 110-year-old Douglas-fir and white fir stands.

1. Leave tree mark. Priority for marking leave trees, other than those left for specific wildlife purposes: >30 percent live crown ratio; free from disease or visible defect.

2. Mark all predominant and open grown dominants with large limbs and crowns.

3. Mark codominants greater than 16 inches d.b.h. to a spacing of 20 to 30 feet except where two or more are <10 feet apart to facilitate intercrown movement of predators and prey. Where possible leave one group of close-spaced codominants per acre.

4. Mark codominants <16 inches d.b.h. to a spacing of 15 to 20 feet.

5. Mark existing wildlife-use trees and a minimum of two forked, broken-top, or decayed trees per acre where existing.

6. Create gaps of 1/10- to 1/2-acre—one every 3 to 5 acres. Avoid expanding existing gaps if falling will likely damage existing vegetation. Look for stand conditions with little or no existing vertical structure.

7. Mark to sanitize the stand, removing damaged and defective trees beyond those retained for wildlife described above.

8. Basal area removed should be approximately 30 percent of existing.

9. Mark all existing hardwoods.

10. Mark groups of submerchantable conifer saplings and poles in existing gaps.

11. Mark leave trees to protect existing patches of hardwoods or conifers.

Using these prescriptions, stands were modeled using FVS. Two simulations are described showing response to silvicultural treatments. Results were dependent primarily upon initial stand conditions. The first scenario was developed for stands of predominantly Douglas-fir. The second scenario was developed for stands dominated by white fir and red fir. Tables 4 and 5 display results of these five decade simulations. Stand parameters predicted by the model include:

Table 4—Results of forest vegetation simulation after five decades with and without treatment of a mid-mature Douglas-fir stand

Parameter	Without treatment	With treatment
Mortality[1] (TPA)	77	38
Stand density[2] (SDI)	89% of max.	86%
QMD increase[3] (%)	38	53
Cover[4] (%)	85	85
Woody debris[5] (cu.ft.)	3,200 >20 in. trees	200
	1,200 >30 in. trees	100
Live trees/acre[6] (TPA)	134	109
QMD[7] (in.)	20	23

[1] Mortality-Number of trees dying over simulation period.
[2] Stand Density Index (SDI)—SDI is a relative index of stand density used to compare the densities of stands of various ages and species compositions.
[3] Percentage Increase in Quadratic Mean Diameter (QMD)-QMD is the diameter of the average basal area tree in a stand. Percentage increase provides a comparison in diameter growth between treatment and no treatment.
[4] Canopy Cover-Displays changes in canopy cover over the simulation period. Cover in this case is expressed in non-overlapping vertical crown projection.
[5] Woody Debris-Cubic feet per acre of large woody debris generated over the length of the simulation, expressed separately in terms of wood incorporated through mortality of trees larger than 20 inches d.b.h., and trees larger than 30 inches d.b.h.
[6] Trees Per Acre (TPA)--Indicates trees per acre remaining at end of simulation period.
[7] QMD-Indicates QMD at end of simulation period.

1. Mortality-Number of trees dying over simulation period.

2. Stand Density Index (SDI)—SDI is a relative index of stand density used to compare the densities of stands of various ages and species compositions.

3. Percentage increase in quadratic mean diameter (QMD)-QMD is the diameter of the average basal area tree in a stand. Percentage increase provides a comparison in diameter growth between treatment and no treatment.

4. Canopy cover-Displays changes in canopy cover over the simulation period. Cover in this case is expressed in percent of non-overlapping vertical crown projection.

5. Large woody debris-Cubic feet per acre of large woody debris generated over the length of the simulation, expressed separately in terms of wood incorporated through mortality of trees larger than 20 inches d.b.h., and trees larger than 30 inches d.b.h.

6. Trees per acre (TPA)-Indicates trees per acre remaining at end of simulation period.

7. QMD-Indicates QMD at end of simulation period.

The Douglas-fir stands selected for simulation (table 4) were well stocked, relatively even-aged, with fairly uniform stem distribution, poor crown differentiation, and either no predominant layer or a very sparse predominant layer. These type of stands are experiencing high intertree competition and it is expected that without treatment, a substantial pulse of density-related mortality would occur over the simulation period.

Thinning treatment in stands representative of this type would substantially increase QMD, reduce

Table 5-Results of forest vegetation simulation after five decades with and without treatment of a mid-mature white fir stand

Parameter	Without treatment	With treatment
Mortality[1] (TPA)	88	28
Stand density[2] (SDI)	88% of max.	67%
QMD increase[3] (%)	28	53
Cover[4] (%)	85	80
Woody debris[5] (cu . ft .)	2,700 >20 in. trees	400
	1,300 >30 in. trees	100
Live trees/acre[6] (TPA)	233	134
QMD[7] (in.)	20	24

[1] Mortality-Number of trees dying over simulation period.
[2] Stand Density Index (SDI)—SDI is a relative index of stand density used to compare the densities of stands of various ages and species compositions.
[3] Percentage Increase in Quadratic Mean Diameter (QMD)-QMD is the diameter of the average basal area tree in a stand. Percentage increase provides a comparison in diameter growth between treatment and no treatment.
[4] Canopy Cover-Displays changes in canopy cover over the simulation period. Cover in this case is expressed in non-overlapping vertical crown projection.
[5] Woody Debris-Cubic feet per acre of large woody debris generated over the length of the simulation, expressed separately in terms of wood incorporated through mortality of trees larger than 20 inches d.b.h., and trees larger than 30 inches d.b.h.
[6] Trees Per Acre (TPA)-Indicates trees per acre remaining at end of simulation period.
[7] QMD-Indicates QMD at end of simulation period.

mortality of old predominant trees (especially pines), and greatly reduce the levels of large woody debris over the simulation period.

The true fir type selected for simulation (table 5) were overstocked, even-aged stands of predominantly white fir and red fir. Understory vegetation is very sparse and tree diameters and heights are very similar. Substantial mortality will occur in these stands over the simulation period and intertree competition will result in a moderate to high degree of stagnation.

Treatment in these stands would accelerate diameter growth and improve stand health. Canopy response would be rapid. Understory development resulting from reduction in canopy cover and creation of small openings would greatly enhance both vertical and horizontal diversity.

Future Landscape Projection

The GIS, FVS, and ecological classification were used to project stand attributes and landscape pattern after 40 years. The projections suggest significant increases in amount, patch size, and large patch frequency of old-growth stands (figs. 2, 8). Amount of old-growth is projected to increase from 20 percent (3,079 acres) to 30 percent (4,519 acres) over the project area (tables 1, 6). Mean old-growth patch size is projected to increase from 134 to 226 acres (tables 3, 7). The frequency of large old-growth patches >100 acres, also increases from 17 percent (2,566 acres) to 26 percent (3,971

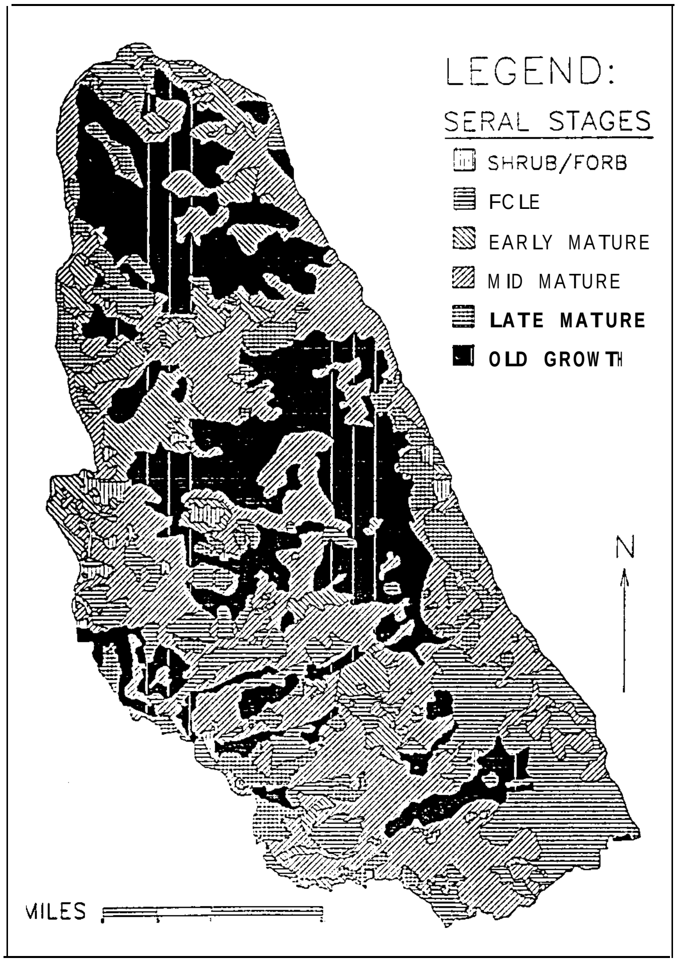

Figure 8-Projection of seral stages within the Pilot Creek project area after 40 years.

Table 6-Future (40 years) description of the vegetation seral stages in the Pilot Creek project area, including number of acres, percent of area, and mean patch size

Seral stage	Number of polygons	Acres	Percent of area	Mean patch size (acres)
Shrub/forb	31	313	2	7
Pole	48	2,195	14	55
Early-mature	77	1,247	8	40
Mid-mature	20	5,633	37	73
Late-mature	40	1,301	9	27
Old-growth	42	4,519	30	226
All stages	258	15,208	100	59

Table 7-Future (40 years) projection of acres and percent of the Pilot Creek project area by patch size and seral stage

	Total acres (%)					
Seral stage	<50	50-100	100-200	200-500	500-1000	>1000
Shrub/forb	313 (2)					
Pole	535 (4)	420 (3)	118 (1)			1,122 (7)
Early-mature	297 (2)	677 (4)		274 (2)		
Mid-mature	746 (5)	314 (2)	476 (3)	1,090 (7)	1,692(11)	1,313 (9)
Late-mature	548 (4)	321 (2)	213 (1)	217 (1)		
Old-growth	281 (2)	269 (2)		422 (3)		3,549(23)
All stages	2,720(19)	2,001(13)	807 (5)	2,003(13)	1,692(11)	5,984(39)

acres). Most of these large patches are projected to exceed 1,000 acres in size (23 percent). The effect of this is a substantial increase in the amount of high quality fisher habitat that will also benefit additional old-growth dependent species such as spotted owl (*Strix occidentalis*), marbled murrelet (*Brachyramphus marmoratus*), and marten (*Martes* americana).

Discussion

In the past, management of forest stands was much more simply directed. Ecological classification was used by silviculturists for determining response to management at time of regeneration. As Bergsvik and others (1993) noted, past silvicultural activities were directed primarily toward the production of wood fiber. These activities resulted in forest stands that tended to be more homogeneous in species composition, structure, age, and stand size.

Today, to be successful, ecosystem management requires that we utilize the information gained from ecological classification and learn by doing. New or different treatments are tried on a limited basis, their affects evaluated and documented, and the results and conclusions are used in future treatment decisions. Established watershed or landscape objectives can be met through the use of silvicultural practices and technologies which direct the manipulation of vegetative structure and composition (Bergsvik and others 1993)

Observation of natural stands in the Pilot Creek and South Fork Mountain areas shows that these early- to mid-mature stands typically contain remnant older trees (predominants), that were survivors of stand replacing fires. There are some openings or gaps within these stands that are the result of changes in soil type, rock outcrops, insect or disease mortality, wildfire, and the demise of either the remnant predominant trees, or pioneer black oak that regenerated following disturbance. Many of these gaps have filled with Douglas-fir, white fir, black oak, and white oak regeneration. There are few snags and logs in these stands greater than 15 inches in diameter.

Late seral stands in the project area show continued development of both vertical and horizontal diversity including large diameter trees, a variety of crown classes, gaps, large snags, and logs. Mortality of predominants will provide future snags and logs greater than 30 inches in diameter. Gaps will be created from competition induced mortality, disease, or disturbance, and occupied by invading vegetation.

These conditions provide the cover, resting, denning, and natal sites that the fisher seem to require. For untreated stands, this process may take 140 years in white fir to well over 180 years in Douglas-fir stands. With the historic incidence of fire, many of these stands are replaced before some or all of these necessary habitat components are available.

The Pilot Creek prescriptions are designed, in time, to provide horizontal and vertical diversity, increased patch size and landscape connectivity, along with the characteristics of older stands, through the following:

1. Improved stand health and vigor through the reduction of stocking. All of the proposed stands are in an "overstocked" condition which causes a degree of stagnation (individual tree growth and health is substantially affected). Continued growth in an overstocked condition eventually results in tree mortality due to direct competition, windthrow, or insect attack.

2. Accelerated diameter growth-Under natural development of even-age stands, live crown ratios decrease with increasing stand density. This results in decreased diameter growth rates. Reducing stand density by the proposed treatments should result in larger tree crowns and constant or accelerated diameter growth rates.

3. Reduced fuels build-up-Natural development of unmanaged stands results in density-related tree mortality. The resulting large accumulations of down woody material greatly increases the risk of catastrophic fires in young stands. Some large woody debris would be retained after harvest treatment (cull logs). The benefits of down woody material for wildlife must be weighed against the risk of loss to fire.

4. Enhanced vertical layering-If untreated, many of the understory trees in these stands would die over time as overstory shading increases. This could result in a progressive decrease in canopy layering (vertical diversity) until gaps due to mortality or disturbance allowed establishment of seedlings. Proposed treatments would retain some of the smaller understory trees and increase lower canopy light levels, thus allowing them to persist in the stand.

5. Decreased fragmentation-Many of the proposed units are adjacent to late seral stands. The proposed treatment would accelerate these young stands toward late seral conditions and increase patch size, while also maintaining connectivity to adjacent watersheds. This increases the amount of high quality fisher habitat that will also benefit additional late seral dependent species.

6. Maintained species diversity-Marking guidelines would favor retention of low frequency species such as black oak. nonderosa nine. and sugar nine. Without treatment, competition from dominant species (Douglas-fir, white fir, and red fir) could reduce the cover and incidence of these species.

7. Retention of trees with special wildlife characteristics-Trees with platforms of branches and cavities would be retained.

8. Enhanced development of understory vegetation-In stands with little or no understory development, small patches of understory tree seedlings and shrubs would be established to function as foraging and hiding cover. These patches would be developed by creating $\frac{1}{8}$- to $\frac{1}{4}$-acre gaps in the canopy at a density of about one opening every 5 acres.

Reentry into stands within the Pilot Creek watershed will depend on natural disturbance and be guided by the success of the silvicultural prescription, desired mix of seral stages, patch size, and location, while staying within a predetermined range of variability.

Conclusions

Based on the knowledge gained through ecological classification, particularly the prediction of stand development, silvicultural prescriptions can be implemented that mimic natural stand development, but at a faster rate than stands left untreated. The variable density marking prescriptions will provide (1) widely spaced dominant and codominant trees to allow maximum utilization of the site and produce large diameter trees with full crowns and larger limbs; (2) groups of trees with interlocking crowns for tree to tree movement by fishers and prey; (3) gaps to encourage natural regeneration for understory cover, horizontal and vertical structure, and maintenance of species diversity; (4) mixture of crown classes from suppressed to dominant; (5) snags and logs through competition and by leaving some live trees with active decay fungi to produce cavities; (6) increased acres of suitable fisher habitat; and (7) from 3 to 10 mbf per acre of saw log volume.

As these stands develop the necessary structural attributes over the next 30-80 years, other stands can be entered either with similar treatment objectives or for regeneration. These decisions will be based on monitoring of not only stand development and vegetative change, but use by target wildlife species.

The treatments allow for maintenance of healthy ecosystems, connectivity to adjacent watersheds, and a predictable level of commodity outputs.

There is confidence in the success of these prescriptions because examples of both naturally disturbed and treated stands verify our predictions of stand development. Knowing these seral progressions should increase the likelihood of successfully projecting future stand development.

Ecological classification is the necessary step to determine what vegetation is present (mapping plant associations), at what stage of development (seral stage) it is in, and what the potential vegetation type will be. This allows selection of the vegetation communities and seral stages within a defined landscape using GIS to sustain a naturally functioning system. This is one of the objectives of ecosystem management. Having this information permits silviculturists to use their knowledge of forest growth to write and implement prescriptions that have broader objectives than those written previously.

A strong partnership between ecologists and silviculturists is a first step in instituting ecosystem management and restoring confidence in national forest management. Within Pilot Creek, this partnership will aid us in achieving ecosystem management objectives that maintain the health of the forest and biodiversity, while producing an array of forest products.

Acknowledgments

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From Single Species Management to Ecosystem Management, "The Goshawk"

Russell T. Graham, Theresa B. Jain, Richard T. Reynolds, and Douglas A. Boyce

Abstract

Natural resource management in the United States is in a state of flux now more than any time in history. Many of the concerns about forest management are related to the enforcement of the Endangered Species Act. This act focuses forest management on preserving the habitat of a single species. But, for the northern goshawk (*Accipiter gentilis*) because it is a habitat generalist and a predator of over 50 birds and mammals, a multiple species approach was used for developing management recommendations. Even with this approach, however, several animal and plant species were not explicitly covered. To ensure that plant and animal species, known and unknown, are conserved and that ecosystem processes, elements, and functions are not overlooked, an ecosystem approach to managing lands occupied by northern goshawks appears to be appropriate. Large landscape units can be designated and analyzed at a variety of spatial and temporal scales offering treatment alternatives that sustain not only the northern goshawk but all forest components.

Introduction

The values, attitudes, and wishes of society and resource managers are in a state of flux now more than ever before in the history of natural resource management (Kennedy and Quigley 1993). What was once perceived as the right course for forest management, that is the production of goods and services, is no longer considered the right direction by many people in natural resource management as well as many in the general public. These changes are causing many shifts in organization, mission, and philosophy within several natural resource agencies.

Within the USDA Forest Service, the foundation for many of these changes started in the late 1960's with the controversies over management of the Bitterroot and Monongahela National Forests (Kennedy and Quiqley 1993). Since the 1960's, various issues have influenced forest management from clearcutting to allowable sale quantities. But, none has had a greater impact than the Endangered Species Act (ESA). In many national forests, enforcement of this act is the culmination of the early concerns about forest management.

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Past forest management practices often concentrated on timber production; similarly, the ESA focuses forest management on a single species. The grizzly bear (*Ursus horribillis*), northern spotted owl (*Strix occidentalis caurina*), pine martin (*Martes americana*), chinook salmon (*Oncorhynchus tshawytscha*), and northern goshawk (*Accipiter gentilis*) (goshawk) represent but a few of the ever-increasing list of species that require money and effort for analysis and protection. Unfortunately, it is not always evident that the addition of another species to the list is for species protection but rather an attempt to stop timber harvesting or some other forest use. The changing issues being emphasized in natural resource management led by the ESA are creating concerns at all levels of society, from the small town to the Congress and Administration of the United States (Anon. 1993).

The Forest Service and other Federal and State resource agencies are responding to these issues. Ecosystem management, evolving from New Perspectives, has been the Forest Service's response. Because a portion of society and some individuals within resource organizations do not want change, adjustments in management are difficult to make. These challenges make natural resource management a very exciting and dynamic profession at this time.

Single Species Management

Most approaches to managing sensitive, rare, or endangered species involve preserving species habitat. For example, the first approach to managing the northern spotted owl and the goshawk was to dedicate areas of the forest specifically for the species restricting all other uses. This entailed reserving 3- to 500-acre buffers around goshawk nests (Reynolds 1983, Crocker-Bedford

1990). Similarly, 1,000- to 3,000-acre buffers were established for the northern spotted owl (Thomas and others 1990). In both cases, timber harvesting and other activities were restricted in these areas. The rationale for these decisions, especially for the goshawk, was that information about nest areas was relatively easy to obtain compared to information on other habitat components. Merely preserving the goshawk nests did not appear to be adequate for maintaining the species. Even with protecting goshawk nests, there was evidence that the species was declining because of forest changes and timber harvesting (Cracker-Bedford 1990). In addition, more information was being assembled on the behavior, habitat, and forest types the goshawk occupies, providing a basis for improved management strategies.

The goshawk is a habitat generalist living throughout North America in a variety of forest types from ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) to subalpine fir (*Abies lasiocarpa* Hook.) (Reynolds and others 1992). Three components of goshawk habitat have been identified: the nest area, post fledging-family area (PFA), and foraging area. Goshawk nest areas (approximately 30 acres in size) which include the nest tree are usually located in one or more forest stands containing relatively big, mature trees. More than one nest area is usually located in each goshawk home range. The nest areas are used year after year by returning goshawks. Adult goshawks and fledglings intensively use an area around the nest. These PFA's provide food, cover, and learning experiences for goshawk fledglings (Kennedy 1988). The average size of these areas is 420 acres and contain a wide variety of vegetation and forest structures. A nesting pair of goshawks can forage over large areas (5,400 acres) depending on the forest type and prey (fig. 1). The foraging area needs to supply a goshawk family (two adults and two fledglings) approximately 400 to 500 pounds of food per year. This area is a

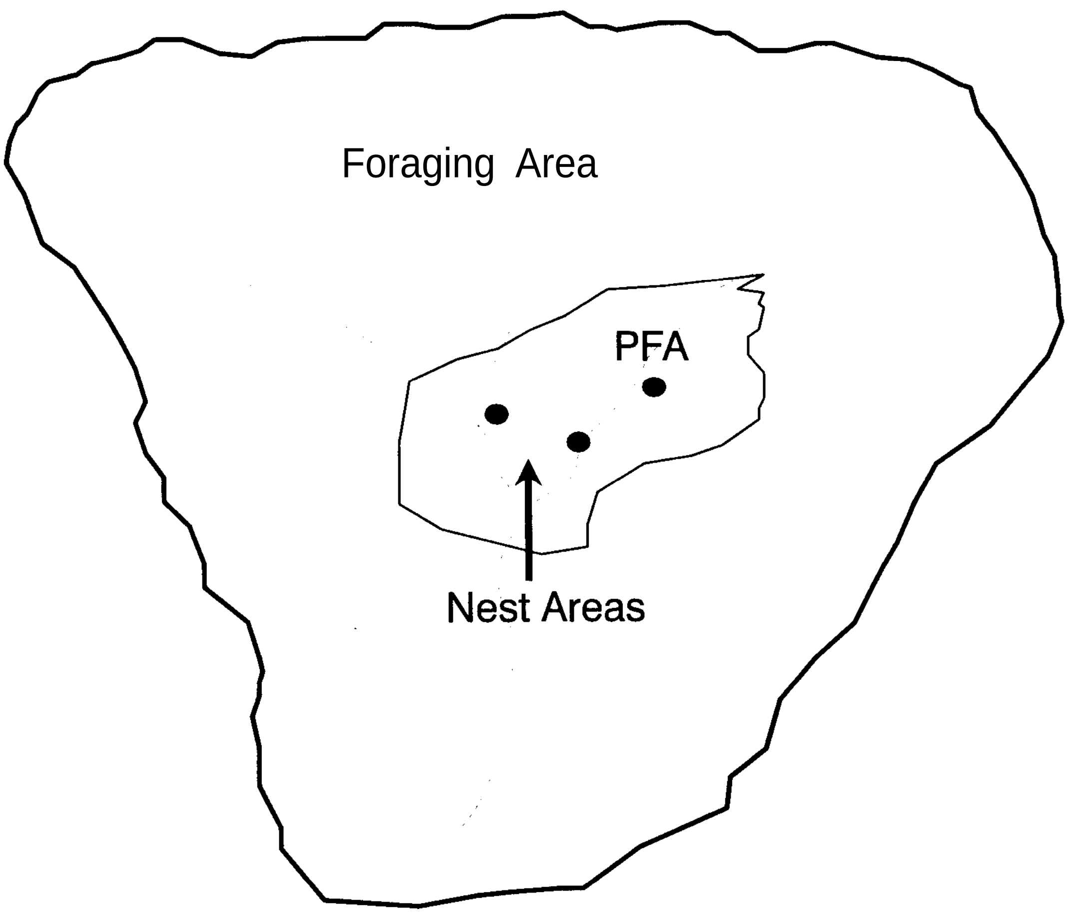

Figure 1—Arrangement of nest areas (30 acres), post fledging-family area (PFA) (420 acres), and foraging area (5,400 acres) for the northern goshawk in the southwestern United States.

forest mosaic containing a variety of trees, shrubs, grasses, snags, downed logs, and other components. Instead of preserving 3- to 500-acre nest areas for sustaining goshawks, the issue became more complex and involved tracts of forest lands approaching 10,000 acres. Consequently, the management of a top-level consumer like the goshawk is difficult because of its complex habitat and the dynamic forests it occupies.

The forest habitat for sustaining goshawks requires a nest area, PFA, and foraging area. The size and structure of the foraging area is defined by the habitats of goshawk prey. The goshawk preys on a wide range of 50 or more birds and mammals ranging from the blue grouse *(Dendragapus obscurus)* to the tassel-eared squirrel *(Sciurus aberti)* (Reynolds and others 1992). In order to maintain viable populations of goshawks, the habitat requirements of the goshawk and the habitats of the prey need to be integrated. Therefore, the management of the goshawk evolved from a single species issue to the management of forests for multiple species.

Multiple Species Management

For a select number of prey species found in the southwestern United States, common habitat attributes include large trees, downed logs, openings, snags, and understory vegetation (fig. 2). A goshawk home range that contains these components will also conserve other forest processes and functions. For example, downed logs and coarse woody debris provide habitat for many small animals and birds. These decomposing materials are important sites for nitrogen fixation and ectomycorrhizae (Harvey and others 1987). In addition, the fruiting bodies of ectomycorrhizal fungi are important in the food chains of many small animals (Maser and others 1986).

Vegetative structural stages (VSS) were used to describe goshawk and prey habitat. VSS are an integrative approach for describing forests ranging from openings (regeneration) to old trees and associated components (Thomas and others 1979; Reynolds and others 1992). VSS are based on tree diameter (table 1) and assume that trees increase in

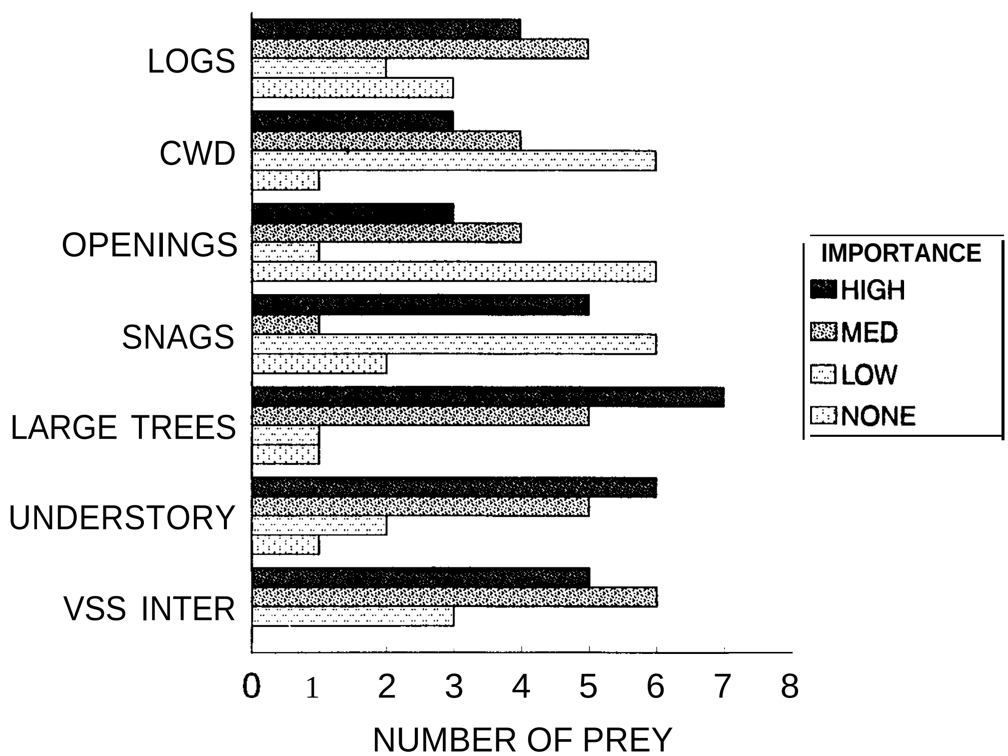

Figure 2-Importance of special habitat attributes for maintaining sustainable populations of selected northern goshawk prey. Snags = dead trees >18 inches in diameter and >30 feet tall; downed logs =>18 inches in diameter; CWD = coarse woody debris >3 inches in diameter; opening = break in forest canopy; large trees = live trees >18 inches in diameter; understory = presence of herbaceous and shrubby species; VSS inter = interspersion of vegetative structural stages (Reynolds and others 1992).

Table l-Estimated tree diameter growth rates, years in vegetative structural stage (VSS), accumulated age, and proportion of the foraging area in each VSS for selected forest types

	Vegetative structural stage and tree diameter					
	Grass/forb/ shrub O-l in	Seedling/ sapling l-5 in	Young forest 5-12 in	Midaged forest 12-18 in	Mature forest 18-24 in	Old forest 24+ in
			Ponderosa pine (PP)			
10-yr. dia. grth. (in)”	0	1.91	1.76	1.64	1.4	1.1
Years (Acc-yrs)[b]	20 (20)	21 (41)	40 (81)	37 (118)	43 (161)	45 (206)
Percent in VSS[c]	10	10	19	17	20	24
			Mixed species (MS)			
Percent in VSS	8	15	22	18	20	18
			Spruce-fir (S-F)			
Percent in VSS	8	14	23	17	19	19
General pct. in VSS for PP, MS, S-F forests[d]	10	10	20	20	20	20

[a]Diameter growth rates from Edminster and others (1991).
[b]Years (Act-yrs) : Number of years in vegetative structural stage and accumulated years.
[c]Proportion of foraging area in each VSS required to sustain a forest indefinitely.
[d]Generalized proportions for sustaining ponderosa pine (PP), mixed species (MS), and spruce-fir forests (S-F) in the Southwest.

diameter as they age. The time a forest tract spends in a VSS depends on forest growth.

Although a goshawk home range is a mosaic of vegetative structural stages, the preferred habitat for many of the prey species are mature and old forests (fig. 3). Therefore, it would be desirable to sustain the majority of the forest in these VSS. But forests are mortal-they regenerate, grow, and die. Consequently, to sustain a large amount of mature and old trees, a mosaic of VSS including regeneration, young forests, and midaged forests are required.

To sustain a large amount of old ponderosa pine in the Southwest depends on the length of the regeneration period, growth rate, site, tree longevity, stand density, and tree size (table 1). In these forests, it usually takes 10 to 20 years to fully regenerate a ponderosa pine stand (Pearson 1950). Between 20 and 40 years are spent in each intermediate VSS, ultimately taking up to 200 years to reach the mature and old forest stage. Consequently, around 10 percent of the forest would need to be regenerated every 20 years to sustain 40 percent in mature and old forests (table 1). In doing so, various proportions of the other forest stages would also be present (seedling/sapling, young, and midaged). A forest maintained for the goshawk would also provide a variety of conditions that would sustain many other wildlife species.

Maintaining Goshawk Home Ranges

Forest dynamics necessitate that the amounts of VSS in a forest or goshawk home range be flexible. The key to maintaining goshawks is to sustain a mosaic of differing VSS, ultimately maximizing the amount of old forests. Unfortunately, the desired proportions of the VSS for individual home ranges were often used exclusively for determining goshawk viability. If forest conditions did not meet the recommendations or a planned forest management activity altered the forest structure outside the recommended proportions, it was considered detrimental to the goshawk.

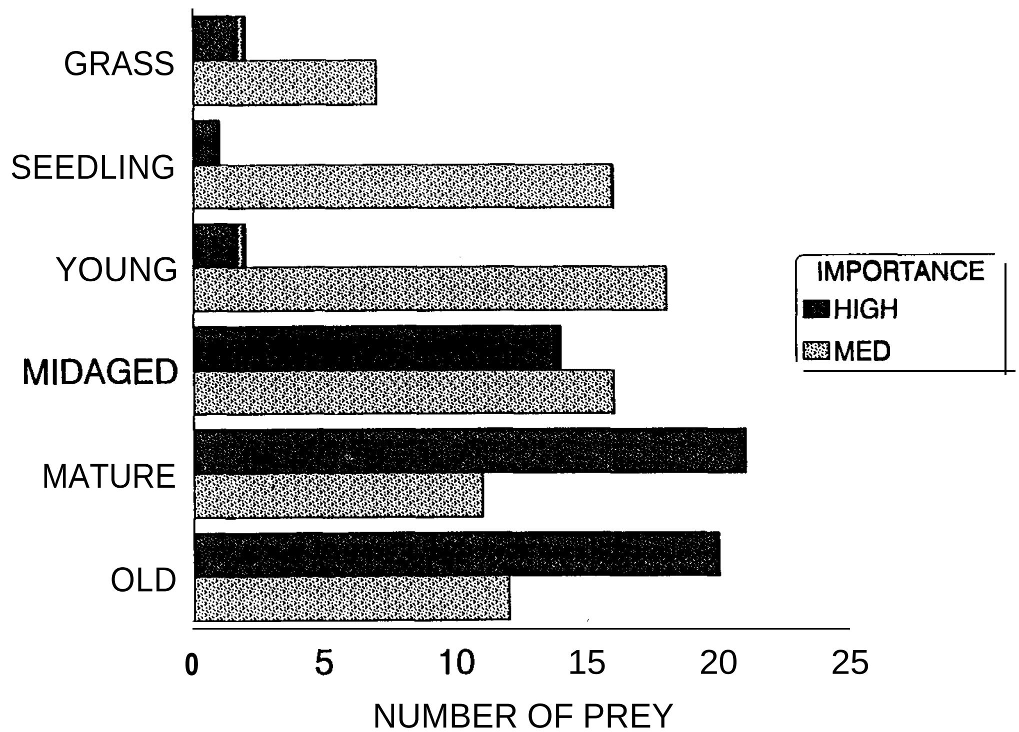

Figure 3-Importance of vegetative structural stages for habitat of selected prey species. The VSS were defined as grass/forb/shrub, 0- to linch trees; seedling, 1- to 5-inch trees; young forest, 5- to 12-inch trees; midaged forest, 12- to 18-inch trees; mature forest, 18- to 24-inch trees; old forest, 24-inch trees and larger (Reynolds and others 1992).

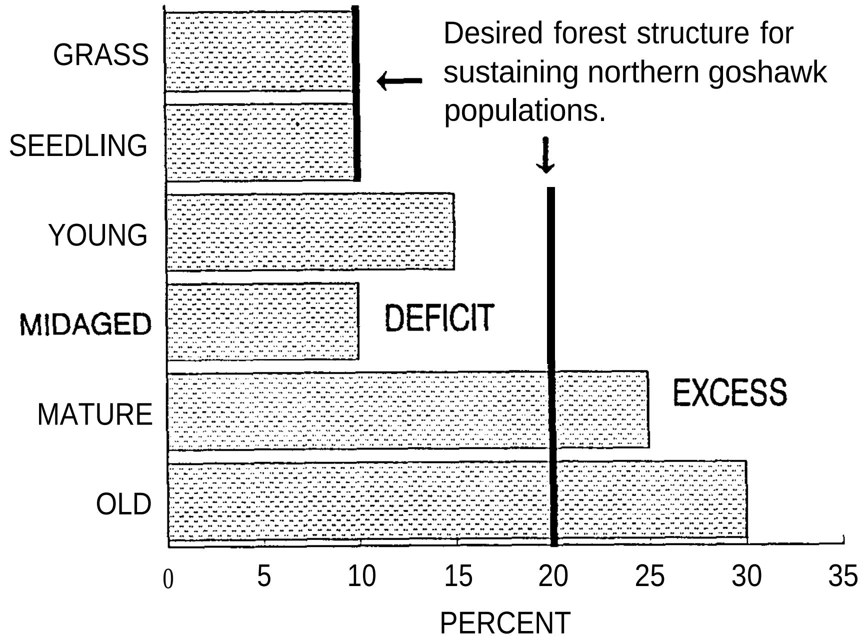

Figure 4-An example of the distribution of VSS showing an excess of trees in the mature and old forest classes and a deficit in the young and midaged forest classes. This type of forest structure would lend itself to regenerating a portion of the mature and old age classes.

The VSS proportions should be used as a reference for planning forest treatments. For example, if more than 40 percent of a goshawk home range was in mature and old forests, treatments could be planned to regenerate a portion of these areas to direct the forest towards the desired structure (fig. 4). As a reference, the VSS proportions for managing goshawk home ranges do not replace sound forestry and site specific prescriptions. In the Southwest, because of timber harvesting, fire exclusion, and grazing, large tracts of ponderosa pine forests have multiple canopies often containing a high proportion of white fir (*Abies concolor* Lindl.) and Douglas-fir (*Pseudotsuga* menziesii (Mirb.) Franco.) understories. Removing the ponderosa pine overstory from these forests, using the desired VSS as a guide, would leave a suppressed, disease and insect susceptible forest (fig. 5).

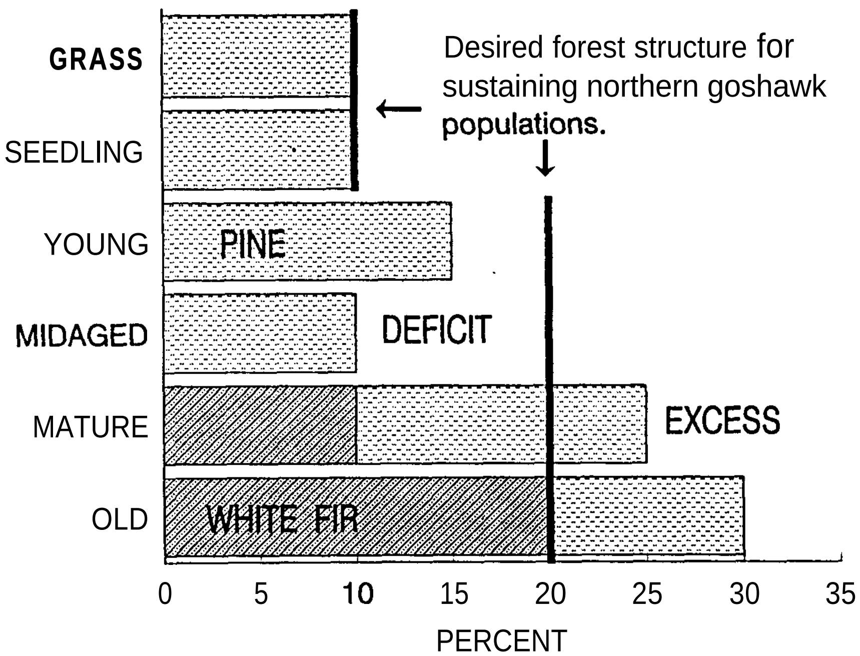

Figure 5-An example of the distribution of VSS showing an excess of trees in the mature and old forest classes, but a portion of these classes are white fir, a species prone to disease and insect attack. If the ponderosa pine were removed leaving these trees, an undesirable and unstable forest would result.

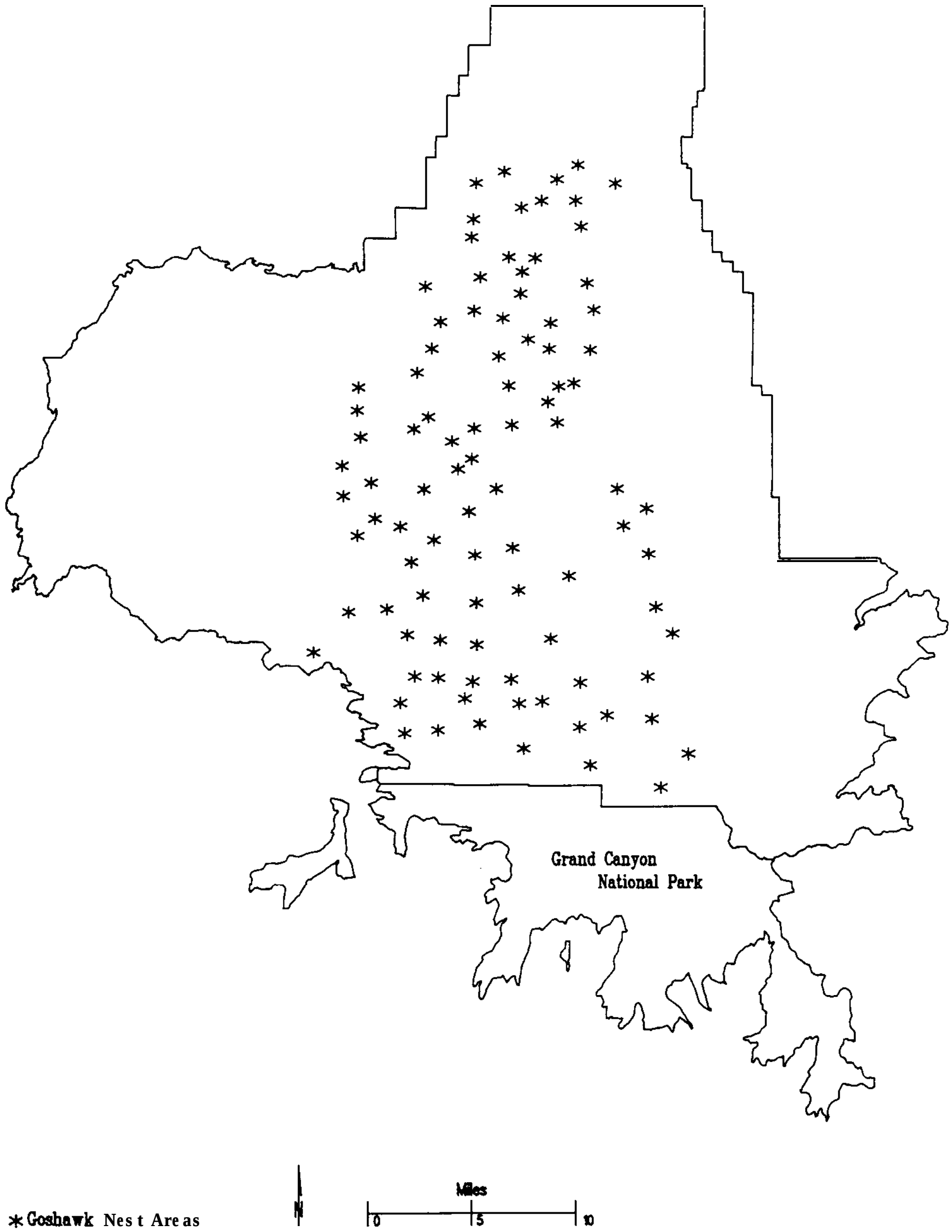

Figure 6-Map showing goshawk nest area locations with potential overlapping of foraging areas.

Goshawk home ranges can occur at densities greater than one per 5,400 acres as assumed in the recommendations (Reynolds and others 1992). Goshawks do not choose nests randomly but they are chosen based on forest conditions. Because of the forest conditions on the northern side of the Grand Canyon on the Kaibab National Forest, the density of goshawks is approaching one nest area per 2,000 acres, leading to overlapping foraging areas (fig. 6). It would be difficult to apply the recommended VSS distribution and sustain goshawk habitat on these small areas, but, unfortunately, it is being attempted.

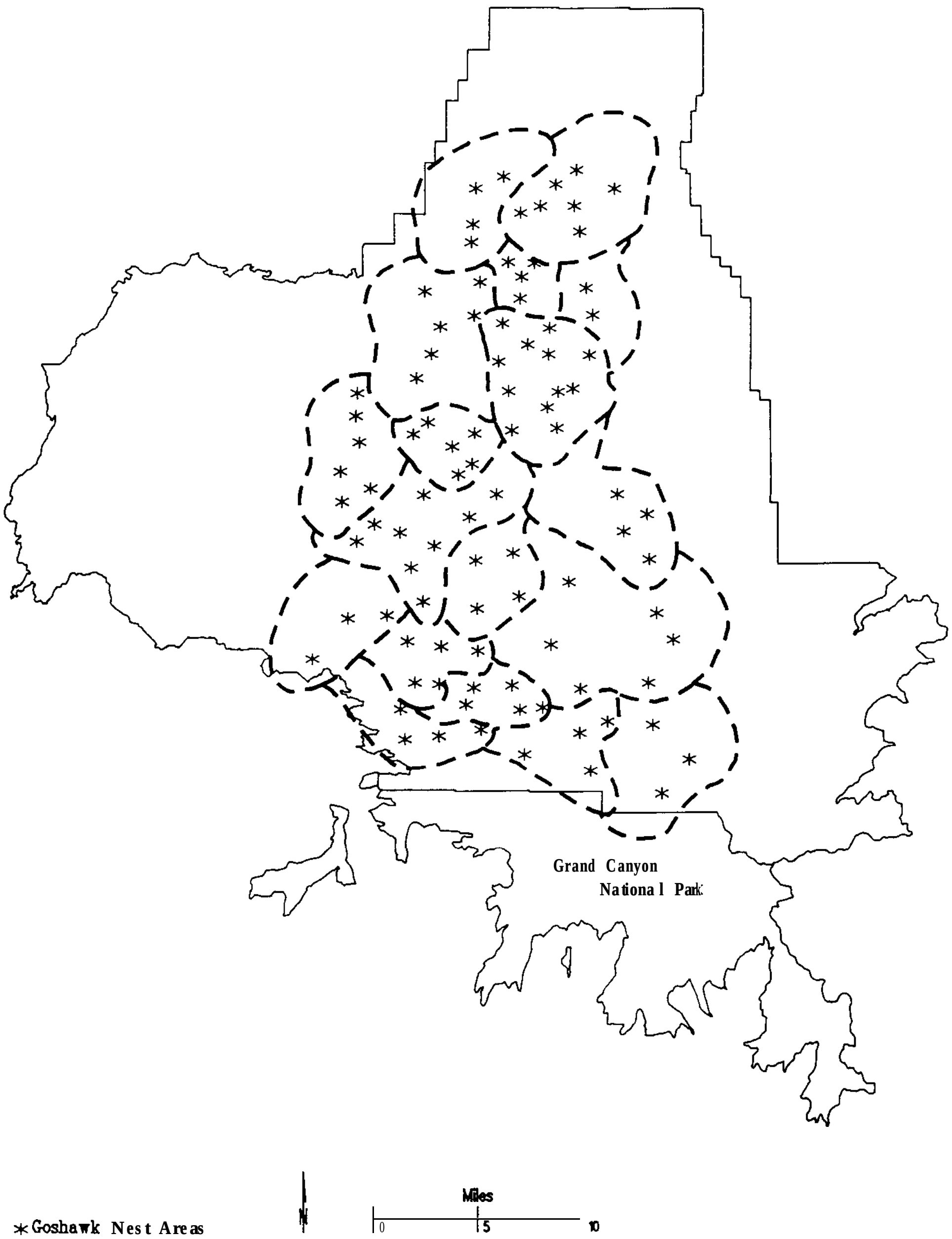

Figure 7-Map showing the grouping of goshawk nest areas, post-fledging family areas, and foraging areas.

An alternative to analyzing and managing these small discrete goshawk home ranges would be to group them into larger units. Units might include 5 or more home ranges and be as large as 10,000 acres (fig. 7). Areas of this size could be more easily managed using the goshawk recommendations (Reynolds and others 1992). Even though the recommendations offer a design that can be used at a landscape level, which is a departure from traditional forest management in the Southwest, they do not include many attributes of ecosystem management.

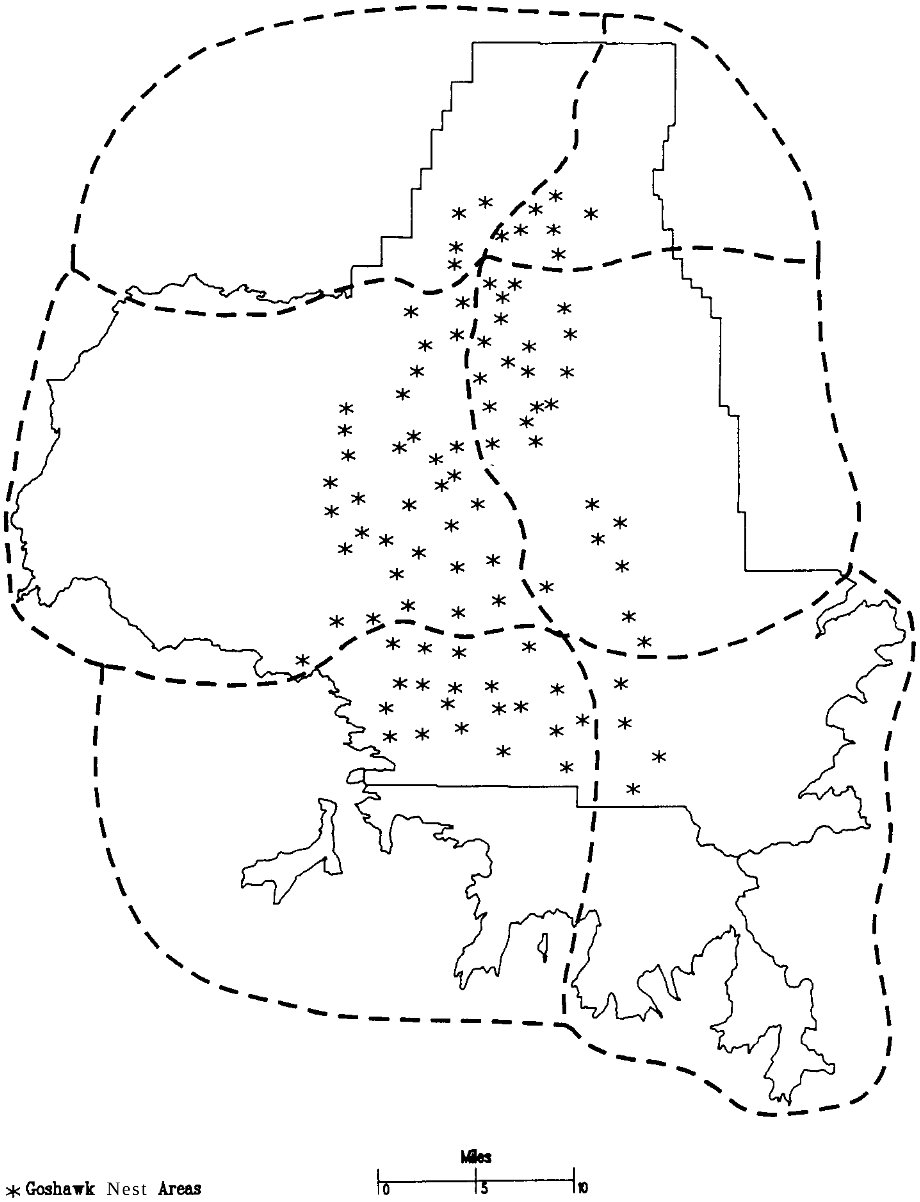

Figure 8—Map showing the development of ecological assessment and management areas of enough size to include and sustain a wide range of ecosystem processes and functions. These units could cross vegetation types, land ownership, and political boundaries.

Ecosystem Management

Ecosystem management which is evolving, can be viewed as blending the economic, social, and ecological needs when managing forest lands. Although the goshawk recommendations included many of these characteristics, they still did not provide a complete framework for ecosystem management. The best approach for accomplishing ecosystem management should use large areas encompassing watersheds or multiple watersheds as the primary analysis unit. For example, on the Kaibab National Forest an alternative to managing and analyzing individual goshawk home ranges, or even groups of home ranges would be to analyze and manage landscapes encompassing not only national forest lands but include other Federal, State, and private lands (fig. 8).

An ecosystem approach on these large landscapes would involve spatial and temporal analysis within a hierarchy of scales (global to site and past to future). This methodology entails developing reference conditions based on the structure and function of ecosystems at the various scales (Bourgeron and Jensen 1993). Ecosystem elements in the analysis could include, for example, insect and disease activity, patch size, vegetative and seral stages, and the risk of fire. Reference conditions for these elements could be determined using historical information, studies on past forest development, forest process models, and other information (Swanson and others 1993). These reference conditions could be compared with existing conditions at different landscape scales to determine if treatments would be advised for directing ecosystem development towards more sustainable conditions (fig. 9). In addition, this analysis technique could be used to show the consequences of management alternatives (campground development, high yield forestry, etc.) especially when multiple agencies and landowners would be involved.

Conclusions

The recommendations for managing goshawks started by using a single species approach, but it soon became apparent that this strategy was not appropriate. The goshawk and its prey involved many different habitats, vegetative structural stages, and forest landscapes. Although the recommendations did not explicitly include other important wildlife, they provided the impetus towards ecosystem management in the Southwest. It became apparent that in order to effectively maintain goshawks, forest ecosystems had to be sustained and the practice of silviculture could provide the tools to do so.

The practice of silviculture has always been closely linked with the production of timber products (Fernow 1916). In producing timber products, silviculturists developed a tremendous amount of knowledge on forest ecology for regenerating and tending forests. As shown by the goshawk recommendations, silvicultural practices can readily be used to create stand and forest structures for sustaining a wide variety of wildlife. Because of the changes in forests caused by natural processes, timber harvesting, fire exclusion, grazing, and urban encroachment, it is likely that some type of active management beyond fire control is going to be required for sustaining western forests. The silvicultural practices used for the production of forest crops can also be used to develop silvicultural systems for sustaining forest ecosystems. In the past the practice of silviculture was associated with the production of forest crops, today it should become intimately associated with ecosystem management.

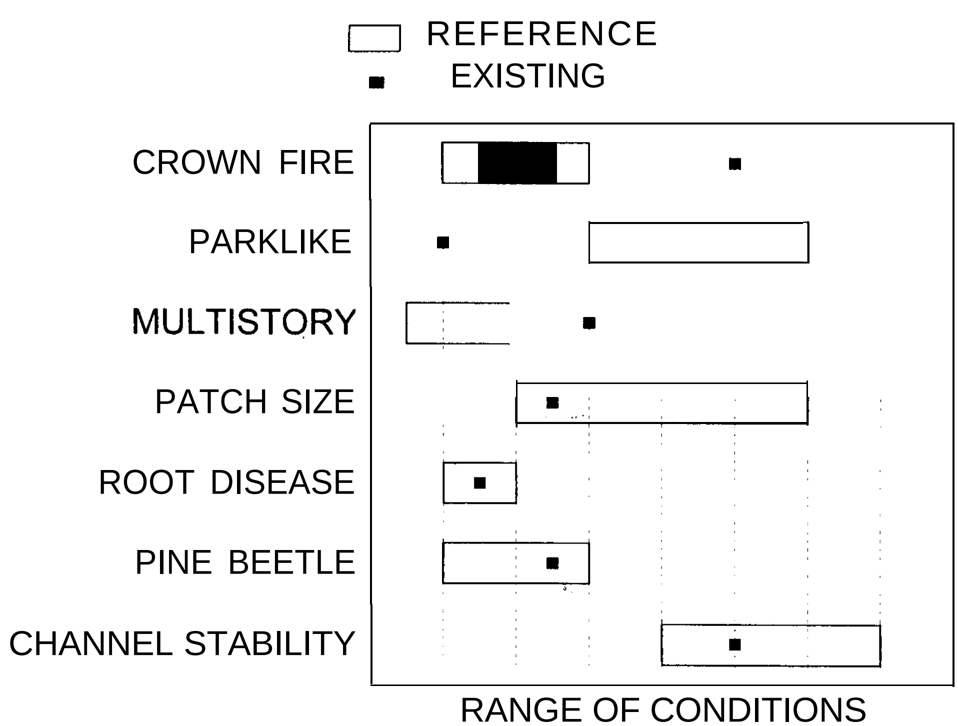

Figure 9—An example of how reference conditions could be used to evaluate if existing forest conditions would be outside the range of conditions that might be sustainable.

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Demonstration of Ecosystem Management Options (D.E.M.O.) A Cooperative Effort Between NFS and Research in the Pacific Northwest

James D. White, Dean DeBell, Mike Amaranthus, and Brenda Woodard

Abstract

The D.E.M.O. project is a demonstration and administrative study of silvicultural options for maintaining, enhancing, or re-creating late-successional characteristics in managed forests in the Douglas-fir region of the Pacific Northwest. Six treatments will be applied in each of eight blocks, four in Washington and four in Oregon. These blocks will be established primarily in the Gifford Pinchot National Forest in Washington and the Umpqua National Forest in Oregon. Responses of vegetation, wildlife, soils, fungi, special forest products, hydrology, economics, and social perceptions will be investigated over time. The project is in the planning and early implementation stages.

Introduction and Background

Forest resource managers and other interested members of society need information about the biological, economic, and social consequences associated with different strategies for managing forest ecosystems in the Douglas-fir region of the Pacific Northwest. Professional and lay opinions about forest management practices have become polarized, caused partly by ideological differences but also by inadequate information about effects of management on many resources and values in the ecosystem.

Forests can be managed under widely differing approaches.

Historically, management systems employed in the Pacific Northwest have changed with changing societal desires, changing resource problems, and changing environments. Selective cutting was the normal practice from the 1930's until the mid to late 1940's. The system used from 1950 through the late 1980's consisted of staggered-setting harvests, generally clearcuts, followed by slash burning and planting. More recently, the preservation and restoration of late-successional forest ecosystem characteristics have become a major concern and have led to retention of green trees in various amounts and patterns in each cutting unit. These may range from a few "wildlife" trees to a stand density approximating that of a shelterwood. Each approach met a specific need when adopted and tended to be applied extensively, to the near exclusion of other methods.

At the same time, it has become increasingly apparent that our knowledge base for such management changes is very limited. Most past forest management research has focused on wood production, while most basic ecology and wildlife research has occurred in unmanaged stands. We know very little about a full range of forest management options. Many questions need answering. How will a given practice influence wildlife habitat, regeneration, nutrient storage, resistance to fire, wind pathogens, insects? What are the impacts on watershed and special forest products? What are the economics of these activities for a full range of forest values? Are activities socially acceptable?

In the past few years, various ideas have been proposed for gathering sound information on various silvicultural treatments and their effects on late-successional forest characteristics. In early 1992, several of these efforts were combined, and Congress allocated $1.5 million to Region 6 for FY 93 to establish a New Perspectives Partners demonstration program, consisting of alternative harvesting experiments in Oregon and Washington.

The study was to be implemented on National Forest System lands in association with the Pacific

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Northwest Research Station and New Perspectives Partners. The Douglas Project in southern Oregon and the Olympic Natural Resources Center at the University of Washington were instrumental in conceptual and supporting activities for the study; they have been joined by Oregon State University, the University of Oregon, and the Washington State Department of Natural Resources.

During late 1992 and early 1993, several meetings occurred for initial planning of the study. These meetings involved the National Forests, Pacific Northwest Research Station, New Perspectives Partners, and various science committees composed of agency and university scientists. The general consensus of the meetings led to a decision to design and establish one comprehensive administrative study of silvicultural options, with installations in the Umpqua National Forest in Oregon and the Gifford Pinchot National Forest in Washington, rather than separate studies at the two Forests. This unified approach increases cost-effectiveness and soundness of scientific evaluations. Also, general trends and findings can be applied with greater confidence to other west-side cascade forests. The study was named Demonstration of Ecosystem Management Options (D.E.M.O.).

D.E.M.O. will focus on attributes and species associated with old-growth or late-successional forests. There are many reasons for emphasizing late-successional characteristics, including the fact that it is the major driver of current controversies and changes in public and private forest land policy today. Although late-successional features will be emphasized in the study, assessments will extend to other resources and values and to many practical considerations in forest ecosystem management.

The D.E.M.O. project will evaluate a wide range of silvicultural treatments for managing forest ecosystems and provide an opportunity to proactively develop information on a range of management options, all of which seem biologically and operationally feasible and each of which may have its time and place in managed forest landscapes. Thus, the proposed design provides for long-term evaluation of effects of treatments on multiple resources and biological, social, and economic values. There will be many near-term benefits and products associated with D.E.M.O., but a long-term study is needed to evaluate sustainability of the various options for regeneration and management of trees, stands, and habitats.

D.E.M.O. Design

The D.E.M.O. project will focus on regeneration harvests and will be installed primarily in mature forest stands. Different methods of regeneration harvest cutting will be examined, all intended to foster the health and productivity of multiple-use forests. The project will focus on attributes and species associated with old-growth or late-successional forests. Within constraints imposed by each regeneration harvesting option, individual silvicultural practices will be selected to retain or accelerate the establishment (or re-establishment) of late-successional features.

The Treatments

The project will evaluate six treatments, which include even-aged, two-aged, and uneven-aged management systems (fig. 1). The systems, differing primarily in the density and arrangement of residual trees for an initial regeneration harvest cut, will create a broad range of biophysical environments. They are defined in relation to the percentage of basal area retained after harvest:

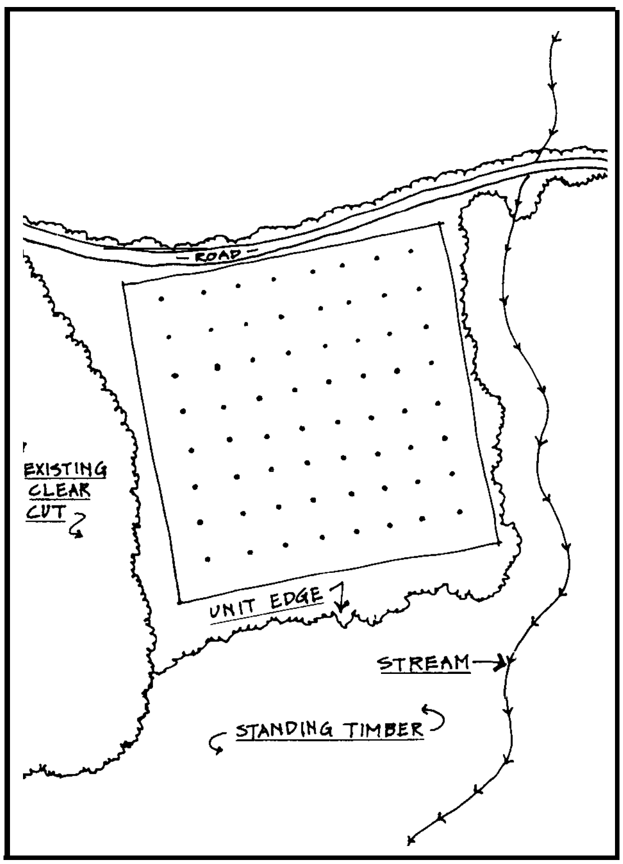


Figure 1D.E.M.O. treatments.

1. 100 Percent Retention-Uncut, unmanaged "control" stand. This treatment will provide a baseline for judging the effectiveness of other treatments in maintaining, re-creating, or accelerating the development of late-successional features.

2. 80 Percent Retention-Initial harvest will occur in small patch cuttings (e.g., about 2 acres or width equal to two times the height attained by dominant trees during the conversion period). Such patches will be dispersed throughout the stand and will occupy about 20 percent of the area. The intent is to develop over time a multiaged (three to five age classes), multistoried stand by means of the group selection system. Future regeneration cuttings will probably occur on 20- to 30-year cycles; some thinnings may be done at the same time.

3. 60 Percent Retention-Initial harvest will be a combination of small patch cuttings, as with the 80 percent treatment, and some thinning dispersed throughout the remainder of the stand. Patches will occupy about 20 percent of the area. The intent is similar to the previous treatment: group selection will result in multiple age classes, with cutting cycles of 20 to 30 years.

4. 40 Percent Retention-Half of the residual trees will be grouped throughout the unit in patches of about 2 acres. No cutting will occur within the patches. The other half of the residual trees will be dispersed throughout the unit and will consist of diverse species and size classes. The intent of the patches is to provide an undisturbed reservoir of biological material that may lead to rapid recolonization and recovery of species in the disturbed area. The intent of the scattered residual trees is to develop a two-aged, multistoried stand. In future entries, trees in younger age classes will be thinned and some of the large trees of the original stand may be harvested. Other large trees will be retained for structure, some eventually becoming large snags for cavity-nesting wildlife.

5. 20 Percent Retention-Specifications and intent of this treatment are the same as for the 40 Percent Retention treatment, except that fewer 2-acre patches and dispersed trees will be retained.

6. 0 Percent Retention-This involves a complete clearcut, "control" area. No green trees (wildlife trees) will be left because the intent of this treatment is to complete the disturbance or retention spectrum. More importantly, this treatment will provide a baseline for judging the effectiveness of some of the other treatments in accelerating recovery and recolonization of selected features in managed forests.

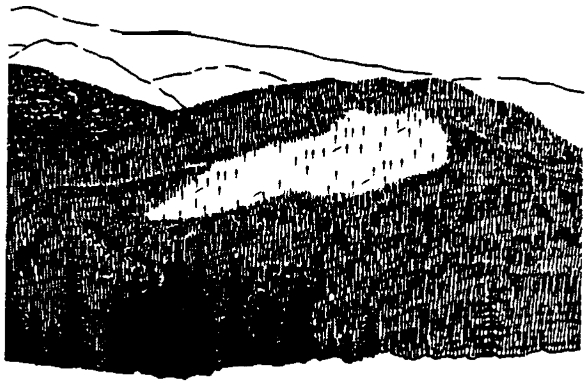
Various silvicultural practices will be implemented as appropriate to secure regeneration and foster the principal goal of maintaining or accelerating the development of late-successional characteristics, These practices may include slash burning, other site preparation, planting, control of understory competition, thinning, pruning, and fertilization. Snags, coarse woody debris, and advanced reproduction will be retained to the extent practicable and appropriate.

Some of these practices also may enhance wood production as they accelerate stand development and associated habitat. In most cases, applications will differ in some respects from those normally used when wood production is the primary objective.

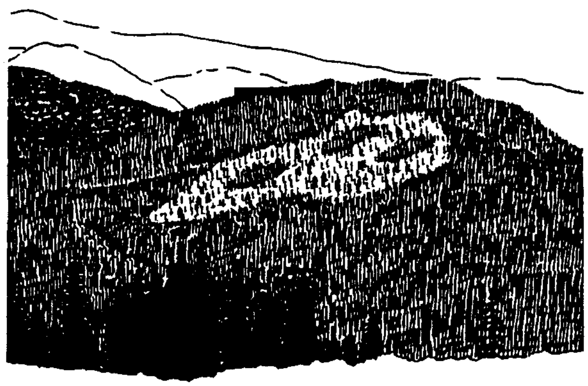
Basic Design or Layout

Treatments will be established in blocks, four each in the Gifford Pinchot and Umpqua National Forests. If suitable blocks cannot be found within these National Forests, we will attempt to locate blocks on other ownerships in the two States. At this time, it seems that one block in Washington will be located on lands managed by the Washington State Department of Natural Resources. Each block will consist of one each of the six treatments, with all treatments within a block applied in stands having similar age and species composition, environment, and surrounding landscapes. Implementation of some treatments at some sites will require variances or release from current or changing constraints, such as Forest Plan Standards and Guidelines, Late-Successional Reserve boundaries, and streamside buffer zones.

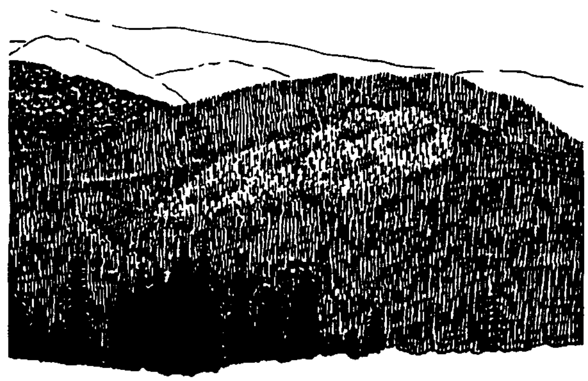
The six treatments will be imposed on units of at least 13 hectares (32 acres); this minimum size constraint is needed to assess effects of treatments on small mammal and bird species. Previous work has indicated that a square to slightly rectangular (length:width ≤ 1.5) grid consisting of at least 63 or 64 points, spaced 40 meters (~ 130 feet) apart, and surrounded by a 40-meter buffer is essential (see fig. 2). Ideally, the units should be at least 20 hectares (50 acres) and contain a grid of 100 points, but reconnaissance of sites to date has indicated that



0% Retention

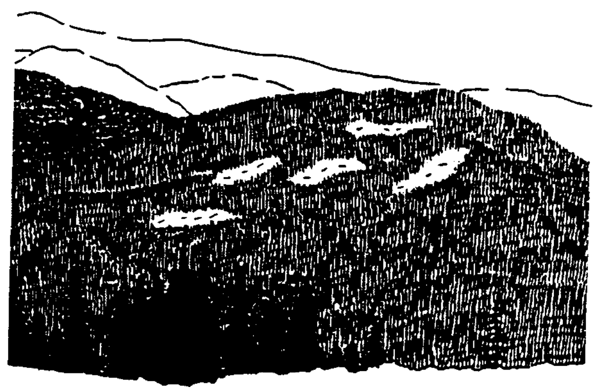


20% Retention



40% Retention

60% Retention



80% Retention

Figure 2-D.E.M.O. sampling grid on the landscape.

we are unlikely to find enough number of stands of this size that would also meet the other site selection criteria. Sites are constrained by roads, existing harvest units in the fragmented landscape, management allocations, and other constraints, such as streamside buffers. It would seem, at first glance, that 32-acre patches of ground should be relatively easy to find. Unfortunately, existing clearcuts, roads, streams, and differing stand types severely limit opportunities.

Ongoing efforts to locate suitable treatment units have yielded blocks composed of a diversity of forest zones and stand age classes for the study. Blocks will be located in the Western Hemlock, Western Hemlock/White Fir, and Pacific Silver Fir Zones; age classes represented by the blocks range from about 70 to 200 years or more. Douglas-fir is the major tree species in all blocks. The majority of conditions faced by resource managers in west-side forests will be represented; thus, basic findings should have general applicability. At the same time, the wide range in conditions increases the need to collect adequate data on pretreatment conditions and wildlife populations. For some of the study variables, such as wildlife, 2 years of preharvest baseline data collection are planned.

Major Areas of Investigation

The D.E.M.O. project provides an opportunity to examine the effects of the treatments on many ecosystem characteristics and in relation to other management considerations, including public expectations and economics. Given limited time and financial or human resources, decisions are now being made regarding which subjects to study. Some of the high-priority items are given below for six general subject categories. Plans have been drafted for trees and snags, understory vegetation (including regeneration and down trees), wildlife, soil, mycorrhizal fungi and other special forest products, hydrology, and social perceptions.

Vegetation

Vegetation assessments will include the survival, damage, and growth of residual trees, advanced tree reproduction, and other woody and herbaceous vegetation; "survival" and dynamics (decay) of snags and down trees; and the establishment and growth of tree seedling regeneration.

Wildlife

Wildlife assessments will determine population densities and habitat use by several species of small mammals, birds, amphibians, and reptiles. For the most part, D.E.M.O. will focus on wildlife species with home ranges at the stand level. The size of the sampling grid, for instance, was driven by the home range size of the flying squirrel. D.E.M.O. also may provide some information about habitat use by ungulates and other farther ranging mammals and birds.

Soils, Fungi, and Other Special Forest Products

Work on soils, fungi, and special forest products will evaluate disturbance and compaction of the forest floor and will determine the abundance, community structure, and dynamics of fungi and special forest products. Mushrooms and other special forest products have greatly increased in demand in the Pacific Northwest during the past few years and are both economically and ecologically important. Fungi also are critically important components of food webs associated with wildlife species of late-successional forests. We find that we know very little, however, about the effect of different management regimes on these increasingly important organisms.

Hydrology

Hydrologic investigations will focus on quantity and quality of water moving along surface and subsurface flow paths, snow accumulation, rain-on-snow events, and potential for cumulative watershed impacts.

Social Perceptions

D.E.M.O. will include investigation of social perceptions of the treatments. Perceptions will be categorized by attitudes and policies, and in relation to the amount of information people have about management objectives.

Economics

Economic investigations will focus on financial evaluation of harvesting costs, stumpage values, future stand growth, and economic values of residual trees, and a wide range of commodity and noncommodity values.

Supporting Studies

The D.E.M.O. installations and data sets developed will provide many opportunities for supporting studies concerning all the above as well as other ecosystem components and values. Examples include (1) the relation of original stand characteristics and thinning and harvesting levels to residual canopy coverage; (2) performance and contributions of genetically selected stock in the diverse environments created by various silvicultural regimes; and (3) depredation of bird nests by corvids (ravens, crows, and jays) and other predators in the different regimes; and (4) effects of treatments on insects, disease, and lichen occurrence and composition. Some of this work may be conducted with D.E.M.O. funds, if resources are sufficient. If not, the fact that such studies can be incorporated into an already established network should make them attractive to other funding organizations.

Challenges and Opportunities

National Forest Managers and Research Scientists

The planning of D.E.M.O. has required close interactions between managers and scientists and has led to better understanding of their respective roles and contributions in management of forested ecosystems. Previously unrecognized opportunities for scientific research and for alternative management approaches have become evident. The interactions surrounding D.E.M.O. also have presented some challenging hurdles, due in large measure to different objectives and working protocols in most scientific and management activities. Researchers must be concerned with being able to evaluate treatment effects and doing so in an objective, unbiased fashion. These concerns have required harvest units larger and more extreme treatments than managers would currently implement; moreover, treatments must be randomly assigned to experimental units to avoid bias, or the appearance thereof, rather than be assigned in some manner considered optimum for current land management objectives. Managers may desire to minimize or mitigate impacts, whereas the purpose of the research is to evaluate those impacts. In the case of D.E.M.O., goodwill and understanding have led to acceptable compromises in resolving conflicting objectives. Scientific objectives were modified so that harvest area size and number of treatments were reduced, thus decreasing impacts on the land. Managers have been willing to impose treatments and involve the public in ways that differ from those currently deemed most appropriate or desirable.

The "Catch-22" of Ecosystem Management

Most forest land managers and much of the public realize that ecosystem science is in its infancy, particularly with regard to intentional management of specific ecosystem components other than trees. Considerable information, much of it based on research, will be needed to place such management on a sound foundation. Ongoing management, however, necessitates the establishment of various standards and guidelines in individual forest plans and other management plans (such as the Forest Ecosystem Management Assessment Team report). Such guidelines commonly represent first approximations based on differing proportions and amounts of data, professional judgment, and prevailing philosophies. In many cases, they have not been validated and in most cases they can be improved. Their existence, however, may pose significant obstacles to stand-level and landscape-level research. In order to implement D.E.M.O., some of the standards and guidelines in existing and proposed plans will have to be relaxed for the study. These include those associated with green tree retention, stream buffer width on intermittent and some small perennial streams, limitations on opening size, and visual quality objectives. The potential impacts associated with departure from current standards will be quite small, and thus, we are hopeful that the essential variances will be obtained.

Optimism and Opportunities

Although implementing any project on National Forest System lands in the Pacific Northwest today is problematic, we believe the D.E.M.O. project has sufficient strength and potential value to overcome the hurdles. Smaller scale efforts, whether designed studies or simply demonstrations, will not, in and of themselves, provide the kind of data needed for valid assessments of treatment responses and the development of sound management guidelines. This effort, and others of similar magnitude, will be needed to develop the science and art of ecosystem management. We expect the D.E.M.O. project to provide excellent opportunities far into the future for training ecosystem managers and for public involvement in many aspects of forest resource management.

D.E.M.O. Update

July 1994

During winter and spring of 1994, the initial D.E.M.O. design was modified, partly to include a retention level similar to that recommended in the new Pacific Northwest Forest Plan for managing late-successional and old-growth forests within the range of the northern spotted owl (the President's Forest Plan). The revised plan will compare dispersed and aggregate tree retention at the 15 Percent Retention level (the level prescribed in the President's Forest Plan) and at the 40 Percent Retention level. It will include one high retention treatment (75 percent), but will not include a complete clearcut (see revised fig. 2). The six treatments are as follows:

1. 100 Percent Retention-Uncut, unmanaged "control" stand. This treatment will provide a baseline for judging the effectiveness of other treatments in maintaining, re-creating, or accelerating the development of late-successional features.

2. 75 Percent Retention-Initial harvest will occur in small patch cuttings, approximately 1 hectare (2.5 acres) in size. Patches will be dispersed throughout the stand and will occupy about 25 percent of the area. Future regeneration cuttings will probably occur on 20- to 30-year cycles; some thinnings may be done at the same time.

3. 40 Percent Retention (Dispersed)-Residual trees will be dispersed throughout the harvested stand, and will consist primarily of dorninant and codominant size classes. The intent is to provide a test of a moderate level of tree retention, with retained trees dispersed throughout the unit.

4. 40 Percent Retention (Aggregated)-Residual trees will be clumped in patches approximately 1 hectare in size. No cutting will occur within the patches. The intent of the patches is to provide an undisturbed reservoir of biological material that may lead to rapid recolonization and recovery of species in the disturbed areas. The treatment provides a test of a moderate level of tree retention, with retained trees aggregated in patches.

5. 15 Percent Retention (Dispersed)-Specifications and intent of this treatment are the same as for the 40 Percent Retention (Dispersed) treatment, except that fewer trees will be retained. Fifteen Percent Retention provides a similar level of forest retention to that recommended in the President's Forest Plan, and provides a comparison with the 40 Percent Retention treatment.

6. 15 Percent Retention (Aggregated)-Specifications and intent of this treatment are similar to those for the 40 Percent Retention (Aggregated) treatment, except that fewer l-hectare patches will be retained. As with the 15 Percent Retention (Dispersed) treatment, this treatment provides a similar level of forest retention to that recommended in the President's Forest Plan.

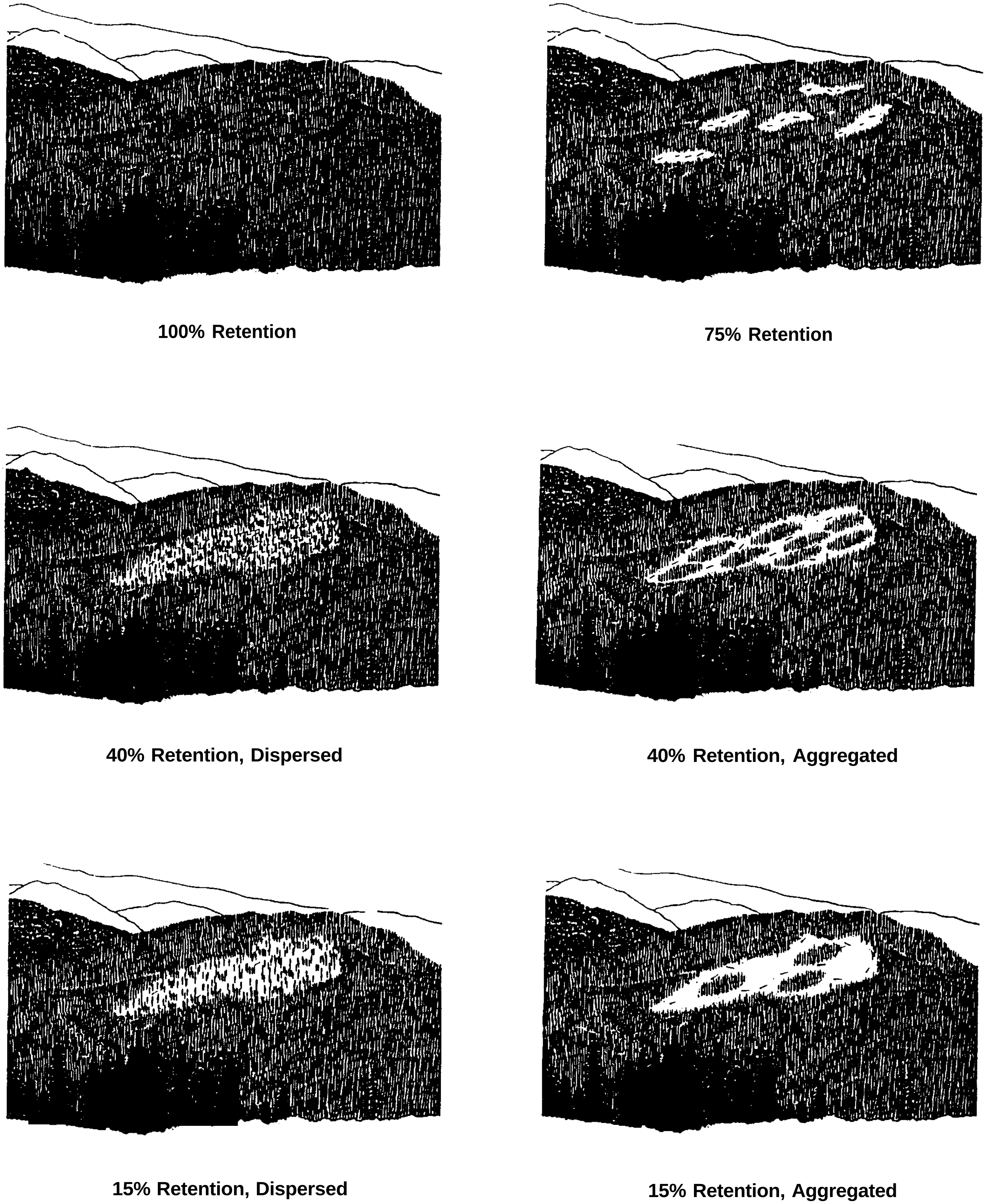


Figure 2-D.E.M.O. treatments (revised drawing of treatments, July 1994).

Using Silviculture to Increase Forest Health: A National Forest/Research/State and Private Demonstration Area

Kurt W. Gottschalk and W. Russ MacFarlane

Abstract

A cooperative area was established on the Glenwood Ranger District, Jefferson National Forest, to demonstrate the effectiveness of silvicultural treatments in minimizing gypsy effects to the public and forest resource professionals and provide additional research data on the effectiveness of the treatments versus direct insect treatments. The silvicultural treatments have been installed and the demonstration area is now available for tours.

Introduction

In 1989-90, several meetings of personnel with the Jefferson National Forest, Appalachian Integrated Pest Management Demonstration Project (AIPM), and Northeastern Forest Experiment Station resulted in an agreement (memorandum of understanding) that the three Forest Service groups would cooperate in establishing a gypsy moth (*Lymantria dispar* L.) silvicultural research and demonstration area on the Jefferson. The initial term of the agreement, 3 years, covered the installation of the demonstration area and expired in 1992. A new lo-year agreement in 1993 continued the demonstration project until gypsy moth reached the area and treatment effects could be evaluated. The expiration of the AIPM resulted in its replacement in the new agreement with the new National Center for Forest Health Management. Background on the use of silvicultural treatments to increase forest health for gypsy moth, history and design of the demonstration project, and case studies of some project treatments are discussed.

Silvicultural Guidelines

Silvicultural guidelines have been developed that provide stand treatments to minimize gypsy effects on forests (Gottschalk 1993, Gottschalk and MacFarlane 1993). Two mechanisms are used to minimize effects: (1) alteration of stand susceptibility to defoliation (probability of defoliation given that the insect is present), and (2) alteration of stand vulnerability (probability of mortality or other damage to forest, resources given that defoliation has occurred). These treatments are designed to increase the "health" of the forest so that disruption is minimal following defoliation of the forest, stand by gypsy moth. A variety of silvicultural treatments is prescribed based on stand conditions and insect populations.

The guidelines have three phases: pre-outbreak, outbreak, and postoutbreak. Pre-outbreak treatments concentrate on increasing the health of stands by thinning or regeneration cutting. Outbreak prescriptions include regeneration treatments and prioritization of stands for protection against, defoliation when necessary to protect values for management objectives. Postoutbreak treatments concentrate on salvaging dead trees and increasing the health of stands through thinning and regeneration cutting. The demonstration area is installed ahead of the gypsy moth defoliation area; pre-outbreak treatments are used rather than outbreak or postoutbreak prescriptions. The following are major treatments on the demonstration area.

Pre-salvage thinnings are conducted in areas with more than 50 percent oak (*Quercus* spp.). Their primary purpose is to reduce the vulnerability of a stand by removing the fair- and poor-crowned oaks and other preferred food species of gypsy moth. Trees with poorer crowns are more likely to die following defoliation, so their removal should reduce total stand mortality and increase the health and vigor of the remaining trees (Gottschalk and MacFarlane 1993, Herrick and Gansner 1987).

Sanitation thinnings are conducted in stands with less than 50 percent oak. These thinnings target the removal of most preferred food species, thus reducing the susceptibility of a stand. Reduction of preferred food species of gypsy moth to about 20 percent of the stand basal area will lower stand susceptibility to a point where little defoliation will occur (Herrick and Gansner 1986).

Project Leader, USDA Forest Service, Northeastern Forest Experiment Station, Morgantown, WV, and Silviculturist. USDA Forest Service, Glenwood Ranger District, Jefferson National Forest, Natural Bridge. VA (respectively).

The primary objective of pre-salvage harvest cutting is to harvest the stand before defoliation, to use the adequate advanced regeneration present, and to preserve stump sprouting to regenerate a new stand. The new stand may be similar in composition to the previous stand or may differ if the advanced regeneration is different and satisfies management objectives. These stands are within 5 years of maturity or they have an unacceptable density of acceptable growing stock.

Pre-salvage shelterwoods do not have adequate advanced regeneration and stump sprouting potential stockings. Their primary objective is to develop adequate regeneration by shelterwood cutting. Selection of trees to be left in the residual stand should be based on seed productivity, species desired, crown condition, and spacing. The species composition of the residual stand can be shifted by the shelterwood cut if desired. When advanced regeneration stocking becomes adequate, usually in 5 to 7 years (though oaks may take longer), the residual trees can be removed.

The primary objective of sanitation conversions is to reduce susceptibility and/or vulnerability by converting to nonpreferred species before the stand can be infested by gypsy moth. Because of high susceptibility or vulnerability, these stands will have frequent, high defoliation levels or high mortality levels. Low-quality sites could be converted naturally to pines such as white, Virginia, and pitch, or artificially to pitch-loblolly hybrids and other conifers. High-quality sites could be converted naturally to mixed hardwoods, white pine, hemlock, or northern hardwoods. Clearcut harvests or shelterwood cutting can be used to obtain adequate advanced regeneration with either natural conversion strategy, while artificial conversion may incur substantial costs. Conversion of mixed-oak stands to other species may be economically undesirable because oaks often are the most valuable species that grow on these sites. However, conversion may be more economically desirable eventually because of fewer impacts on the stands from the gypsy moth and lower or no costs for stand protection.

Demonstration Area

The primary objective of the Silvicultural Demonstration Project (SDP) is to demonstrate the effectiveness of the pre-outbreak phase (Gottschalk 1993) in reducing stand susceptibility and vulnerability before gypsy moth infestation in Appalachian hardwood forests. The area will be used to educate the public and forest resource professionals about gypsy moth effects and the use of silviculture to maintain forest health. The secondary objective is to compare the effectiveness of silvicultural and direct high- and low-level gypsy moth treatments (i.e., pesticide applications). Given these objectives, this project contains demonstration. education, and research aspects.

The Arnold Valley Silvicultural Demonstration Project, a cooperative effort, was begun in 1990. The AIPM project within the Northeastern Area, State and Private Forestry provided funding for the first 3 years. The Southern Region (Region 8) of the National Forest System provided the facilities, land, and support staff needed to implement the project. The Northeastern Forest Experiment Station provided technical guidance and advice for implementing the guidelines and design of the research portion of the demonstration as well as partial funding to continue data collection. The Northeastern Station will analyze the data as they are collected. Most recently, Region 8 Forest Health provided funding to complete the implementation of the project, and to continue the data collection and monitoring. The National Center for Forest Health Management has taken over the AIPM role in the application and evaluation of high- and low-level gypsy moth treatments.

The project is located on the Glenwood Ranger District of the Jefferson National Forest in southwestern Virginia. The Glenwood District comprises 76,000 acres on the Blue Ridge just south of the dames River gorge and north of the city of Roanoke, VA. Arnold Valley, opportunity area selected as the specific site for the project on the Glenwood, is a 26,000-acre area with emphasis on multiple use. Approximately 11,000 acres of wilderness, a popular, developed campground and lake, and about 9,500 acres of land suitable for timber production are within Arnold Valley. More important to this discussion, the area is characterized by high-quality timber and good sawtimber and pulpwood markets. Forests are dominated by mature oak/hickory and oak/poplar stands. Site indices of suitable land range from 65 to 80 feet, for red oak. Ages of the stands range from 60 to 120 years.

Methods

The design of the demonstration area has two complete series of treatments: (1) one in moderately susceptible stands with less than 50 percent basal area in oak, and (2) one in highly susceptible stands with more than 50 percent basal area in oak (table 1). There were at least, three replications of each treatment, in each series to meet research objectives. Selection of the specific stands to be included in the project was made after the available stand inventory database was screened and approximately 2,000 acres were sampled. Upon completion of the project, 46 stands (counting each group selection as a "stand") occupying approximately 434 acres will have received a silvicultural treatment. An additional 19 stands occupying 491 acres are assigned to research control or insecticide treatments. Thus, 65 stands and approxirnately 925 acres are included in the SDP (table 1).

The thinning treatments in areas containing more than 50 percent oak are pre-salvage thinnings. Sanitation thinnings are located in the moderately susceptible stands. Shelterwoods are intended to regenerate stands that lack advanced reproduction in the understory. The same principles of pre-salvage and sanitation described for thinnings can be used for shelterwoods. However, one must recognize that the regeneration of the stand is the primary goal of a shelterwood treatment. This may require consideration of seed productivity of individual trees when deciding which trees should be removed. Clearcut harvests regenerate stands that contain adequate numbers of advanced reproduction reducing both the susceptibility and vulnerability of a stand for 20 to 40 years. Group selections are used to create uneven-aged stands that regenerate intolerant and midtolerant species. High-level gypsy moth treatments to be applied when populations exceed thresholds will be application of Bacillus thuringensis (Bt) or Dimilin; low-level treatments will include the application of pheromone flakes to disrupt mating. A series of untreated controls will be used to show the effects of gypsy moth on these same types of stands.

Prescribing and documenting these treatments was the primary activity during the first several years of the SDP. As mentioned previously, stand selection began with screening the available data on stand inventory. The search was limited to stands in oak forest types on land suitable for timber production in areas that were accessible. The District Silviculturist and Timber Management

Table l----Treatment design and allocation of stands and acreages for the Arnold Valley Silvicultural Demonstration Project

	Moderately susceptible stands (<50 percent oak)			Highly susceptible stands (>50 percent oak)		
Treatment	Number of stands	Number of acres	Size range (acres)	Number of stands	Number of acres	Size range (acres)
Thinnings	3	35	10-15	5	109	15-35
Clearcuts	3	63	li-25	3	37	10-15
Shelterwoods	5	111	10-40	3	49	10-20
Groups	12	15	0.5-2	12	15	0.5-2
Control	4	121	12-45	3	36	10-16
Pheromone	3	51	15-18	3	51	12-24
Insecticide	3	157	39-52	3	75	10-40
Total	33	553		32	372	

Assistant were heavily involved throughout the selection process. Once a randidate stand was identified, the forester responsible for implementing the project performed a cursory stand examination. If the stand appeared to have good potential for inclusion in the project. it was formally sampled. A basal-area factor 10 prism cruise was performed in each stand according to protocols established for the Silviculture of Allegheny Hardwood Expert, System (SILVAH) (Marquis and others 1992). SILVAH takes raw data from a point,-sample or prism cruise. analyzes and summarizes the data in many forms, and assigns tentative silvicultural prescriptions. SILVAH has been programmed with gypsy moth hazard-rating functions and can compute both susceptibility and vulnerability estimates for a stand. Using the SILVAH summary, each stand was assigned a prescription based on the decision chart for the pre-outbreak phase presented in Gottschalk (1993).

Once the decision was made to include a specific stand in the project. permanent monitoring points were installed in the stand. These are perrnanent 0. l-acre circular overstory plots with three 0.385-acre regeneration subplots. A variety of vegetation data was taken on these plots before the treatments were installed. The stands to be treated silviculturally were then incorporated into the normal timber sale program on the Glenwood. National Environmental Policy Act requirements were documented in an Environmental Assessment. Stands were laid out. marked, and appraised by District staff. The forester responsible for irnplementing the project supervised the marking crews to ensure proper marking of the stands based on the prescription. Approximately 25,000 board feet of sawtimber and pulpwood were produced from seven sales over a ‘L-year period.

After cutting, both point-sample cruises and remeasurements of the permanent monitoring points were done. The permanent plots were monumented and trees within them painted to facilitate future remeasurements. In the future, annual vegetation measurements such as crown condition and defoliation will be made. In addition. gypsy moth populations are monitored in the stands using pheromone traps and egg-mass surveys. A good record of defoliation in each stand is vital to draw correct conclusions. After defoliation has occurred, gypsy rnoth populations have collapsed, and sufficient time for mortality to accrue has passed. a final remeasurement of all the permanent plots will be made. Then the data will be analyzed and conclusions and recommendations will be made

Case Studies

While results will not be available until gypsy rnoth populations have run their course through the area, we can make predictions about, the efficacy of the silvicultural treatments based on the SILVAH estimates of stand susceptibility and vulnerability from point-sample cruises. Case studies using this data are presented for some treatment, stands within the SDP.

Stand 16

Stand 16, a 27-acre upland oak stand. has a site index of 75 feet (red oak). is approximately 65 years old, and contained 120 square feet, of basal area. This stand was dominated by chestnut. oak, yellow-poplar. and red maple. A component of red and black oak also was present, and the total oak component accounted for 67 percent of the stand. This percentage of oak results in a high susceptibility. Much of the red and black oak was declining in vigor: this was evident by the fair and poor crown conditions throughout the stand. A predicted 15.8 percent of the stand would die because of defoliation stress. A thinning treatment also was prescribed for this stand because of its youth and density. However, because of the-large oak component and declining vigor, a pre-salvage thinning was prescribed. This thinning concentrates on removing the poor and fair crowned trees (those rnost likely to die because of defoliation stress). After all poor/fair crowns have been removed. the rest of the stand is thinned from below to meet spacing and stocking targets.

Stand 16 now contains 72 square feet, of basal area and is dominated by yellow-poplar. chestnut oak, and hickory. The percentage of oak was lowered to 42 percent. More important, because of the removal of poor/fair crowned red and black oaks, it is now estimated that 11.3 percent of the stand would die because of defoliation stress. The pre-salvage thinning significantly lowered the vulnerability of the residual stand and “captured mortality” of trees that would most likely die once defoliated.

Stand 13

Stand 13 is IO acres and occupies a cove site. This stand has a site index of 75 feet, [red oak), is 80 years old, and contained **121** square feet of basal area. It was dominated by yellow-poplar, chestnut oak, and hickory. Only 30 percent of the basal area in this stand was oak. resulting in moderate susceptibility. Stand vigor as indicated by crown condition was good throughout the stand. An estimated 10.9 percent. of the stand was predicted to die because of defoliation stress. Advanced regeneration was lacking. though the amount of yellow-poplar in the stand all but guaranteed sufficient regeneration potential in seed stored in the litter layer. Given the species composition. high stocking, and good vigor of this stand, a sanitation thinning was prescribed. This thinning concentrates on reducing the basal area of oak in a stand to 20 percent or lower. At these lower percentages of oak, research has indicated that gypsy moths do not severely infest a stand. Although thinning in a stand of this age would be recommended by few silviculturists, it was felt that this stand could be carried for at least another 20 years.

Stand 13 now contains approximately 75 square feet of basal area and still is dominated by yellow-poplar and chestnut. oak. Black birch has replaced hickory as the third most, dominate species. Hickory, being moderately to highly preferred by gypsy moth also was targeted for reduction in this treatment. Because of thinning, this stand contains only 16 percent oak, making it significantly less susceptible to severe defoliation. Further. only vigorous, good-crowned oaks were left, lowering predicted mortality in the stand to 9.6 percent.

Stand 20

Stand 20, a 15-acre upland oak stand, has a site index of 65 feet (red oak), is 90 years old, and contained 107 square feet of basal area. The stand was dominated by chestnut oak, black oak, and white oak; oak comprised 74 percent of the basal area resulting in a high susceptibility. Further, the black oak and scarlet oak (a lesser component) had reached pathologic maturity for this site. This was evident by the many fair and poor crowns, indicating low vigor and a high mortality risk of the stand. An estimated 15.5 percent of the stand was predicted to die because of defoliation stress. The amount of advanced regeneration combined with the expected sprouting potential for the stand was sufficient to ensure adequate stocking of a future stand. Given the maturity of the stand and presence of regeneration, a pre-salvage harvest, by clearcutting was prescribed.

Removal of the entire overstory except where protection of other resources was necessary has greatly reduced both the susceptibility and vulnerability of this newly regenerated stand. It now contains a much greater diversity of both woody and herbaceous plants. In terms of biomass, the percentage of preferred food species of the gypsy moth has been greatly reduced. This should make the stand much less attractive to invading gypsy moth. The regenerated stand also is in a much more vigorous state of growth. Young saplings and sprouts can withstand defoliation stress much better than the aging stems present on the site before treatment. Therefore, predicted mortality because of defoliation in this stand also is greatly reduced. How long these effects will last is subject to debate, though most scientists agree that effects should last 20 to 40 years.

Summary

The SDP has been installed successfully on the Glenwood Ranger District, of the Jefferson National Forest. Defoliating gypsy moth populations are 25 to 30 miles north of the area and should reach the demonstration area in 2 to 3 years. As gypsy moth defoliates the stands and the high- and low-level treatments are applied for population control, we can collect, the data necessary to evaluate the various treatments. Treatment influences on forest health and the response of the forest to gypsy moth will be the final determinants of success. The demonstration aspects of the project are available for use by foresters, other professionals, and the public. Tours can be scheduled by contacting either of the authors of this paper.

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An Ecological Model and Information Needs Assessment for Longleaf Pine Ecosystem Restoration

Joan L. Walker and William D. Boyer

Abstract

Selected ecological principles are presented as a basis for a simple model of ecosystem restoration. Based on that model, information needs for developing a longleaf pine restoration project were identified. This ecological approach should facilitate the development of projects that effectively address the problems of ecosystem restoration.

Introduction

Longleaf pine ecosystem restoration is a complex problem that demands the cooperation of research and management. It will require integrating different kinds of information from various fields of study. However, managers and researchers are trained and experienced in tackling discrete problems at the stand scale or smaller. Since most of us have specialized training, we will tend to continue addressing narrow questions. To direct our individual efforts toward solving the larger problem effectively, we must develop a common understanding of ecosystem restoration.

We suggest that a model based on the ecological concepts of dynamic ecosystems and natural ranges of variation in ecosystem components and processes (Bourgeron and Jensen 1993, Jensen and Everett 1993, Swanson and others 1993) can be used to establish that common understanding. Such a model can help us identify information needs, formulate individual project proposals, and evaluate how effectively an integrated project meets overall goals.

In this paper we (1) briefly discuss selected ecological principles relevant to restoration; (2) present a conceptual model of restoration as both a management and a research problem; and, (3) based on this conceptual model, provide a preliminary analysis of information needs for restoring the vegetation components of longleaf pine ecosystems.

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Ecological Definitions and Principles for Restoration

Definition of Restoration

Management of ecological systems involves prescribed treatment of an ecological system to achieve a desired condition. Restoration is a special case of management where the desired condition is a condition that previously existed. Because the recent interest in longleaf pine ecosystem restoration is rooted in a concern for managing or conserving "natural" biological diversity (Means and Grow 1985, Noss 1988, 1989), restoration objectives should reflect our collective understanding of "natural". In the discussion that follows, we use "historical/natural" to refer to ecosystem condition and function prior to extensive European exploitation, i.e., before clearcutting the primary forest.

Underlying Ecological Principles

1. Ecosystems consist of elements and processes, and both occur over a variety of scales (e.g., individual trees in a stand, kinds of plant communities on a landscape, etc.). Ecosystems may be described in terms of composition (kinds of elements at a given scale) and structure (how the elements are arranged with respect to each other) and ecosystem function (how the elements interact with each other and with the physical environment)(Forman and Godron 1986, Franklin 1988, Noss 1990).

2. Ecosystems are dynamic and naturally exist in a variety of conditions (fig. 1A). Describing an ecosystem at a point in time would fail to describe that system completely. Incremental changes are mediated by continuous processes, such as growth and mortality of individuals, species interactions,

responses to weather variations, etc. More abrupt changes may occur in response to disturbance events that alter structure, function, and composition.

3. Ecosystems develop and function within a disturbance regime. Disturbance regimes describe the patterns of disturbance in an ecosystem through time and space. They are characterized by the type of disturbance, e.g., fire or wind; the frequency, intensity, and timing of its occurrences; and the variability of those parameters (Pickett and White 1985). Although disturbance events may be stochastic, they also are predictable.

4. Ecosystem responses to disturbances vary within limits (fig. 1A). In the context of a disturbance regime, characteristics of ecosystems, such as aboveground productivity, nutrient cycling rates, species richness, etc., will vary through time within a characteristic range of variability (Swanson and others 1993).

5. If an ecosystem is changed beyond the historical/natural range of variability, ecosystem processes may not be able to return the system to the range of conditions typical of the historical/natural regime (fig. 1B,1C). The ecosystem could become part of a different system characterized by a different range of variability. Prolonged fire exclusion has produced such changes in the longleaf pine system by eliminating species, changing fuel characteristics, and obscuring landscape patterns.

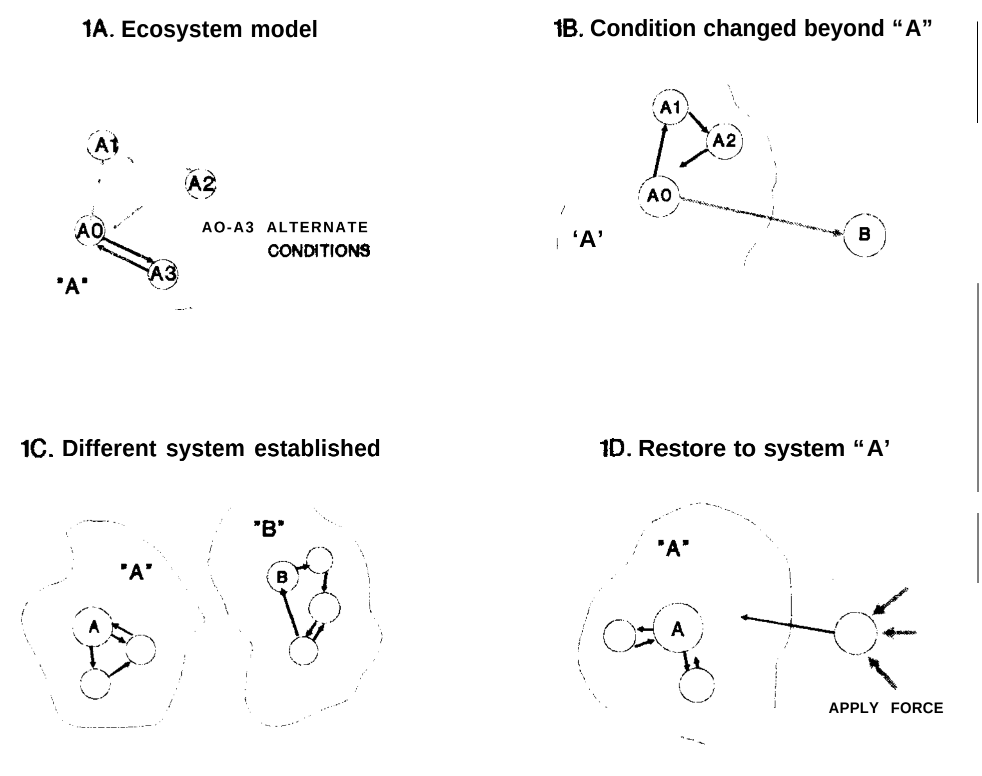

Figure 1Representation of ecological principles relevant to restoration. (1A.) Various possible states of a given ecosystem exist within some range of variation determined by a disturbance regime. "A" represents some multidimensional "space" that contains the range of conditions. AO-A3 represent some alternative states within "A". (1B.) If a system from "A" is changed significantly, it may assume a condition beyond the original range of variation. (1C.) Once moved beyond the historical/natural range, a different set of variations "B" may be established, but existing ecological processes are not likely to return the changed system to "A". (1D.) Some "force" must be applied to return the changed system to the original range of variation represented by "A."

Model for Ecosystem Restoration as a Management and Research Endeavor

Based on these definitions and principles, we view ecosystems as dynamic systems that exist within a range of conditions (fig. 1A). The range is determined by the historical/natural disturbance regime and the processes by which ecosystems respond to those disturbances.

Furthermore, we recognize the range of historical/natural variability as the desired condition for restored ecosystems ("A" in fig. 1) and ecosystems lying outside that range of variability ("B" in fig. 1C) as units to be restored. Presumably, national forest targets for restoration are lands outside the range of historical/natural conditions or, under current management strategies, moving toward the "edge" of that range.

If managers are to restore ecosystems that lie outside the desirable range of variability, some "force" must be applied to move the system back to the desired condition (fig. 1D). Such forces represent management actions or projects. From a research perspective, they may also be established as experimental treatments designed to test hypotheses about ecosystem function.

This model suggests three classes of information needed to develop an effective restoration program: (1) historical/natural ecosystem conditions; (2) current conditions; and (3) processes that affected the changes. The historical/natural system serves as a template for restoration. The current conditions, or starting conditions, will dictate the kinds of actions that may be required to achieve restoration objectives. Understanding the factors involved in reaching the current conditions provides insights into how the ecosystem functions, and leads to testable hypotheses and potential treatments. The stated ecological concepts also prompt us to consider ecosystem components and processes at multiple scales.

Ecological Information

Ecological information needed to develop a longleaf pine ecosystem restoration project is reviewed in this section. Our discussion is limited to vegetation and is mostly qualitative. It does not consider human use. We divide this section into discussions of historical and current conditions. Processes of change are included. We discuss vegetation components (composition and structure) and environmental factors that influence them, disturbance processes, and known mechanisms of vegetation responses (aspects of ecosystem function). These are discussed at two spatial scales: regional/landscape and community/stand.

The Historical/Natural Range of Variation in Composition, Structure, and Function of Longleaf Pine Ecosystems

Regional/landscape scale-At the time of European settlement, longleaf pine forests and woodlands were found on the Atlantic and Gulf Coastal Plains from southeastern Virginia to eastern Texas. These forests extended inland to the Piedmont Physiographic Province (Upland Section), the Blue Ridge (Southern Section), and the Ridge and Valley Province (Southern Section). (See Fenneman 1938 for physiographic maps and Little 1971 for a map of longleaf pine distribution.)

Across this geographic range, landforms and soils vary considerably. Moving inland from the coast, the soils and underlying geologic strata are older and show the effects of long periods of erosion. Coastal landscapes are nearly flat, with small rises (old dunes systems, for example) and depressions of various sizes. More inland landscapes are hilly or rolling. In the upper piedmont and mountains, longleaf vegetation was found on steep, exposed rocky slopes and ridges. Longleaf dominated forests over a variety of soil types in at least four soil orders-Ultisols, Entisols, Spodosols, and Alfisols. In most cases, surface soils were mineral soils with low nutrient (nitrogen and/or phosphorus) content (Wahlenberg 1946).

A recently published longleaf pine vegetation classification indicates the importance of major soil drainage classes and geographic variation in determining community composition. Peet and Allard (in press) used multivariate analysis techniques to describe vegetation in the longleaf range east of the Mississippi River. The major groups of communities (series) are distinguished by soil drainage classes: Xeric, Subxeric, Mesic, or Seasonally Wet. Community types within these series are distinguished by physiography and geography. For example, within the Xeric Series the following community types are recognized: Fall-line, Atlantic, Southern, Atlantic Maritime, and Gulf Maritime.

Geographic variation is also evident in the composition of the rare plant species component. Of nearly 200 rare plant taxa, 96 narrow endemics (confined to a single State) were identified (Walker, in press). Cluster analyses grouped wider-ranging rare species into four geographic groups: species generally confined to the Carolinas, those found in the Carolinas plus Georgia and Florida, species nearly confined to Florida, and those restricted to Louisiana and Texas. The geographic variation in longleaf ecosystems is significant from a biodiversity perspective and must be factored into a restoration strategy.

Descriptions of virgin longleaf pine forests provide some insight into the patch structure of the forested uplands. Accounts agree that landscapes included patches of primarily even-aged forests (Schwarz 1907, Chapman 1923, Wahlenberg 1946). Schwarz reported that uniform stands may have been as large as several hundred acres, but were often smaller and interrupted with groves of poles or saplings (about 1/2 acre in size). Within the longleaf landscapes, Wahlenberg (1946) also describes 1/4- to 1/2-mile-wide strips of young even-aged trees that originated in tornado paths.

Historically, fire was the dominant disturbance influencing composition and distribution of landscape elements across the region (Christensen 1981, 1988). Frost (1990) divides the range of longleaf pine into two areas (1) longleaf-dominated coastal plain uplands and sandhills where fires returned every 1-3 years, and (2) other areas where fire ignitions were less frequent or where topography protected areas from fire. In the latter areas, longleaf pines grew with various other pines, such as shortleaf, loblolly, and slash, and/or hardwoods. Frost suggests the typical fire return time in these areas was 3-5 years for pine mixtures and longer for pine-hardwood mixtures.

Hurricanes were/are responsible for large scale disturbances in longleaf systems. Hooper and McAdie (in press) used historical records to model hurricane return times, specifically to sites of recovery populations of red-cockaded woodpeckers, an endangered species that prefers old longleaf pine forests for nesting. Their work indicates the likelihood of hurricanes striking longleaf forests varies inversely with distance from the coast. Landscape-sized areas of 100,000 ha within 50 miles of the coast can expect destructive Category III class winds on average about every 100-250 years. On the other hand, areas over 150 miles from the coast are essentially immune from such destructive wind (excluding downbursts associated with local storms and tornadoes). However, they can expect at least minimal hurricane force winds about every 200 years. These are average return periods, and it is likely that some areas will be hit more often than the return period, while others will not be hit at all for more than twice the length of the return period.

We have described some characteristics of historical landscapes acknowledging available information about patch size and distribution, connectivity, and heterogeneity is incomplete. We also lack an evaluation of how historic landscape structure influenced landscape functions such as movements of fire and water, animal use patterns, or movement of pollinators for rare plants.

Community/Stand

Regularly burned longleaf communities, probably common historically (Wells 1928, 1942; Garren 1943; Christensen 1981, 1988; Frost, in press), are often described as parklike forests with a species rich herbaceous layer dominated by grasses. Little, if any, shrub layer exists, and the sparse subcanopy and sapling layer consists of patches of longleaf pines. The density and size of canopy trees and the density and abundance of the herbaceous layer are site dependent. Mesic sites with somewhat richer soils are more productive and may support additional tree species, especially in microsites that are somewhat naturally protected from fires (Wells 1928, 1942; Heyward 1939; Blaisdell and others 1974; Monk 1968; Peet and Allard, in press; Shafale and Weakley 1990).

Studies of relatively undisturbed longleaf vegetation have documented the importance of moisture in determining the plant community composition (Walker and Peet 1983, Christensen 1988, Taggart 1990). In the most recently published classification, Peet and Allard (in press) provide descriptions and indicator species for all the community types in their study: five Xeric types, six Subxeric, four Mesic, and eight Seasonally Wet. Low-disturbance research sites are assumed to represent historical conditions; however, some community types are not well represented on current landscapes, and their composition will remain unknown without further paleobotanical investigation.

Virgin longleaf pine stands have been described as uniform and even-aged, as well as heterogeneous with multiple size classes (Schwarz 1907, Chapman 1923, Wahlenberg 1946, Landers and Boyer, draft). The disparity in descriptions may simply reflect differences in spatial scales considered, but it is likely that the whole range of conditions existed. As discussed earlier, larger disturbances, such as hurricanes, may have produced even-aged stands. At the same time, smaller scale processes such as individual tree deaths from lightning strikes or blowdowns could account for regenerating patches within older forests (Chapman 1923). Deaths due to insects and disease are rare in natural longleaf stands, unless individual trees are previously stressed, for example, by fire or extended drought. Undoubtedly, the processes that established stand structure varied considerably.

The understories of some mesic, frequently burned longleaf forests support species richnesses (species/m^2) as high as any in the world (Walker and Peet 1983). Even at larger scales, comparable to those typically reported for forest vegetation (species/O.1 ha), mesic longleaf pine forests are among the richest in North America (Peet and others 1990). In addition to overall richness, the communities contain many rare plant species (Hardin and White 1989, Walker, in press).

Fire is critical to maintaining understory composition and richness. Researchers suggest that maintaining high species richness in coastal plain sites required fire return times of l-3 years on more productive (often mesic) sites and 6-10 years on less productive (xeric) sites (Frost 1990, Christensen 1988, Walker and Peet 1983, Peet and others 1983). The historical/natural fire regime included fire during all seasons, but lightning-caused ones were concentrated during a few months, mostly cited as April-July (Platt and others 1988a, 1988b, in press). Further experimental work will sort out the effects of timing, frequency, and intensity of burning (Streng and others, in press, Platt and others 1988a, Robbins and Myers 1992).

The Current Conditions of Longleaf and Formerly Longleaf Lands

Region/landscape-Acres dominated by longleaf forests have decreased from about 92 million at the time of European settlement (Frost in press) to about 3.7 million by the mid-1980's (Kelly and Bechtold 1990). 0 ver half (54.5 percent) of lands typed as longleaf pine are in private ownership. Of the remaining lands, about 18 percent is private industrial forest land and 27 percent is public land (Kelly and Bechtold 1990). Frost discusses the patterns and causes of longleaf pine ecosystem decline. He notes the failure of longleaf pine to regenerate after the first harvest, which he attributes to lack of seed sources, widespread grazing, and the nationwide fire suppression policy in effect until about 1950. Site conversions, especially in private holdings, contribute to a steady and continuing decline (Landers and others, manuscript in revision).

It is useful to consider the remaining longleaf landscapes in two classes: multiple owner/manager areas and single owner/manager areas. The former are aggregates of small privately owned tracts and are likely to include forested patches embedded in a nonforested matrix of agricultural, home, and industrial sites. In contrast, single ownership public and corporate timber lands have a matrix of forested habitats containing smaller developed or open patches. As a consequence of widely used even-aged management systems, the forested landscapes consist of even-aged patches that on southern national forests can be up to 40 acres. Undoubtedly, the nonforested landscapes differ from historical landscapes, but we have not determined to what degree the predominantly forested landscapes have been changed.

Current disturbance regimes also vary with ownership. On private land, site conversion to other forest types and development continue. On corporate timber lands and public lands, disturbances include activities associated with recreational development, military uses, wildlife habitat manipulation, and timber resource management. Typical landscape level effects on southern national forests include the development of a patchy or fragmented landscape. We have not quantified these changes, and their consequences could be important. For example, Conner and Rudolph (1991) have suggested that forest fragmentation contributed to the decline of red-cockaded woodpeckers (but see discussion in Hooper and Lennartz, in press, for a different opinion).

Natural landscape disturbances, such as hurricanes and wildfires, are superimposed on management disturbances, and the cumulative effects have not been evaluated. Natural recovery processes that might have functioned to maintain natural diversity in a continuously forested landscape (e.g., the movement of animals into nearby suitable habitat) may not function under current conditions.

Community/stand-Canopy composition ranges from pure longleaf to monospecific loblolly or slash pine stands, pine-hardwood mixtures, or mixed hardwood stands. Some relatively undisturbed herbaceous vegetation remains despite widespread replacement by layers of pinestraw or ruderal species. With a few exceptions, most of the possible combinations of overstory and herbaceous conditions can be found. Unlikely combinations include diverse herbaceous understories with dense natural pine or mixed pine-hardwood overstories and natural ground layers in plantations where fire was excluded to facilitate pine regeneration or intensive site preparation methods were used.

Forest management decisions affected notable changes in community composition and function. Frequent burning favored natural longleaf stand structure and composition. Fire exclusion or reduced frequency, selected to facilitate loblolly pine and slash pine regeneration, yielded reduced species diversity at the stand level (Wahlenberg and others 1939, Walker and Peet 1983, Peet and others 1983, Christensen 1988). Intensive soil disturbing treatments on previously undisturbed sites are associated with losses of understory species, including dominant grasses (Outcalt 1994). We have some evidence that fertilization to increase stand productivity may have adverse effects on ground layer diversity (Peet and others 1990). Though we can predict general effects of some management actions on ground layer vegetation, experimental design elements, such as establishing studies on already disturbed sites or sampling growth form rather than species abundances, leave unanswered questions about the establishment and persistence of herbaceous species.

Scientists have been studying longleaf pine biology, ecology, and management since the 1930's. Technology is available to regenerate longleaf stands naturally and artificially (Barnett and others 1990, Boyer and White 1990). Much of the information available for managing longleaf pine has been updated and summarized in a symposium proceedings edited by R.M. Farrar (1990). The challenges in silviculture seem to lie in developing regeneration technologies and management systems that also promote the conservation or restoration of associated plants and animals.

Summary of Information Needs

Ecological information needs for longleaf ecosystem restoration are summarized in table 1. The listed needs, phrased in terms of ecosystem composition and structure and ecosystem processes, are organized to show concerns at two spatial scales. The most significant information gaps involve historical and current landscape structure and function, and the processes that maintain the composition and structure of the herbaceous components.

Summary

We could base a restoration project on our current management and research interests and areas of expertise. However, such a conventional approach is likely, to yield a group of loosely related projects that may or may not lead to ecosystem restoration. Therefore, we recommend that a longleaf pine ecosystem restoration project be approached in the context of ecological principles, and we evaluate information availabilities and needs in that context.

In studying longleaf pine vegetation, much work has been dedicated to learning about regenerating the canopy. The challenges to longleaf pine management lie in developing techniques to establish and manage longleaf while enhancing the entire community. Even though we can predict general responses to management treatments at the community or stand level, we cannot describe plant population processes underlying the responses. Work that provides descriptions and understanding of historical and current landscape phenomena must continue. Understanding the landscape patterns will help us understand the limits of restoration activities, as well as build predictive response models. Finally, we have restricted our discussion to the ecological aspects of ecosystem restoration, but recognize that restoration efforts will succeed only if social and economic contexts are taken into account.

Table 1 Types of information needed to develop management treatments and experimental designs

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Historical/natural ecosystem structure and function

Regional/landscape

- Quantitative description of landscape structure and composition
- Understanding of regional variations in landscapes
- Fire regimes and fire behavior on various landscapes
- Implications of fire behavior on landscape structure
- Implications of fire behavior on other landscape functions such as animal use and hydrologic functions

Community/stand

- Quantitative and/or qualitative descriptions of herbaceous components; special attention must be given to areas where little original vegetation remains
- Age and spatial structure of the longleaf pine canopy; conditions and processes associated with even- versus uneven-aged structures
- Processes by which herbaceous plant populations were established and maintained
- Processes and conditions that influenced canopy and ground layer composition

Current conditions

Regional/landscape

- Quantitative descriptions of landscapes
- Assessment of quality and quantity of deviation from historical patterns
- Understanding of landscape flows and functions, e.g., fire behavior, animal use patterns
- Evaluation of landscape flows (functions) related to degree of deviation from historical conditions

Community/stand

- Assessment of quality and degree of deviation from historical patterns
- Understanding how communities in various conditions respond to management treatments (rates and kinds of responses)
- Understanding how communities in various conditions respond to the historical/natural fire regime; variations are associated with timing, frequency, intensity
- Understanding plant population processes that underlie the community responses; special attention must be given to dominant grasses that provide fine fuels, and to rare species about which little is known
- Develop techniques and silvicultural systems for longleaf pine that are compatible with restoring ground layer species diversity

Processes that led to observed current conditions

- Better understanding of the relationships between historical land uses and current conditions across the longleaf pine range
- Understand patterns associated with multiple treatments (cumulative effects through time)
- Evaluate the effects of cumulative small management actions compared to catastrophic discrete events such as hurricanes or wildfires

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Silvicultural Implications of the Biological Diversity Issue

James W. McMinn

Abstract

The biological diversity issue is about saving threatened and endangered species and avoiding threats to other species through sound ecosystem management. Silvicultural implications include (1) conserving representative forest types on a larger scale; (2) collection of data, rather than output-oriented interpretations, in the field; and (3) developing and applying what now seem like subtle techniques to effect substantial ecosystem influences.

Introduction

Natural resource professionals often request a definition of biological diversity on the assumption that the definition will clarify the issue and imply desirable actions. A Keystone Policy Dialogue (Keystone Center 1991) resulted in the following widely-accepted definition:

> "Biological Diversity is the variety of life and its processes ... it includes the variety of living organisms and the genetic differences among them and the communities and ecosystems in which they occur."

The problem with this and other definitions of biological diversity is that it confuses more than it clarifies the issue to be addressed. One might logically infer from the definition that it would be desirable to create variety of some sort on any given area: this is not necessarily so. The purpose of this paper is to clarify the issue and identify some silvicultural implications.

The Biological Diversity Issue

The biological diversity issue can be characterized as widespread educated concern over the rapid rate at which the earth's species are disappearing or coming close to extinction and the real possibility that entire ecosystems will be lost (McMinn 1991). The breadth and depth of that concern is illustrated by two recent publications. The first is a book entitled "Living Treasure: Saving Earth's Threatened Biodiversity" (Pringle 1991). It is oriented towards the fourth or fifth grade age groups and the information it contains is quite consistent with the much more detailed and technical "Incorporating Biodiversity Considerations Into Environmental Impact Analysis Under the National Environmental Policy Act" (Council on Environmental Quality 1993). Three important conclusions can be drawn from these two publications:

1. The biodiversity issue consists of global concern about the loss of species and ecosystems.

2. A key concept is that of viable populations. I define viable populations as populations that occur with a sufficient genetic base, over large enough areas, with the requisite environments to perpetuate the organisms.

3. Maintaining some degree of ecosystem structure and function is just as important as taxonomic composition, in fact, it is vital to the perpetuation of many organisms. The Endangered Species Act, is to a large degree, about maintaining habitat.

Hence, the biodiversity issue is about saving threatened and endangered species and avoiding threats to other species through sound ecosystem management.

Clarification and General Approach

Because of preconceived ideas by many natural resource professionals, as well as laypersons, there is often a need to explicitly recognize what biological diversity is not. It is not about maximizing the number of species in a given area. Neither is it about maximizing the variety of communities, age classes, or management regimes in a spatial pattern of land allocation. It does not imply the designation of preserves or natural areas unless such designation is necessary to perpetuate some species or communities (Soule and Kohm 1989).

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It is not politically or economically possible to establish biodiversity preserves for the perpetuation of most species. The primary challenge, then, is to learn how to conserve biodiversity in the presence of manipulation or management. We must continually ask the question, "What is happening to biodiversity as we manage forests-how can we adapt our management to prevent a loss in biodiversity?" This leads to a need for measures of performance and an associated tendency to try to adapt traditional ecological measures or indices of diversity, such as Shannon's or Simpson's index (Magurran 1988). Generally, the use of these indices would be inappropriate because the measures do not reflect ecosystem and genetic diversity, and they usually treat all species alike, whether native or introduced, common or rare. According to the Council on Environmental Quality (1993), "... managing for maximum diversity might actually impoverish natural biodiversity. For example, introducing small-scale habitat disturbances might increase local biodiversity by favoring the spread of opportunistic, "weedy" species. However, the same activity may decrease the available habitat for species at risk regionally, and regional or global biodiversity may be diminished."

Whatever measures are developed, geographic scale must be carefully considered and population viability must be reflected.

Consideration of some endangered species and the role of disturbance in different regions may further clarify the issue and suggest appropriate actions. If projects were undertaken to increase woody species diversity in the habitat of the red-cockaded woodpecker, Kirtland's warbler, or the northern spotted owl, those species would be threatened, thereby threatening biological diversity in the context of the issue (Norse and others 1986). In another example, we can almost always create high herbaceous plant diversity by disturbance in the Southeast: however, the herbaceous diversity would be comprised of early-successional plants that are common in that region because disturbance is common. Late-seral or old-growth conditions are uncommon in the Southeast and more desirable in the context of the biological diversity issue. Conversely, in parts of New England late-successional vegetation is more common and early-successional vegetation is becoming less common. Ensuring all successional stages of all representative forest types is necessary for conservation of biological diversity (Sharitz and others 1992). This suggests a need to examine silvicultural traditions in more detail.

Silvicultural Implications

Implications for the silviculturist are categorized here under three topic areas (1) perpetuation of forest types, (2) data collection versus interpretation, and (3) development and application of more sophisticated ecological knowledge. Each of these will be discussed briefly.

Perpetuation of Forest Types

Traditional forest management frequently alters the species composition and structure of an existing forest type to create a more valuable forest type (valuable in the sense of producing more of some desired output). The more valuable target type is referred to as the "management type." In the past, there were about a dozen management types and about 40 recognized forest types in the southern region. Each of the forest types was assigned almost automatically to one of the dozen or so management types. This meant that if management were successful over the long haul, the number of forest types would be reduced by about 70 percent. This reduction could have possible dire consequences for plant and animal species dependent on specific types, and thus, risk reducing biological diversity. The obvious solution is to maintain all representative forest types, but all types need not be maintained everywhere they exist. The decision on whether to maintain a stand in a given type should be based on the predominance of that type on the district, on the forest, or in the region. Consideration could even be in the context of the predominance and likely perpetuation of the type on all forest land, regardless of ownerships, in the region. If, for example, on public land no more loblolly pine (*Pinus taeda* L.) were planted and the existing loblolly were maintained into older age classes, there would still be an abundance of early-successional loblolly pine in the South. The decision context should change literally from a compartment to a region. Simultaneously, a future increase in average stand size can be expected in order to favor interior species, rather than the edge species that have been almost exclusively favored by recent past practices.

Data Collection Versus Interpretation

It has been common in the management of natural resources, for information collected in the field to be in the form of interpretations relative to desired outputs. As biological diversity and other ecosystem management issues become more important, fewer field interpretations (qualitative classifications, such as "sparse") can be expected and more actual data (size, species, numbers, basal area, etc.) will be collected. Raw data are necessary to develop interpretations for a wider array of uses and to respond as different issues emerge. Also, as budgets permit, data will be collected on more organisms and more size/density classes than in the past. The expense of data collection will almost certainly force greater cooperation and data sharing among disciplines and agencies.

Ecological Knowledge and Application

There will be a need to develop and apply more detailed ecological knowledge for vegetation management. Two general reasons for such applications are (1) restoration of missing, underrepresented, or declining forest communities, and (2) the creation of species composition and stand structure to favor specific plant and animal species. The knowledge and application will involve variables that are currently overlooked or which seem unnecessary to have under management control. This can be illustrated by research results on harvesting as a vegetation management tool in the oak-pine type. Table 1 presents the general species composition of stands in which four whole-tree harvesting treatments were imposed. The treatments consisted of harvesting to l-inch and 4-inch lower diameter limits in the dormant season and the early growing season (McMinn and Nutter 1988). None of the specific treatments would necessarily ever be recommended, but were chosen to examine the influence of harvest season and intensity on mixed species regeneration and site productivity. The stands were allowed to regenerate naturally with absolutely no additional treatments of any kind. Table 2 shows species composition of the initial stands (year 0) and of the same stands 10 years after harvesting for each of the four treatments. Note the drastic differences in 10th year species composition induced by the harvesting variables alone in stands that were initially very similar.

Table 1-Studywide mean basal area of initial stands by species group in the Upper Piedmont of Georgia

Species group	Basal area Ft^2/Ac	Basal area Pct.
Pines	24.64	27.79
Red oaks	29.56	33.33
White oaks	19.17	21.61
Other hard hardwoods	8.32	9.38
Miscellaneous	6.59	7.44
Shrubs	0.39	0.44
	88.67	99.99

Table 3 shows how the same harvest variables influenced general stand structure: note the predominance of pines versus hardwoods and the differences in the way the two species groups are distributed across diameter classes. A fairly comprehensive review of the ecological literature on forest disturbance revealed that in almost every past study of disturbance, there would have been no distinction among these four treatments-they would all have been considered in the same treatment category. This is a powerful example of how we may, in the future, be focusing on variables that heretofore have seemed too subtle to merit attention. It also suggests the need to examine contractual provisions and procedures to identify adaptations that give managers more control over ecologically important factors.

Conclusions

The biological diversity issue is a strong impetus for a more holistic multidisciplinary approach to land management. Several topics that are often treated as separate issues fall, at least conceptually, under the biological diversity umbrella. Old-growth, the spotted owl, and ecosystem management are all really part of the same issue when viewed in this context. It is recognized that there are specific statutory requirements and political pressures that often force piecemeal responses. However, a more comprehensive approach to management could avert many urgent issues. The truly adaptive

Table P-Percent basal area composition in initial stands and after 10 years for four harvest treatments

Harvest		Data	Species group				
Season	Limit	year	Pine	R. oak	W. oak	Other HH	Misc.
	- in -		- - - - - - - - - -	pct. basal area	- - - - - - - - -		
Dormant	1	0	31	31	21	9	7
		10	78	8	6	2	5
Dormant	4	0	24	33	23	9	9
		10	41	16	19	12	11
Growing	1	0	32	32	21	8	6
		10	14	31	31	10	10
Growing	4	0	23	37	21	11	7
		10	19	22	21	23	14

Table 3-Basal area after 10 years by species groups and diameter class for four harvest treatments

Harvest		Species	Diameter class midpoint (inches)					
Season	Limit	group	1	2	3	4	5	6
	- in -		- - - - - - - - - - -	ft^2/Ac	- - - - - - - - - -			
Dormant	1	Pine	16.38	29.53	16.81	6.01	1.48	0.00
		Hardwood	6.01	6.23	4.84	1.74	0.00	0.00
Dormant	4	Pine	3.44	7.27	4.44	2.96	1.35	2.44
		Hardwood	5.14	5.49	4.92	9.84	4.53	0.70
Growing	1	Pine	0.57	0.61	0.70	0.57	0.00	0.00
		Hardwood	6.66	9.54	2.48	0.00	0.00	0.00
Growing	4	Pine	0.30	0.44	0.74	1.57	0.57	2.53
		Hardwood	4.75	6.66	3.92	4.01	3.48	0.87

silviculturist is uniquely positioned to play a key role by expanding the disciplinary scope of silvicultural considerations and adopting a landscape or regional perspective.

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Costs, Benefits, and Tradeoffs of Ecosystem Management

Tree Quality in Hardwood Ecosystem Management—What are the Biological and Economic Tradeoffs?

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Abstract

Tree quality was rated 20 and 40 years after cutting at various intensities in a northern hardwood stand in Wisconsin. Average residual tree grade in 1991 (1.5) and tree grade improvement (1.1) were best in plots cut to a residual basal area of 17.3 m^2/ha. Trees grown after individual tree selection cutting were of significantly better quality than trees grown under no cutting and diameter-limit cutting regimes. Marginal economic analysis showed the heavy (14.3 m^2/ha) had the greatest total economic returns. Managers can choose either heavy or medium selection cutting to balance high residual stand quality and economic returns in northern hardwood ecosystem management.

Introduction

An important goal in managing hardwood ecosystems for timber is to maximize all components of tree quality. Although hardwoods can be managed either even- or uneven-aged (Godman and Erdmann 1981), research in the northern Lake States has shown that uneven-aged management of good sites can result in superior stand tree quality (Erdmann 1986).

Various hardwood management guides (Eyre and Zillgitt 1953, Arbogast 1957, Leak and others 1969, and Tubbs 1977) have been proposed, but most have been developed to maximize and sustain yield. Few cutting guides have addressed how to develop tree quality or how alternative management practices affect tree quality over time.

Researchers have developed tree and log grading systems (Hanks 1976) based on diameter, merchantable height, length of clearcuttings, and amount of cull. When managers select a cutting guide, they should carefully consider how their cutting decisions affect these tree quality attributes.

Improved information is needed on costs and returns of quality hardwood management because managing stands for tree quality can pay handsome dividends. For example, a recent lumber market newsletter (Lemsky 1993) reported white ash (*Fraxinus americana* L.) first and seconds (FAS) lumber prices of $755 per thousand board feet, yet only $265 per thousand for #2C lumber. The spread between top-grade and medium-to-low grade prices of other northern hardwood species was similar.

Forest managers are concerned about both the quantity and quality of outputs from forests; economics plays an important role in these resource allocations. The Oxford ***English Dictionary*** defines economics as: "the social science that relates to the production, distribution, and consumption of material wealth." However, the same dictionary also defines an economist as "one who manages a household; one who understands the art of housekeeping." In this age of ecosystem management, as we learn to get our ecological households in order, this definition would make all of us economists, even if we have not all formally studied economics. As land managers, therefore, we need to be concerned with the economic tradeoffs of our management activities, including the tradeoffs between quantity, quality, and value.

In this paper, we discuss the tradeoffs between tree quality and value after managing a hardwood ecosystem under different cutting methods for *40* years.

Methods

Study Area

The study was located on the Argonne Experimental Forest in northeastern Wisconsin. The second-growth, even-aged hardwood stands there are typical of those found throughout the northern Lake States. They developed from a series of harvests in the early 1900's which first removed white pine (*Pinus strobus* L.) and hemlock (*Tsuga canadensis* L.), and later removed most of the hardwoods (Stearns 1986). Regeneration established during this series of harvests developed quickly into fully stocked, even-aged, pole-sized stands about midcentury. Occasional poor quality, larger diameter trees left during the original logging were scattered among these stands.

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Sugar maple (*Acer saccharum* Marsh.) dominates the overstory (63 percent); and white ash, yellow birch (*Betula alleghaniensis* Britton), basswood (*Tilia americana* L.), hemlock, and red maple (*Acer rubrum* L.) make up about 4 to 9 percent each. The sugar maple site index at 50 years was 19.5 to 21.0 m, indicative of a good hardwood site.

Study Design

This study was established in 1951 in a randomized block design to assess the effects of six different cutting methods on tree and stand development (table 1). One-hectare treatment plots were installed in each of three blocks. Three levels of selection cutting, a 20-cm stump diameter-limit cut, and a crop tree release were compared to a control. Throughout this paper, we will refer to the three levels of selection cutting as heavy, medium, and light with residual basal areas of trees >11.4 cm diameter breast height (d.b.h.) of 13.8, 17.3, and 20.7 m^2/ha, respectively.

Data

Tree quality-The stand in 1951 primarily consisted of pole-sized trees (11.6 to 24.2 cm d.b.h.) with some larger diameter residual trees left from the earlier

Table l-Description of treatments before and after the first cut in 1951 and in 1991

		Stocking (m^2/ha)[a]		
Treatment	Description	1951 before cut	1951 after cut	1991
Control	Uncut through entire period	21.6	21.6	33.8
Crop tree	Crown-released 30 to 50 crop trees per acre, residual basal area was between 13.8 and 17.3 m^2/ha; Cut 1951, 1971, and 1981	20.0	14.5	20.0
Diameter limit	Cut all trees with stump diameters of 20-cm and larger; Cut 1951 and 1991	19.3	5.3	28.5
Light selection	Cut to residual basal area of 20.7 m^2/ha; Cut 1951, 1961, 1971, and 1991	23.9	20.2	24.4
Medium selection	Cut to residual basal area of 17.3 m^2/ha; Cut 1951, 1961, 1971, and 1991	22.5	17.7	20.0
Heavy selection	Cut to residual basal area of 13.8 m^2/ha; Cut 1951, 1961, 1971, and 1991	19.6	14.3	16.8

[a]Stocking reflects average of all plots or three replicates for each treatment.

logging. Because grade changes are unlikely in these poor quality residual trees, we followed tree grade improvement of only those trees that had grown from pole size in 1951 to saw log size by 1991. The analysis does not include trees cut during the period.

D.b.h. was measured at 5-year intervals, beginning in 1951, from five 0.04-ha sample plots within each treatment plot. Saw log trees (trees larger than 24.4 cm d.b.h.) were graded in 1971, 1981, and 1991 according to Hanks' tree grading system (Hanks 1976). Cull was estimated with the technique suggested by Hanks (1976) only in 1991. Merchantable saw log heights (number of 4.9 m logs) were measured to a diameter inside bark of 19.3 on the small end or to a merchantable log stopper.

Lumber prices-Reported Wisconsin hardwood lumber prices (table 2) were used for economic analysis of cutting method treatment values. These are the nominal prices paid for five grades of green, 4/4 hardwood lumber-FAS, selects, #1 common, #2 common, and #3 common-priced at the mill.[1] The hardwood market report, Northern Market (Lemsky 1971, 1981, 1991), was the major source of data used. Supplemental data were obtained from the Wisconsin Forest Products Price Review, Lumber edition (Peterson 1981, 1991).

[1] Grades 2A and 2B were combined into a single 2C grade for red maple; FAS, FAS-IF, and selects grades for all species were combined into a selects and better grade to faciltate analysis.

Table 2-Nominal lumber prices by grade used to evaluate lumber yields (U.S. dollars/mbf, 4/4 lumber, F.O.B.). Source: Lemsky's Hardwood Market Report (1971, 1981, 1991)

Species	Lumber grade				
	FAS	#1C	#2C	#3A	#3B
			November 1971		
Sugar maple	270	180	90	70	65
White ash[a]	250	175	78	--	65
Basswood	260	157	80	--	59
Yellow birch	345	175	100	83	65
Red maple	240	180	a5	--	65
			November 1981		
Sugar maple	450	335	210	190	140
White ash	540	350	182	152	127
Basswood	462	295	136	145	100
Yellow birch	585	325	210	192	137
Red maple	370	207	160	140	127
			November 1991		
Sugar maple	620	415	305	285	165
White ash	755	515	215	170	140
Basswood	650	295	170	110	100
Yellow birch	625	325	220	190	150
Red maple	485	335	200	160	150

[a] Prices for ash in 1971 were quoted for brown ash, the trade name for black ash. In most markets, white and black ash lumber were mixed with the same price.

Costs-Only variable costs (table 3) for the 20-year period were used in the analysis. Since fixed costs of the operation do not affect relative choice, they were excluded in this comparative analysis (Davis 1966). Marginal costs included sale layout, timber cruise and marking, and timber stand improvement. These data came from two Lake States forest management cost surveys (Winebar and Gunter 1984, Vasievich and Potter-Witter[2]). Only costs common to northern hardwoods management on similar Lake States hardwood sites were used.

Lumber volumes-Gevorkiantz and Olsen's (1955) volume equations were used to calculate individual tree gross cubic meter yields, according to the formula:

Volume (Scribner) = ANTILOG 10 -.727 - 4.21(1/d.b.h.) + 1.76(log10 d.b.h.) - .306(1/merch. length) + .723(log10 merch. length).

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[2] Vasievich, J.M.; Potter-Witter, K. Costs of timber management practices in the Lake States, 1987-1988. Unpublished draft manuscript (dated 8/16/90) of a cooperative study. East Lansing, MI: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station and Michigan State University, Department of Forestry. 16-19.

Net cubic meter yields were determined by multiplying gross cubic meter yield derived from the above equation by the percent cull for each tree. Factory grade lumber yields for 1971 (before treatment) and 1991 (after treatment) were derived following methods developed by Hanks (1976).

Economics-The lumber value due to tree quality changes has two components: value from harvested trees, and the value of residual trees. Because cutting treatments change both harvested and residual tree quality over time, both measures of value were included. Economic values of treatment yields were calculated before the 1971 cut and after the 1991 cut to determine the effect of quality treatment on lumber value yield.

We conducted a marginal cash flow analysis using Quick-Silver v. 2.0 (Vasievich and others 1984), to compare each treatment's performance with the control. Cash flows from harvests and residual lumber values were combined and then discounted at a real discount rate of 4 percent (Row and others 1981) to obtain total economic values for lumber yields. Marginal costs for each treatment were also applied to obtain net present value (NPV) rankings. All economic returns are reported in real (net of inflation) 1990 dollars.

Table S-Marginal costs (U.S. dollars/ha) used in the analysis, by type of operation

Operation	Wisconsin[a]	Michigan[a]	Marginal costs Lake States[b]
Timber stand improvement	37	54	91
Sale layout	207	40	22
Cruise/mark partial cut	40	57	--
Cruise/mark improvement cut	40	42	39

[a] Vasievich and Potter-Witter (unpublished).
[b] Winebar and Gunter (1984).

Results and Discussion

Tree Quality

Diameter growth-We measured tree diameter growth from 1951 to 1991 on only those trees present before cutting in 1991. Initial average tree diameters of these trees were significantly different by treatment and ranged from 21.6 cm in the light selection cut down to 15.0 cm in the 20-cm diameter-limit cut (table 4). Generally, the heavier cutting resulted in smaller initial average size of these trees because the heavier cutting treatments concentrated on removing the large, poor quality residual trees.

Tree diameter in the selection treatments averaged more than 2 cm greater than tree diameter in the other treatments in 1991 (table 4). Since our initial diameters were different depending on cutting intensity during the period, we had to compare average diameter growth during the period as well.

Diameter growth increased with cutting intensity. Diameter growth was greatest in the heavy selection and diameter-limit cut (18.3 and 18.3 cm, or 0.46 cm/year, respectively) (table 4). Growth in the medium selection treatment averaged about 1 cm less, but was not significantly different from the other selection treatments. Growth during the period averaged 13.2 cm or 0.33 cm/year in the control plots, significantly less than growth in any of the managed plots.

Diameter growth of saw log-sized trees is a key component of tree quality. After tree grade improvement, diameter growth is the next most important factor in increasing tree value (Godman and Mendel 1978). For example, a tree needs to be 39.6 cm in diameter before it is considered grade 1. Thus, one of the major goals of managing for high quality timber is to maximize diameter growth while preserving other components of tree quality.

Table 4-Average diameter at 1.37 m in 1951 and 1991, growth and average annual growth over 40 years for six treatments

Treatment	Diameter (cm) 1951	1991	Diameter growth (cm) 1951-1991	Average annual
Heavy selection	18.8	37.3	18.3	0.46
Diameter-limit	15.0	33.3	18.3	0.46
Medium selection	19.6	36.8	17.3	0.43
Crop tree release	17.5	34.0	16.5	0.41
Light selection	21.6	37.6	16.0	0.41
Control	21.1	34.3	13.2	0.33

Cull-Trees in the selection treatments had significantly less cull than did trees in the diameter-limit cut and control (table 5). Cull amounted to only 3 percent of the sawtimber trees in the heavy selection cut and was 6 and 9 percent in the medium and light selection cuts, respectively. Cull in trees in the crop tree release (7 percent) was not significantly different than in the selection treatments.

Cull in trees influences tree grade. Trees with more than 9 percent cull can never make grade 1, whatever the diameter (Hanks 1976). Trees with more than 40 percent cull will fail to make a grade 2, and trees with more than 50 percent cull are considered below grade. Through management, most of the high cull trees are removed early, improving growth on quality trees (Erdmann 1986). In our study, as would be expected, the heavier the cut the less the cull, except in the diameter-limit cut. In that treatment, all trees 20 cm and larger were cut in 1951 with no further cutting after. Trees left to grow were generally suppressed, high cull trees.

Merchantable **saw** log height-Merchantable saw log heights before cutting in 1971 and after cutting in 1991 were significantly higher in the selection treatments than in the other treatments (table 5). This trend is also true for the increase in merchantable heights from 1971 to 1991, but these differences were not significant. The 20-cm diameter-limit cut had the shortest merchantable heights in both 1971 and 1991.

Merchantable heights among the selection treatments were not affected by level of thinning. Previous studies also have found that merchantable heights have not been decreased at these levels of thinning (Roberge 1975, Sonderman and Rast 1987). Levels of thinning below those used in this study did reduce merchantable heights in hardwood stands growing in Ohio (Sonderman 1984, Dale and Sonderman 1984).

Merchantable heights can be limited by epicormic branches if the branches grow large enough. Godman and Books (1971) reported greater epicormic branching with increased thinning intensity 25 years ago in this study. Epicormic branches that developed after cutting in the selection treatments either died after crowns closed or have not developed into large branches that limit merchantable heights. Height to the first branch is lower in the heavy selection treatment than in the other selection treatments, indicating some epicormic branches have persisted (data not shown). These branches on the leave trees are not currently reducing merchantable heights, but continued periodic cutting in the heavy selection treatment may induce these branches to grow in diameter and reduce future merchantable heights.

Tree **grade**—Tree grade depends on the combination of tree diameter, length of clearcuttings, and the amount of cull (Hanks 1976). Live limbs and limb-related defects are the primary source of degrade in hardwood stems (Godman and Books 1971). Stand quality is improved either by

Table 5-Average cull (percent) in 1991 and merchantable height (number of 4.9 m logs) and tree grade in 1971 and 1991 and their increase during the period

Treatment	Cull 1991	Merchantable height 1971	Merchantable height 1991	Merchantable height Increase	Tree grade[a] 1971	Tree grade[a] 1991	Tree grade[a] Increase
Medium selection	6	1.7	2.0	0.3	2.6	1.5	1.1
Crop tree release	7	1.4	1.7	0.3	2.8	1.9	0.9
Light selection	9	1.6	2.0	0.4	2.6	1.8	0.8
Heavy selection	3	1.6	2.0	0.4	2.6	1.8	0.8
Control	19	1.5	1.7	0.2	2.8	2.1	0.7
Diameter-limit	21	1.4	1.6	0.2	3.0	2.3	0.7

[a]Smaller numbers indicate better quality.

eliminating these defects through branch mortality, by stimulating growth over the defects, or by removing poorer quality trees (Jacobs 1966). In our study, tree grade improvement through the 40-year period was best in the medium selection cut. Average tree grade for this treatment was 2.6 in 1971 and 1.5 in 1991, an average grade improvement of 1.1 for the period (table 5). Average tree grades in the selection treatments were better than average tree grades of the diameter-limit cut and control in 1991. Tree grades were poorest in the diameter-limit cut.

The medium selection treatment had the greatest proportion of trees in the better grades (32 percent in grade 1 trees and 34 percent in grade 2 trees) (table 6). The light selection treatment had the same proportion of grade 1 trees but fewer grade 2 trees. The heavy selection treatment had fewer grade 1 trees, but more grade 2 trees. Because the control trees grew slower and the diameter-limit cut had smaller, more defective trees, these treatments had fewer grade 1 and grade 2 trees. Fifty percent of the trees in the diameter-limit cut were grade 3, more than in any other treatment. The selection treatments and crop tree release treatment had significantly fewer trees below grade. About a third of the saw log-sized trees were below grade in the control and diameter-limit cut. Only 2 percent of the saw log-sized trees in the heavy selection treatment were below grade.

Economics

Harvested lumber volumes and values (1971-91)—The **diameter-limit treatment had the greatest net harvested** volume for the study period, 51.9 m (net) per hectare (table 7). Its undiscounted

Table 6—Proportion of trees by grade (percent) in 1991 after cutting (before cutting in the diameter-limit cut)

Treatment	Tree grade Grade 1	Grade 2	Grade 3	Below grade
Medium selection	32	34	24	10
Light selection	32	25	31	12
Heavy selection	19	43	36	2
Crop tree release	17	34	39	10
Control	12	25	26	37
Diameter-limit	5	14	50	31

Table 7-Net harvested lumber volumes (m^3/ha) and values by treatment, 1971-1991 (1990 U.S. dollars/ha)

Treatment	Net harvested volume	Net harvested lumber values Undiscounted	Discounted at 4 pct
Diameter-limit	51.9	4,355	1,988
Heavy selection	37.5	3,470	2,354
Medium selection	25.4	2,665	1,823
Light selection	25.3	2,305	1,440
Crop tree release	22.3	2,267	2,043

lumber value averaged $4,355/ha. The heavy selection treatment was second with 37.5 m harvested per hectare and a value of $3,470/ha. Ranking third was the medium selection with 25.4 m/ha and $2,665/ha. Fourth ranking went to the light selection (25.3 m/ha) with $2,305/ha. Finally, the crop tree treatment had the lowest net harvested volumes, 22.3 m/ha, and an undiscounted lumber value of $2,267/ha.

Residual values-Residual lumber value (real 1990 dollars) was greatest in 1991 in the light selection treatment ($7,837/ha) (table 8). The control treatment ranked next ($7,161/ha), followed closely by the medium selection ($6,597/ha), and the crop tree release ($5,753/ha). The heavy selection was last of the four uneven-aged treatments in residual lumber value ($5,390/ha). The diameter-limit ($0/ha) had no residual lumber value; all saw logs were harvested in 1991.

Table 8-Average residual values of lumber yields by treatment, 1991 (1990 U.S. dollars/ha)

Treatment	Average residual value
Light selection	7,837
Control	7,161
Medium selection	6,597
Crop tree release	5,753
Heavy selection	5,390
Diameter-limit	0

Marginal benefit/cost analysis of treatment lumber values-Informed decision-making in hardwood management requires marginal analysis of treatment costs and benefits, with appropriate discounting. In our study, marginal analysis (1971-91) of the four uneven-aged treatments found that the heavy selection treatment had the highest NPV ($1,339/ha) (table 9). The medium selection treatment ($1,205/ha) came next, and the light selection was third ($1,094/ha). Net present value was lowest for the diameter-limit cut (-$610/ha). Lumber value in the diameter-limit treatment was far below the value of lumber in the control treatment.

Table 9—Comparison of net present value of the difference between the control and cutting treatments for total lumber value yield (1990 U.S. dollars/ha, 4 percent discount rate)

Treatment	Net present value difference
Heavy selection	1,339
Medium selection	1,205
Light selection	1,094
Diameter-limit	- 610[a]

[a]Marginal revenues for the diameter-limit treatment were negative because residual (total) lumber value of the control treatment exceeded the diameter-limit treatment.

Forest managers must be careful to balance both harvested and residual lumber values when they manage for high-quality saw logs. Harvested value is important because it pays for ongoing management activities while providing current income. Residual value must be considered because one of the key objectives is to build sufficient high-quality growing stock levels to provide sustained future harvests of the highest value. Both measures are incorporated in the total value criterion. The discussion of our results focuses on the tradeoffs between these value objectives.

In our study, marginal revenues of both the heavy and medium selection treatments clearly out perforrn the others. The heavy selection treatment had the highest total value of marginal revenues (table 9), the highest discounted lumber value of harvests (table 7), and the lowest percentage of poor quality trees in 1991 (2 percent). The medium selection treatment was second in NPV of marginal revenues and had the greatest improvements in tree grade, merchantable height, and number of residual grade 1 and 2 trees. Although it also had a high total lumber value, the value of the light selection treatment was heavily weighted by its residual value, and harvests were often too light to be economically feasible. The crop tree treatment had a high total lumber value, but more than 70 percent of its harvested value came in the first cut, giving it excessive weight under discounting assumptions.

The diameter-limit treatment had the highest harvest volumes and cash flow, but was only third in present value of lumber (table 7). Net present value of marginal revenues (-$610/ha) was lowest for the diameter-limit treatment (table 9), which had by far the highest (81 percent) number of grade 3 and below-grade trees before harvest in 1991.

The light selection treatment had the highest percentage (71 percent) of total lumber value in the residual stand (other than the control). The medium selection had 62 percent of total lumber value in its residual, the crop tree release had 57 percent, and the heavy selection had only 51 percent. The diameter-limit cut had none of its total lumber value in its residual stand because all saw log-sized material had been harvested in 1991.

We found large differences in economic performance between the medium to heavy selection treatments and the diameter-limit treatment because the analysis explicitly includes low-value, below-grade sawtimber, while previous work (Niese and Strong 1992) has not. Also, this analysis only includes lumber value returns of saw logs and does not include pulpwood, the primary product of the most heavily cut treatments. These results also do not include potential returns to veneer production, although veneer trees may make up 50 to 75 percent of residual large saw log trees in the carefully-managed selection treatments.

These results are based on lumber value of harvested and residual saw logs. Costs of production-cutting, trucking, and sawing-are included in these lumber values. Therefore, differences among treatments may be magnified by these conversion costs. How might these lumber values be translated back into stumpage values?

We know that lumber grade premiums of upper quality lumber can make these grades two to five times as valuable per unit as grades 2 and below. We also know from limited market data that delivered prime and #1 quality hardwood logs often command more than twice the price of #2 and #3 logs (Hoover[3]). Also, we know that high-quality northern hardwoods can appreciate in grade value growth at rates of 6 to 8 percent per year, on the stump (Davies 1991, Godman and Mendel 1978). Assuming a 1991 conversion cost of $32 m^{3r}, owners and managers can reasonably expect upper quality logs to have premiums two to three times higher on average than lower quality logs of the same species.

Stumpage markets, however, because of widely acknowledged imperfections, may not always recognize or pay these premiums for high-grade saw logs. With imperfect information, fewer stands will be managed for high-quality products because the market does not always appear to reward those who do. Therefore, the key to high-quality hardwood management is for managers to identify, market, and capture these premiums for high-quality saw logs.

These results also underscore the importance of *one's* management perspective and underlying assumptions. A long-term view makes it possible to realize these higher returns to quality improvement. A shorter term view will favor pulpwood production. This analysis of tree quality returns does show that with current high prices in hardwood lumber markets, long-term management for tree quality can yield excellent returns.

Summary

In this study, intermediate selection cutting (residual basal area of 17.3 m^2/ha in trees >11.4 cm d.b.h.) provides adequate diameter growth, minimizes stem defects, and at the same time removes most cull trees. Tree grade improved the most over 20 years in this treatment. This treatment best approaches the uneven-age guides that were prepared by Eyre and Zillgitt (1953) and Arbogast (1957) and were confirmed by Crow and others in 1981. We suggest using Erdmann's (1986) guide for the first entry to bring an even-aged hardwood stand under uneven-age management. Further cutting should be according to the Arbogast guide.

The heavy selection treatment had the highest economic returns in this study, yet its silvicultural quality-in terms of tree grade, merchantable heights, and lumber quality-improved nearly as much as the more lightly cut selection treatments. Although the medium selection treatment also had high total economic returns, a greater proportion of its value was in the residual stand. Diameter-limit cutting resulted in low net revenues and by far the lowest lumber and stand quality.

[3] Hoover, W.L. Unpublished data on delivered log prices according to grade.

For managers who want the highest economic return while enhancing overall tree quality, we suggest the heavy selection treatment, which gave the best results in this analysis. However, more conservative managers who desire the greatest improvements in silvicultural quality, but also high total value, may find that the medium selection treatment meets their objectives. We cannot recommend the light selection treatment, because harvest revenues and volumes are too low to be operable even though it has high residual quality. Finally, the diameter-limit treatment cannot be recommended where management for high-quality saw logs is an objective.

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Operational Factors Affecting the Implementation of Ecosystem Management Objectives

Joseph F. McNeel and Ron L. Copstead

Abstract

The shift to ecosystem management on our national forests will emphasize partial harvests and thinnings during forest operations. This change in harvest based management will require modifications to the techniques and equipment used during the harvesting process. Ecosystem management implementation will reduce harvest production rates and increase the cost of harvesting. Access will be much more extensive for sites placed under ecosystem management than required when using even-aged management. Harvesting equipment may require some redesign to better handle the smaller stem sizes and partial harvest limits associated with ecosystem management. More emphasis must be placed on education of foresters, logging contractors, and the public regarding the changes associated with ecosystem management implementation. Finally, research is needed to evaluate concerns such as the effect of multiple entries on stand productivity.

Introduction

Forested areas have traditionally been viewed as production sites where primary wood products such as saw logs, pulpwood, and chips were manufactured in an economical fashion. Operating systems to produce this material were continually modified to emphasize higher rates of production at lower costs. Some emphasis was placed on the development of systems which reduced site and stand impacts, but the primary goal of forest operations was to produce forest products at minimum cost.

As the practice of ecosystem management is refined on public lands, this philosophy has changed. Ecosystem management uses an ecological approach to achieve multiple-use management of forested lands to produce diverse, healthy, productive, and sustainable ecosystems (Robertson 1992). This change in the focus of forest management on public lands has profound effects on forest operations. Less emphasis is placed on the production of "crop" trees for future wood products, while greater emphasis is placed on maintaining biodiversity in managed ecosystems and enhancing diversity in plant, animal, and biological communities within the forest.

This paper examines the effect of ecosystem management on operational planning and implementation. Specific objectives of this paper include the following:

1. Discuss how ecosystem management has affected stand level management tools and techniques on national forests;

2. Evaluate how efforts to attain ecosystem management objectives affect forest operations planning and operational activities; and

3. Define the general needs of the forest operations community to adequately meet the challenges of ecosystem management in terms of planning, education, and research.

Ecosystem management affects nearly every aspect of the operational phases associated with planned ecosystem management entries. If a system of management is developed which will work under the constraints of ecosystem management, efforts must be made to modify silvicultural tools, operational planning, and operational implementation activities. Techniques used in the past may not suffice, but can be modified to work under ecosystem management constraints.

Stand Management

Management on our national forests has traditionally focused on the production of wood for public consumption. In contrast to this fairly straightforward objective, ecosystem management objectives are more intricate, require a greater amount of cooperation among professional disciplines and society at large, and focus on the whole range of resources and values over the landscape.

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Management Options

As defined by Hunter (1990), an ecosystem is all of the interacting populations of plants, animals, and microorganisms occupying an area, plus their physical environment. Management for these various populations requires a shift in focus from a purely timber-baaed philosophy to one which considers other factors that can help to improve the physical environment and maintain the diversity of the forest.

The ability to enhance the physical environment for all species within a forest community is impossible in diverse forest environments (Hunter 1990). Alternatives to an all-encompassing management style include the coarse filter-fine filter, and guild approaches (Noss 1987; Severinghaus 1981).

The coarse filter approach requires the maintenance of a representative group of forest ecosystems which should sustain the majority of species within a region. In conjunction with this approach, fine filter management focuses on individual species which are known to be endangered and require special environmental conditions to survive. By using indicator species and keystone species to evaluate forest conditions and management efforts, managers can adjust from a coarse to a fine filter approach as needed.

The guild approach suggests that a guild or species group requires very similar environmental conditions to exist within a forest ecosystem. By selecting a representative guild member, one representative species, and developing management objectives to enhance the physical environment for that species, the other guild members would be inherently considered in the management plan due to the similarities between them and the representative guild species.

Management in recent years has focused on fine filter management, where the physical environment is managed for one species after another on an individual basis. Examples of efforts in fine filter management in the Pacific Northwest include the northern spotted owl and the marbled murrelet; while in the South, work has focused on the red-cockaded woodpecker. These efforts provide only part of the parameters needed by forest managers and operations specialists to initiate an ecosystem management focus on large forested areas.

Single species management has not provided a consistent platform for dedicated operations efforts or management strategies. Efforts need to be initiated to develop coarse filter management-or a similar type of diversity management-in as many forest areas as possible. With a broad-based management program that focuses on the enhancement of multiple species, we gain the experience needed to properly manage for diversity. These efforts, over time, may also reduce the number of endangered species requiring fine filter management in our forests.

Implementing any of these large-scale management techniques at the stand level requires an understanding of what level of diversity is needed within an area, the extent to which each stand plays a role in maintaining that diversity, and how to manipulate stand components, specifically the forested component, to attain desired future conditions within the area.

The tools available to foresters for manipulation at the stand level include the final harvest, stand tending (pre-commercial thinning, pruning, fertilization, etc.), and the thinning harvest. As they are applied at the stand level to achieve ecosystem management objectives, these techniques are being modified to reflect what we learn about the mosaic relationships within the forest ecosystem.

Final Harvest

Final harvest options include the clearcut, shelterwood harvest, seed tree harvest, and selection harvest. Under ecosystem management objectives, these options will probably be used sparingly, since a major ecosystem management goal is to develop and maintain late-successional stage forests. Some sites will, however, be modified dramatically to produce openings for wildlife and to develop greater age and stand structure diversity within the larger forested area.

Clearcutting has been considered one of the least desirable options for implementation of ecosystem management, primarily because this technique does not allow for stand diversity (Robertson 1992). Traditionally, management has used large clearcut areas to develop monotonic stand, age, and species compositions.

Under ecosystem management guidelines, clearcutting specifications will probably be modified so that only a small area, often just a few acres, of a stand is clearcut. This technique, often called patch clearcutting, is useful, however, since clearcutting opens the site for more shade intolerant species to regenerate. Without these openings, the species distribution in managed stands would greatly favor shade tolerant trees and exclude those species requiring full light to establish and grow. The reduction in clearcut area will also improve the visual effect of clearcutting which is often described as a scene of complete destruction.

Shelterwood harvests are now being used in the Pacific Northwest as the preferred approach to the final harvest under ecosystem management guidelines. Traditional shelterwood harvests typically left "seed trees" on site for 3 to 5 years to insure that the stand would be regenerated from this seed source. Ecosystem management guidelines suggest leaving these "seed trees" to provide greater structural diversity in the newly established stand. Grouping of seed trees on the site to produce small islands of habitat is also becoming a popular option. Higher densities of leave trees are being considered as part of ecosystem management, since higher residual levels improve stand diversity and reduce the visual effect of the harvest.

The seed tree harvest option has few advantages over shelterwood harvesting, other than economics. A stand harvested using this technique is more prone to windthrow and may require more time to develop a viable understory of seedlings. The visual impact of a seed tree harvest is almost as severe as that obtained with a clearcut, particularly if the residual trees are left in a dispersed pattern. If this option is used, the "seed trees" would be left on site to provide structural diversity within the newly regenerated stand.

A last option is the selection harvest technique which is used to develop an uneven-aged stand. This would be achieved through selection harvest operations where specific percentages of each major diameter class in the stand would be removed at set intervals of time. Most naturally regenerated stands, over time, will evolve to uneven-aged conditions. The most adaptable type of selection method is the group selection harvest where small groups of stems are removed in a manner similar to clearcutting. The sizes of these openings range between one-quarter to one acre, depending on the size of the trees, the species, and the silvicultural goals. The group selection method of regeneration may be the most effective option available for implementing ecosystem management.

Thinning

Thinning provides an excellent way to meet ecosystem management objectives of developing structural diversity within the stand. As indicated by Hunter (1990), vertical diversity within the stand can be enhanced through careful thinning of the dominant and codominant trees, an approach called crown thinning under conventional silviculture. Wildlife diversity may be enhanced through the creation of small openings in the stand where browse can grow. Finally, thinning increases the growth of selected trees in the stand and promotes late-successional conditions much earlier than typically occurs in nature.

Crown thinning removes certain dominant and codominant stems from the stand to provide openings and promote growth. Understory browse species are enhanced using this approach, since large openings are made when a percentage of the dominant trees is removed. Crown thinning operations are extremely risk-prone if left unmonitored. Past experience with partial cuts of this type on private forests in the eastern United States produced large areas of high graded stands with poor quality genetic stock for reproduction. One study of this type of partial removal by Bennett (1993) in British Columbia suggests that this type of thinning is better from an operational perspective, since the value of the removed timber is much higher than logs obtained from "low" thinnings.

"Low" thinning or thinning from below is a silvicultural prescription commonly used with even-aged stands managed for timber production. This approach is less favorable for ecosystem management, since the stand is not opened as effectively as with a crown thinning. Thinning from below creates only small openings with little potential for the regeneration of shade tolerant seedlings in the openings. Wildlife browse is released through low thinning, although not to the extent provided through crown thinning.

In most cases, row or strip thinning techniques must be incorporated with other types of thinning approaches to allow harvesting system access. This technique does not allow selection of superior genetic stock or preferred species, and simply harvests rows of trees to allow selection of trees to either side of the row. More important, the area taken up by these rows, or thinning trails, will easily encompass as much as 15 percent of the stand (McNeel and Ballard 1992).

Future thinning treatments will probably include some combination of these three techniques. Low thinning is desirable since there is less risk to the residual stand through high grading. Crown thinning may be used in parts of the stand to promote more stand diversity and create larger openings for wildlife. Row or strip thinning is necessary to reach other parts of the stand. Operational testing will be necessary in coming years to determine the appropriate mix of thinning prescriptions that will produce desired future stand conditions.

Stand Tending Operations

Operations such as site preparation, planting, pruning, and pre-commercial thinning are important tools that will prove useful under ecosystem management. Each will play a role in defining individual stand structure and composition. Each may be slightly redefined to suit the objectives associated with ecosystem management.

Site preparation efforts will probably be minimalistic and practiced in small areas to modify site conditions to suit a specific species. Planting will also be modified to allow for more species to be planted on a given site and to allow for more spot planting in areas where species modification is desirable.

Since some effort will be made to rely on natural regeneration, pre-commercial thinning will be required on many sites to control stand population and species composition. The techniques currently in use will probably be suitable for use under ecosystem management constraints, although more specific prescriptions will be required to promote greater species diversity.

Pruning may play a significant role under ecosystem management objectives. Pruning can produce aerial pathways for predatory birds such as the northern spotted owl.[1] While these conditions would occur naturally, pruning can speed up the process and pathways can be specially created as needed within specific stands where prey populations are large. Pruning can also be used to enhance vertical diversity in the stand through specific pruning strategies. Pruning strategies currently focus on quality enhancement within the stand and do not consider other ecological factors, although these factors could easily be considered in future pruning operations.

Dead and Downed Trees

Ecosystem management objectives typically encourage development of a large component of dead and downed trees in the stand. Felling to waste has not been common in the past, particularly in commercial thinning operations, but the process is simple. The greatest problem from an operational perspective is identification of the appropriate types of trees to leave on the ground and how many of these trees must be left. Specific treatment options should be developed and used during operational planning efforts. In addition, the effect of these operations on productivity and costs should be quantified to guide planning efforts.

Snag Management

Snags are also a desirable component of the stand under ecosystem management. This poses a problem for forest operations, since snags are considered hazards and have traditionally been removed through felling to create a safe working environment for woods crews. Creation of snags is possible, particularly when using fully mechanized

[1] Personal communication. 1993. S. Reutebuch, USDA Forest Service, Pacific Northwest Research Laboratory, Seattle, WA.

systems during the harvest. Silvicultural prescriptions must be developed to assist forest operations specialists in planning these operations and determining the cost of such work.

Riparian Management

Amelioration of riparian zones may also be a critical concern under future ecosystem management objectives. Forest operations planning in these areas would require substantial input from silviculturalists and other scientists to develop appropriate operations that will achieve the desired results. Research efforts into determining the most appropriate silvicultural techniques for managing these sites are relatively new, although a number of studies focusing on silvicultural and operational questions are underway.

Operational Factors

Managed stands of timber have often been subjected to intensive silviculture to control species diversity, stand structure, and stand growth. The resulting stand conditions have led some scientists to suggest that intensive silviculture leads to reduced species richness and uniform stand structures (Grime 1979; Gamlin 1988).

An opposing viewpoint suggests that using intensive silviculture in a careful manner will allow foresters to develop stands with late-successional characteristics more rapidly than if the stands were allowed to evolve naturally. At least one proposal has suggested that stands be placed on long rotations of 200 years, using spacing, pruning, and multiple thinnings-up to eight-to create late-successional stand conditions (Kuehne 1993).

While multiple entries into a stand can produce highly desirable effects, foresters must also consider the potential site and stand degradation that might occur from these entries. Such impacts include soil disturbance, soil compaction, rutting, tree damage, erosion, and stream degradation. Few tools currently exist that can be used to predict, even in a general fashion, what effect specific operations have on the site and stand. Foresters must learn to balance the need to create desirable stand conditions with the potential loss in stand quality and site productivity if forest operations adversely affect the site.

Harvest Layout

The most important aspect of the harvest layout is communication. Because management objectives will involve more multidisciplinary efforts, the forest manager and the logging contractor must maintain communication with a number of disciplines to insure that planned harvest operations meet management goals.

As a result, more time will be spent planning entries and evaluating potential harvest options. Time will also be spent translating these plans in the field. Foresters will spend more time marking trees for removal and retention, flagging designated skid trails and yarding corridors, identifying road and landing locations, and coordinating these plans with the logging contractor.

Two aspects of planning which have not been considered in the pas-skid trail designation and marking of the residual stand-will be much more important as harvest operations shift to partial removals. Proper designation of primary skid trails will help to reduce the amount of nonproductive area produced during the partial harvest. Trail systems must be developed with care and forethought, since they will be used in all subsequent harvest entries. The need to reach all parts of the site will be countered by the need to minimize trail area. In two recent studies, trail concentrations measured after partial harvests averaged about 20 percent of the harvested site (Bennett 1993; McNeel and Ballard 1992).

Residual tree marking is an expensive aspect of partial removals. Marking residuals can also affect harvesting productivity, since the logger must operate under constraints made prior to harvest. Trees should be marked with some emphasis on maintaining operability within the stand. By considering the operational aspects, tree marking can reduce the amount of residual damage and improve the productivity of the harvesting system. Compromises must be made between the desired silvicultural prescription and the ability of the harvest system to achieve these results.

Access will also be a major consideration during the harvest layout. Selection harvests, where a watershed is placed under uneven-aged management, have been estimated to require as much as 100 percent more open road area per decade when compared with requirements for conventional even-aged management using clearcuts. These findings were the results of a simulation study conducted to estimate road access requirements for three different silvicultural systems (Nelson and Manna 1991). Shorter entry periods and small openings, as associated with lo-year and 20-year group selection harvests tested in the model, require significantly greater amounts of road area per decade when compared with a clearcut system using a 120-year rotation period (fig. 1).

Foresters working on harvest layout and design must understand how to lay out openings for newer systems, like the small skylines and harvester-forwarder systems. They need to understand the tradeoffs between systems, such as understanding where a manual felling-forwarding system might work better than a fully mechanized harvester-forwarder system. They need to be aware of the capabilities of each system; i.e., understanding when to use a medium capacity yarder and when to use a small machine. They need to know how each system affects the site and stand and which system would have the least impact when working a specific stand of timber.

The cost tradeoffs of each system, specifically whether a system is feasible economically and environmentally, are also important. Kellogg and others (1991) found that layout costs for group selection harvests in young stands ranged from $2.66 per million board feet (mbf) for skidder harvests to $2.40 per mbf for cable harvests. In contrast, the cost to plan clearcuts on similar sites ranged from $0.14 per mbf for skidder harvests to $0.38 per mbf for cable. These findings suggest that planning partial harvests can be a significant factor in the overall harvest costs.

Harvest System Selection

Ecosystem management will emphasize partial retention as an objective in many harvests. As a result, harvest system selection should consider stand and site concerns as significant factors. In addition, the availability of preferred systems and their cost of operation will affect the selection process.

Availability and cost factors will also affect system selection. Many alternative systems, particularly the harvester-forwarder system, are expensive to acquire and operate. These newer systems are often available in limited quantities, and ownership costs are so high that contract loggers are hesitant to purchase them. Conventional systems are more common, but can potentially

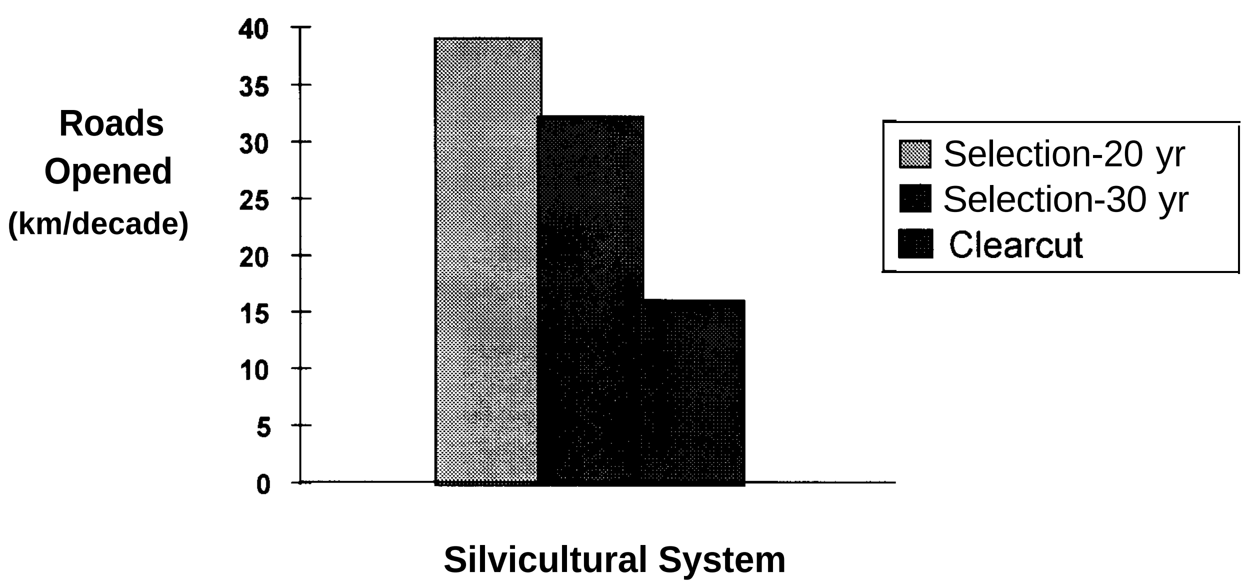

Figure 1—Roading required for three different silvicultural systems (Nelson and Manna 1991).

lead to high levels of soil and stand damage. In addition, most conventional systems were designed to work in clearcut conditions at high rates of production. Using these machines in partial harvests at relatively low production rates will affect system profitability. Studies suggest that operations working in partial harvests, when compared with clearcut operations, have substantially lower production rates (Kellogg and others 1991; Bennett 1993).

Falling-Constraints associated with ecosystem management will cause some changes in falling operations. Manual falling will not change substantially, although some improvements may take place in placement techniques and falling patterns. Manual falling will probably adopt several tools currently used in Scandinavia to improve falling placement, falling patterns, and log handling during the bucking phase. Some retraining may be necessary for fallers used to clearcut operations. Training should emphasize directional falling techniques, appropriate falling patterns for partial removals, and techniques to index or bunch logs prior to transport. Many of these techniques have already been successfully applied in Scandinavia and may be easily adapted for use in North America.

Conventional mechanized falling equipment, particularly feller-bunchers, are not designed to reduce soil compaction or to leave slash at the point of felling. The need to minimize stand and site damage, while adequately maintaining falling production, will produce some changes for both manual and mechanical operations.

Mechanized systems used for these partial removals will have a number of features not currently available with conventional systems. Future machines should minimize the effect of falling and machine movement on the stand and site. They should also leave slash on site, rather than pile the material at roadside or concentrate it at the central landing.

The mechanized harvester is one of the few machines with these characteristics that is being used on a limited basis in many parts of North America. Harvesters are designed to fell, delimb, and buck trees at the stump. The smaller-sized logs ($\leq$ 20 feet in length) produced by the harvester are less difficult to maneuver through the residual stand and the machine typically rides on a cushion of slash, further reducing the amount of soil disturbance caused during operation. The cost of this machine is somewhat prohibitive and production may be reduced on steep sites or in areas of broken terrain.

Another popular option is the tracked carrier equipped with a harvester head. These machines are less expensive than the rubber-tired harvester, and some self-leveling units can operate productively on slopes as great as 40 percent. Tracked machines can damage shallow rooted species, however, and create heavy soil disturbance in organic soils.

Ground-based primary transport-Current ground-based primary transport systems consist of either skidders or forwarders. Of these machines, the forwarder provides the best protection to the residual stand and the site. The skidder typically removes stems in a tree-length form or as long wood. Transporting long logs or tree-length timber, even on well-planned designated skid trails, will create substantial amounts of residual stand damage. In addition, skidding produces ruts caused by dragging the logs to the landing or roadside.

A recent study by McNeel and Ballard (1992) suggests that, even when using low impact forwarders, the site and stand are still affected. In this study, trail density for the site was estimated at 20 percent of the site. Heavily traveled trails constituted nearly 7 percent of the area, and these trails were found to have increased soil bulk density levels which could affect subsequent growth in the stand (fig. 2). Residual stand damage, where at least 40 cm^2 of the stem was exposed to the cambium level, was reported at less than 5 percent. Multiple entries, however, could exacerbate this problem over time.

More conventional systems, such as those using skidders for primary log transport, can have long lasting effects on the site. In one case, skidder-related soil compaction was measured 32 years after the harvest (Wert and Thomas 1981). Residual stem damage also occurs when using skidders to remove tree-length stems or long logs during thinning operations, particularly when turning on trails.

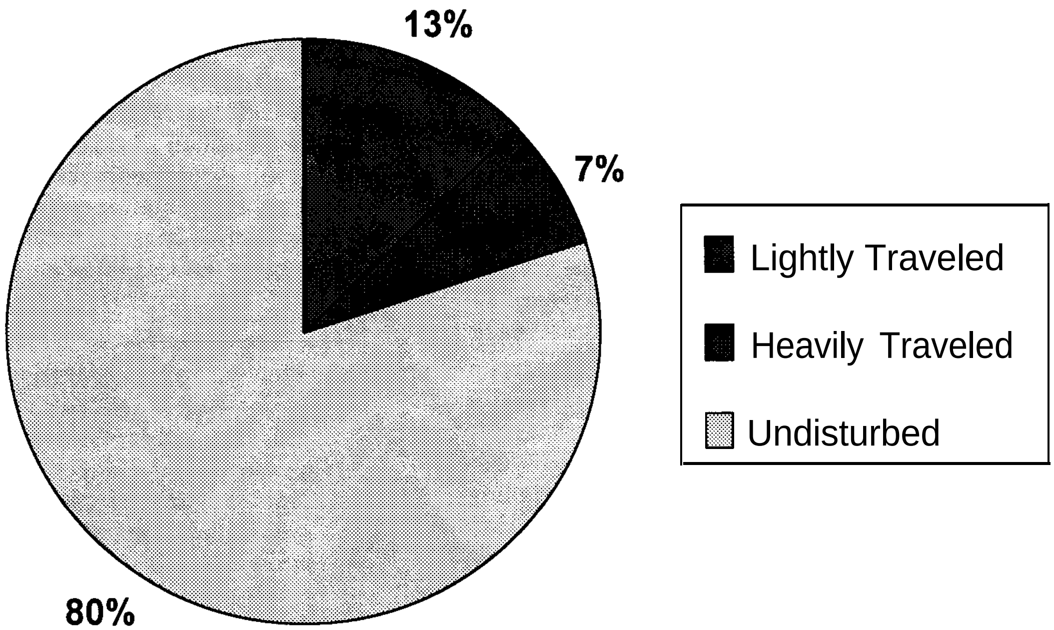

Figure 2-Trail concentration by type for a harvester-forwarder thinning operation (McNeel and Ballard 1992).

Damage can be significantly reduced with ground-based systems if proper planning is conducted prior to entry. By designating skidding trails and designing travel corridors to minimize stand damage, the site and residual stand can be well protected. These planning procedures can reduce the effect of machine travel on the site and the residual stand, even when using conventional ground-based systems.

Cable-based primary transport-Traditionally, cable systems were large, high production units designed primarily for clearcut operations. Turn volumes have averaged as much as 7.5 tons, as reported in one study (McNeel and Howard 1992). Use of these large machines for yarding in partial harvests is not a viable option in partial harvests. With management shifting to second-growth stands, turn volumes would never reach the level needed to maintain profitability.

Smaller machines, such as conventional swing yarders, are being used on some sites with mixed results. Production with these machines, even though they are smaller, is still too low for the machine to be profitable.

The greatest potential for profitable yarding exists in small skyline yarders costing under $200,000. At least three manufacturers currently offer this size yarder and the machines are being profitably used in partial harvests across the Pacific Northwest. Even these systems, however, have difficulty generating a profit, since total daily production rarely exceeds 45 tons per day.[2]

Aside from production constraints, small yarders need certain design characteristics to improve operations in partial harvests. The machines should be able to deck to either side to reduce the area required for landings. They also need to have a long reach, preferably 2,500 to 3,000 feet, to reduce road concentrations. The carriages used on these machines should be radio-controlled, self-clamping units with a long skidding line to allow for longer lateral yarding. Finally, these systems must be profitable, suggesting a need for greater productivity that may only be attainable through better planning and layout.

Foresters involved with the planning process must recognize that highlead systems are incompatible with most ecosystem management-based operations. Highlead systems are most effective in clearcuts and will not work well in partial harvests. The best options for partial removals are skyline systems, either running or live, which increase lift, reduce stand and site-related damage, and have minimal effect on regeneration.

[2] **Personal communication. 1993. P. Larsen, Larsen Forest Products, Port Angeles, WA.**

Production and cost factors-As noted in the previous section, production rates for many conventional systems will be reduced due to the constraints associated with ecosystem management. Newer systems which are designed to work in smaller timber and in partial harvests will also have low rates of production, simply because these systems are designed so that a tradeoff exists between harvest-related impacts and production rates.

Kellogg and others (1991) compared the production and cost associated with clearcuts, group selection harvests, and two-story harvests using conventional harvesting equipment. Only two live trees were left in the clearcut with any snags that could be salvaged during operations. The group selection harvests removed about one-third of the volume in the stand in small openings about one-half acre in size. The two-story harvests removed two-thirds of the volume in the stand, left 12 trees per acre in the overstory, and created 1.5 snags per acre.

Layout times for these three harvests were radically different, with layout for clearcut operations costing significantly less than the other two options. Costs per mbf for a clearcut layout ranged from $0.14 to $0.38 per mbf. In contrast, the cost for laying out a group selection harvest ranged from $2.40 to $2.66 per mbf. Wide variations in layout costs were noted for the two-story harvest with the ground-based layout costing only $0.72 per mbf, while the cable layout costs were over $2.50 per mbf.

For the ground-based operations, felling production was higher-about 11 percent higher-and costs were lower with the group selection harvest than with the clearcut. Skidding production was also higher in the group selection harvest and costs averaged 3 to 4 percent less than the costs involved with clearcutting. The two-stage harvest averaged 15 percent higher costs, due to more difficult operational requirements required when removing scattered stems across the site.

Cable operating costs in the two-story and group selection harvests were 20 to 24 percent higher than the clearcut operations. This resulted from lower production rates caused by the removal of less volume per acre. In this case, the two-story harvest was slightly less expensive than the group selection harvest, and production averaged only 0.10 mbf higher with the two-stage approach.

Total costs, including the layout expenses, were somewhat lower for the clearcut system in both the ground-based and cable operations (fig. 3). This type of cost differential may be expected where ecosystem management goals require partial harvests like group selection.

In a selection harvest on a coastal site in British Columbia, Bennett (1993) found that the combined unit cost for falling and skidding was 20 to 30 percent higher than for a conventional clearcut harvest. The efficiency of the harvest operation was influenced by the layout of the designated trails, orientation of the marked trees relative to the trails, and the quality of directional felling.

Generally, the application of partial harvests on small acreages results in less volume harvested per acre at a higher cost to the logger. The planning associated with this type of harvest is more expensive and requires more time from the forester and field crews. Logging equipment design is focusing on characteristics which will reduce damage to the site and stand, rather than production. As a result, the cost of using newly developed equipment will continue to be high with continued low production rates.

Other Concerns

New objectives for forest management require effort in at least three areas relating to operations-education, planning, and research. Without a concerted effort in each of these areas, little progress will be made in implementing ecosystem management at the operations level.

Education

Foresters, loggers, and contracting personnel need to understand how various operational techniques relate to ecosystem management goals. One example of this focus is through the LEAP program. This program of extension education teaches loggers and contractors about the silvicultural and biological aspects of forest management. Foresters, particularly those

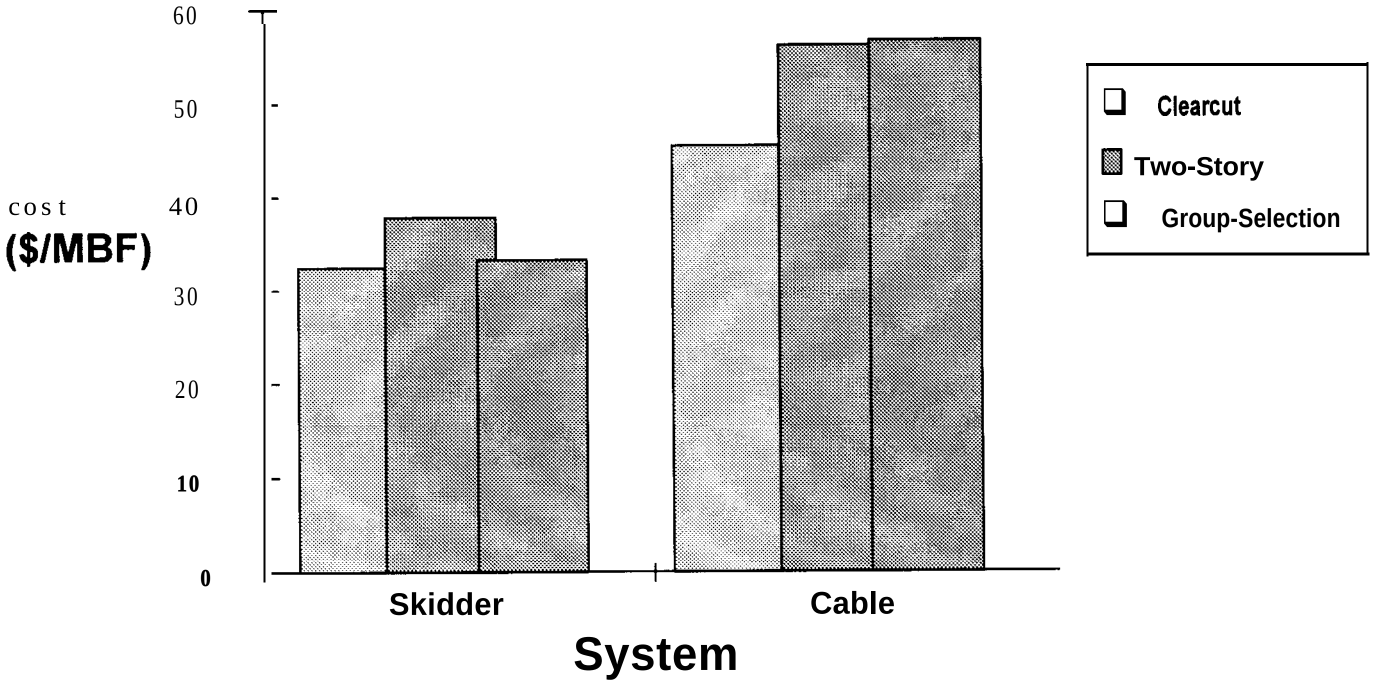

Figure 3-Comparison of three silvicultural systems based on operational and planning costs (Kellogg and others 1993).

working at the district level, will also benefit from training in harvest layout techniques for some of the newer harvesting systems, such as the harvester-forwarder system and small skyline systems. In addition, more effort needs to be spent educating the public about the effects of ecosystem management and the role harvesting plays in implementing ecosystem management objectives.

Planning

Operations under ecosystem management will require more planning, particularly in the area of harvest layout. Constraints on area-based planning will require greater emphasis on computer planning tools that incorporate Geographic Information Systems and database management tools. Adjacency rules, size of the harvest area, and landscape management will become more important in area-based planning operations. At the project level, more emphasis will be placed on operational layout. New techniques must be incorporated to take advantage of the different systems available for harvest operations. Interdisciplinary type planning is critical to the success of ecosystem management and must be incorporated into all future forest operations.

Research

Research will emphasize both large scale planning concerns, and will focus on testing and evaluation of different operating techniques to determine how these systems affect ecosystem viability. The effect of multiple entries with different systems must be evaluated to determine what options best create the desired future stand conditions called for by ecosystem management. Finally, more emphasis must be placed on integrated research between forest engineering and other disciplines.

Conclusions

Managing for one or two endangered species will never result in an enhanced ecosystem. Coarse filter management techniques offer the best opportunity for sound ecosystem management. In contrast, fine filter techniques are currently driving many of our management decisions to protect a few at a cost to many.

Harvest planning is critical to the success of ecosystem management. Partial harvests will replace clearcuts on most national forests, and field foresters must be capable of properly planning these harvests.

Logging equipment design will continue to focus on light impact systems for use in partial harvests. Conventional systems will still be used in many parts of the country and field foresters should know where and how to apply these different systems to meet ecosystem management goals.

Production and cost factors may restrict operations on some sites, since partial harvests will result in lower production and higher costs. Foresters should understand the effect of partial harvests on logger profitability and account for these effects in any contract arrangements.

More effort is needed in education, planning, and research. Forest operations will change dramatically over the next 5 to 10 years, as ecosystem management is implemented on our national forests. Without some effort in each of these areas, ecosystem management will be more difficult to implement and few of the people involved with its implementation will understand its purpose.

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Integrating Social Science and Public Input Into Ecosystem Management on National Forests

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Abstract

Social science research in forestry examines the relationships between people and natural resources. It seeks to identify the opinions people hold regarding natural resources, determine how individual opinions are aggregated and expressed in community values and market processes, and how these social and market processes affect resource management. Social science research can help improve our ability to determine public opinions, the appropriate roles for public land management, and the best means to implement public policies to achieve social objectives. This paper reviews social science research and applications to ecosystem management on national forests, discusses the public values important in natural resource allocation and management, and illustrates how public input may be improved via a case study of a midlevel planning effort on the Sumter National Forest in South Carolina.

Introduction

Social sciences have been identified as being important in most current discussions of ecosystem management. However, specifically identifying the role for social sciences in ecosystem management on national forests is difficult. In this paper, we present three related subjects in order to clarify how social science can enhance ecosystem management. First, we discuss social science research as a discipline and its differences from biological sciences. Second, we discuss the American values that form the basis for the application of social science to national forests. Last, we describe an actual application of social science methods to improve public input and resource management on the Sumter National Forest in South Carolina.

Ecosystem management has been defined by the Forest Service as an ecological approach that "will be used to achieve the multiple-use management of the National Forests and Grasslands. It means that we must blend the needs of people and environmental values in such a way that the National Forests and Grasslands represent diverse, healthy, productive, and sustainable ecosystems" (Robertson 1992). This definition-and most of the other discussions about ecosystem management on national forests-suggests that social science is important in implementing of ecosystem management.

While there is general agreement that people and values are fundamental in ecosystem management, there is almost no consensus about what this really means. What do people want from the national forests? How should we determine people's opinions? How do we determine which of those can be incorporated in national forest management, or left to market processes? How do we reconcile differing public values in management plans and actions? What social science contributions are important-sociology, recreation, economics, policy analysis? How do we apply social science research to national forest/ecosystem management? How do we quantify public values and document responses to public inputs clearly? How do we measure success? These and a host of other questions must be resolved if we are to successfully implement ecosystem management on national forests.

Social Science

Social science in forestry examines the relationships between people and natural resources. It seeks to identify the opinions people hold regarding natural resources, determine how individual opinions are coalesced as community values and reflected in market processes, and how these social and market processes affect resource management. Social science has never been the first love of foresters, who have focused on the biological bases for management-identifying, understanding, measuring, and managing how trees, stands, and forests grow. Our biological knowledge about forests has expanded rapidly, and we appear to be shifting our paradigms from solely improving forest productivity to broadly enhancing forest health and ecosystem functioning. While social sciences certainly have broadened our understanding of people and their motivations, translating that better knowledge into better forest management has been more elusive.

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Nevertheless, if ecosystem management on national forests is to be a success, improved social science applications will be indispensable. Indeed, if the Forest Service and the national forests are to be retained in their present form, surely we must do a better job of divining, understanding, and responding to public opinion and values. Better ecological management of the national forests does seem to respond to implicit public demands for the forests. But before we glibly start managing for some nebulous desired future conditions, we must determine those conditions through transparent and defensible public input systems, we must understand how people fit into ecosystem management, and we must have appropriate management tools and responses to reach selected ecological and economic goals.

Social Science Research Needs

Several national reports about forestry research have identified social science research as an important component of national research and management needs. The 1990 National Research Council (NRC) report "A Mandate for Change" summarized the results of a national review of the status of forest research and recommended increased research in five broad areas: (1) biology of forest ecosystems, (2) ecosystem function and management, (3) human-forest interactions, (4) wood as a raw material, and (5) international trade, competition, and cooperation. The USDA Forest Service (1990) Research branch identified three major research program emphases: (1) understanding ecosystems, (2) understanding people and natural resource relationships, and (3) understanding and expanding resource options. The Southeastern Forest Experiment Station (1990) identified seven areas of research emphasis: (1) fisheries, wildlife, and sensitive species, (2) forest inventory and health monitoring, (3) forested wetlands, (4) global change, (5) social benefits of forests, (6) silviculture and ecosystem responses, and (7) water quality and watersheds. People and public values are a component of all of these proposed forestry research priorities.

The human-forest interactions section of the NRC report noted that "The needs of people drive the use and misuse of forests." (p. 37). Based on this premise, six human-forest subjects were identified for study: (1) community systems, (2) urbanization and forestry, (3) regional resource systems, (4) recreation and aesthetics, (5) resource sociology, and (6) extension.

Other social science disciplines could be added that might be useful for ecosystem management applications on public or private lands. Political science research on institutional structure, policy analysis, laws and regulations, public opinion and input, and program evaluation also bear research. So do the continuing economic questions of market allocation of resources, production economics, macroeconomics, nonmarket valuation, regional impacts, and related subjects.

In a survey of national forest personnel, social science applications dominated the research needs identified by line managers (Jakes and others 1990). Seven out of 11 of the top problems they perceived focused on social issues, not inadequate biological knowledge. The top five problems were all social science questions, including legal and political challenges to forest management decisions, conflicts among user groups, conflicts among national and local groups, inconsistent planning and budgeting priorities, and constraints from laws or regulations. Only three of the major problems-declining resources, adverse impacts of certain uses, and watershed and water management-were biophysical in nature, and they too had social components.

At present, our knowledge of social science and incorporation of public values into national forest management is not adequate. The integration of social values into ecosystem management should go beyond attaching appendices full of social system facts into records of decisions and forest plans. We must determine public values, and determine how to use them in forest planning. Integrated research and application efforts should simultaneously identify and incorporate public values and opinions into ongoing planning and management efforts. These efforts should include improving public input processes, developing better tools for managers to quantify social and ecological information and tradeoffs, and designing appropriate training for staff personnel and line managers in the national forests.

Social Versus Biological Sciences

Many similarities and differences exist between biological and social sciences. Both disciplines are extremely diverse and use related scientific methodologies. Biological sciences related to forestry range from cellular genetics to dendrology to physiology to stand dynamics to ecosystem management, for both flora and fauna. Forest productivity, protection from biological pathogens, and the effects of anthropogenic change on forest health are types of biological and ecological research. Social science disciplines reflect a breadth at least equal to that of the biological sciences. The scientific methods employed in biological and social sciences are somewhat similar. All disciplines employ description of systems and processes, hypothesis formulation and testing, model building, and synthesis of existing knowledge and research findings.

Differences between the disciplines are found in three key areas: type of data available, use of theories and laws, and potential resource management impacts. A principal difference is the type of data that biological and social scientists collect and the power of the experiments performed. Biological sciences are widely reputed to be more scientific or "hard" than the social or "soft" sciences. Performing experiments at laboratory benches or performing field tests of tree growth responses with treatments and controls can provide reasonably reliable primary data and statistical tests of scientific hypotheses. However, ecosystem management science-the effects of broad scale vegetative manipulations on forest health and productivity-is considerably less elegant. Debates over the viability of the northern spotted owl still exist and the effects of clearcutting on sustainable forestry are moot.

Social science data are generally far less elegant than the data gathered in biological laboratory or field experiments. Social science usually relies on secondary data about people, whose actions are more complex than the response of plants or animals to isolated treatments. Social scientists must analyze the causes and effects of individual actions or public programs in the context of a much more diverse environment. The multiple factors affecting social problems, and the lack of elegant control and treatment populations, have led social sciences to be labeled soft sciences, because they appear less precise or accurate than the hard biological sciences.

A second difference involves the use of theories and laws. The harder biological sciences are based on widely accepted theories and laws about cell composition and growth, plant biophysical relationships, habitat characteristics and needs, etc., although they too are sometimes challenged or overthrown, The moderately hard social science discipline of economics has a set of widely accepted neoclassical microeconomic theories, although paradigms about macroeconomics are more prone to dispute. The softer disciplines of political science, sociology, and anthropology do not have universal theories or paradigms that are widely accepted, but rather have a plethora of theories about how people and societies act and respond to external factors. The lack of widely accepted paradigms is viewed as evidence of a lack of "science" in the social sciences. We beg to differ. Instead it is an indication of the complexity of humans, and the lack of any ironclad rules that describe how people will act. And even the hard science and scientists have often been shown to have theories and experiments that are not borne out in the long run or are subject to debate, such as cold fusion or global climate change, or researchers that seem to promote themselves more than truth, beauty, and science.

A third difference is found in the potential impact of biological and social science research. Biological research can help trees grow better, and ecosystems function better, if we can incorporate better knowledge into better management. Using either biocentric criteria or anthropocentric criteria, one can assume that better biological research and applications will increase ecological or social welfare. On the other hand, social science research aims to help people improve their working and living conditions, not enhance ecological systems per se. Reducing public lands conflicts, increasing acceptance of forest management plans and actions, and improving the public trust of the Forest Service all are tangible benefits that are important for enhancing ecosystem health and management. Given the substantial need for improvements in social welfare and public input and for public acceptance of national forest management, even a modest improvement in the forestry applications of social science research could have greater impacts than biological research. After all, left alone, biological systems can replenish or restore themselves; social systems by definition depend on human intervention. Reducing conflicts among users and increasing public acceptance of national forest management can allow us to improve application of biological research findings.

Public Values

People value natural resources for a variety of economic and noneconomic reasons. Increased social science research and applications can improve identification of and incorporation of public values into forest plans and actions, in order to reduce conflicts and improve management efficiency and success. Thus, it is appropriate to briefly discuss public values as they relate to national forest management in order to clarify the types of policies likely to be acceptable or divisive.

Classifying and understanding all American values related to natural resources in a brief paper is impossible. However, some discussion of the broad spectrum of American values that may be relevant in resource management decisions follows, drawing from literature by Cubbage and Brooks (1991) and Cubbage and others (1993).

American values range across many spectrums, from the promotion and protection of individualism to the social norms of community and equity; from utilitarian, materialistic, and anthropocentric interests to preservationist, spiritual, and biocentric interests; and from local to regional, national, or global interests. Expecting consensus among all these interests is unrealistic. Improving identification of interests, enhancing public discourse and forest planning, and balancing competing interests is achievable.

Individualism and Community

The United States has always tried to ensure individual, market, and political freedom, including preservation of law and order. In addition, our society has usually sought to ensure equal opportunity, if not equal outcomes, as well as fairness and community stability. America also attempts to improve the living standards of its citizens by encouraging economic growth and by providing essential services for the needy. It also has sought to protect natural resources from waste or destruction, with varying degrees of commitment.

Americans have favored individual effort and enterprise since first becoming a nation, including strong protection of freedom of expression and of property rights. Life, liberty, and the pursuit of happiness were watchwords of the American revolution; the Bill of Rights guarantees our basic individual freedoms. This individual freedom also favored the use of markets to allocate resources, rather than governments, unless market failures proved severe. Private market allocation of natural resources requires clear assignment of property rights that confer exclusive use and disposition of property.

The heritage of individual freedom is balanced by strong social pressures to ensure equality, to protect the family, and to conform to community mores. The Preamble to the Declaration of Independence states that all people are created equal. The Puritans, the Protestant work ethic, the Catholic emphasis on family and community tempered unbridled individualism in early America. The influence of religious and community groups remains pervasive in national debates and politics. Indeed, even newer immigrants and ethnic groups in America still try to balance the pursuit of individual freedoms with the retention of their community identity. Community norms suggest a role for government in allocating natural resources, particularly to protect public goods such as air quality, water quality, and wildlife diversity, which are not traded effectively in private markets.

Utilitarianism and Preservationism

Another spectrum of American values ranges across a continuum from utilitarian, materialistic, and anthropocentric to preservationist, spiritual, and biocentric. This spectrum of values may or may not correlate with the individual/community dichotomy; individualists or communities may favor either utilization or preservation. The values ranging from anthropocentrism to biocentrism also raise questions of environmental ethics-for whom and for what are natural resources used, or not used?

The utilitarian, materialistic, and anthropocentric values have been embodied in American private land and public policies throughout U.S. history. Taming the wilderness, plowing the prairies, and disposing of the public domain were done to favor land settlement and resource use. Even setting aside and managing the national forests focused on protection and use, not preservation. The utilitarian legacy of Pinchot remains imbued in most Forest Service policies, and in the hearts and minds of many Agency employees and public lands interest groups. While the recent talk of value identification often focuses on aesthetic and spiritual considerations, one should not be misled into thinking that utilitarian values are dead or irrelevant. Nor should anthropocentric values be left out of ecosystem management. Forests for use and forests for people retain an anthropocentric view-as do private property rights bumper stickers proclaiming "Wilderness: Land of No Uses." Even in developing countries, the exploitation of natural resources for material gain is the norm, not the exception.

Many ecosystem management discussions focus on preserving forests for their biological, ecological, recreational, aesthetic, or spiritual values. These values are becoming increasingly important as the United States changes from a society that was predominantly resource dependent to one that balances resource exploitation and service economies, and as individuals satisfy more of their basic needs and aspire to higher-level needs. Ecosystem management on public lands, and its possible extension to private lands, embodies a biocentric approach to resource management. Preservation of natural communities and management to recreate prior natural states is viewed by many resource professionals and environmental groups as desirable. The recreational, aesthetic, and spiritual values of forests are increasing in importance, especially as forest users from urban or ex-urban areas depend less on a timber-based economy for their livelihood. The pervasiveness of these world views and the extent to which they are increasing, and their implications for land management need further quantification. However, biocentrism should not be used as a ruse to support continued narrow professional management of resources without regard for broader public opinion or as a means of favoring the elite and affluent at the expense of the working class and the poor.

Local to Global Values

Another spectrum in the values classification ranges from local to regional to national to global interests. These often may be divergent. Landowners who live next to public lands, at least in current times, are apt to prefer uncut forests and pristine natural conditions. Woods and mill workers in nearby communities may favor timber management and harvests. Recreation service sectors may prefer developed natural conditions. State and regional interests may favor development or preservation, depending on economic and environmental conditions, or on the utilitarian or preservationist orientation of various interest groups. National interests may prefer commodity uses to stimulate economies, or protection to preserve ecological values. Global interests may value carbon production and retention, oxygen production, or existence benefits. Among such divergent interests, unanimity, or even much agreement, is apt to be rare.

Integrating Values into Management Decisions

As the preceding overview suggests, explicitly integrating people's values into public or private forest management decisions is not easy. The Forest Service has always implicitly incorporated people's values into national forest management. However, in the last three decades, this implicit incorporation of public values has diverged more widely from the plurality of values held by Americans, causing more conflict and opposition to forest plans and actions. The Forest Service must improve its explicit recognition of and measurement of changing public values, increase discourse with concerned interest groups, and improve incorporation of new values and new goals into natural resource management plans. Ecosystem management applications can assess the potential for improving these aspects of the Forest Service mission by examining the following actions:

1. Resource valuation: Use social science research methods from psychology, sociology, anthropology, political science, or economics to determine how individuals and groups form opinions and value natural resources, ranging from use to preservation, and from local to global scales. Assess how people modify or change opinions, and how those opinions about natural resource use are changing over time. Examine comparative benefits of market (private, exclusive) goods and nonmarket (public, nonexclusive) goods.

2. Public opinion: Determine how large interest groups or segments of the public view forest resource management and preservation, land and environmental ethics, resource utilization, and other natural resource management tenets. Assess how opinions change over time and vary among groups. Determine how public relations may influence public opinion.

3. Resource allocation: Determine the stated and implicit goals of interest groups affecting forest resource management and analyze the strategies and

tactics they use to influence policy and management. Assess alternative management strategies for effectiveness in meeting multiple goals. Examine impacts of public land management on private land management.

4. Public planning: Develop methods that improve public input and discourse in forest planning, identify acceptable desired future conditions in forest management plans, and incorporate professional expertise and experience into resource management decisions. Use social science in developing management plans; use decision analysis, dispute resolution, mediation, or other techniques for public planning; and enhance documentation of planning inputs and outputs.

5. Demographics: Relate changes in population structure and composition to changes in values. Project impacts of forest management on rural development, community dynamics, and other forest-related activities.

Sumter National Forest Case Study

The following example illustrates how social science applications can improve incorporation of public values into ecosystem management. The case study began in 1991 on the Pickens Ranger District of the Sumter National Forest in South Carolina (Maguire 1991). Using decision analysis/dispute resolution (DA/DR) techniques, Maguire and Lloyd began a process intended to develop improved public participation methods for forest planning, and to reduce conflicts when national forest plans are implemented. The Pickens case study provided a means of assessing the merits of DA/DR methods to improve public input and professional management on national forests.

The Cedar Creek area of the Pickens District of the Sumter National Forest is in the western tip of South Carolina. The 8,000-acre study area runs east from the Chauga River, which is a designated scenic river. The area includes hardwood and mixed pine-hardwood stands ranging in age up to 160 years; loblolly pine plantations; steep slopes; habitat for endangered and threatened species, including the smooth coneflower; and trout streams. Human uses of the area include timber harvest, mainly by clearcutting, and dispersed recreation. The study area typifies the major resource management conflicts of Southern Appalachian national forests, and indeed of national forests nationwide: disputes among timber interests, environmentalists, and the Forest Service over the best distribution of consumptive and nonconsumptive uses of forest resources.

Decision Analysis and Environmental Dispute Resolution Process

Under the National Environmental Policy Act (NEPA) and the National Forest Management Act (NFMA), land management on the national forests has been characterized by an uneasy blend of technical analysis, including forest planning models, public participation in meetings, and appeals and litigation. The process often has been unsatisfactory, failing to satisfy the interests of forest user groups and at times resulting in virtual paralysis of forest management activities. By combining quantitative techniques from decision analysis with qualitative techniques from environmental dispute resolution, Maguire and Lloyd designed improved methods for integrating scientific analysis with public input to meet conflicting human needs while protecting environmental resources.

To develop these DA/DR methods and to test their effectiveness, Maguire and Lloyd worked with a core group of interested citizens and Forest Service representatives to develop a consensus view for managing the Cedar Creek area over the next 10 years, Goals of the process included increasing public consensus about managing the Cedar Creek area and providing the Forest Service, as an interest group and as land managers, a more active role in the process.

The working group used the existing forest plan as background and developed a vision for future management activities that could be implemented through the NEPA processes. Working group members represented timber, hunting, biodiversity, and local community interests. They were selected by consensus of these constituencies during two large public meetings. When an initial meeting failed to provide satisfactory representation of local residents concerned with traditional uses of the area, a special effort was made to solicit appropriate representatives during subsequent meetings. Working group meetings were open to the general public. Ground rules were used to maintain order and Maguire and Lloyd served as meeting facilitators.

The working group first developed a chart describing management goals important to each major constituency: timber, biodiversity, and recreation. These were assembled on a common chart, emphasizing the collaborative approach to problem resolution. The overall goal was defined as: manage the forest to meet social goals. These goals included protecting the ecosystem, providing a variety of goods and services, preserving the quality of life, promoting economic well-being, and educating the public. Each of these was further broken down into specific subobjectives that could be monitored.

For example, northern red oak sawtimber is a good whose output can be measured.

The initial focus on goals gave direction to later steps of the process-gathering and analyzing information and developing alternatives. It also served the important purpose of turning people's attention away from demands for action (or inaction), and toward the underlying goals themselves. Understanding the underlying goals is an essential ingredient for developing solutions that meet the needs of multiple interests.

The next task involved developing "means-ends" charts describing how actions taken on the ground would affect the previously identified goals. Unlike identifying goals, describing the expected results of management actions requires technical expertise, which was supplied in part by the working group members themselves and in part by other professionals from the Forest Service, universities, and State agencies. Three "mixed" subgroups, with representatives from different constituencies, worked together to develop means-ends charts for the three areas of recreation, timber, and biodiversity. Mixing membership in these subgroups promoted the goals of sharing information and mutual education, providing a common background for developing management proposals specific to the Cedar Creek study area.

In the same mixed subgroups, the working group developed a view of management for the Cedar Creek area. Using a Geographic Information System (GIS) database, the groups summarized and mapped forest resources, including stand ages and types, locations of rare plants, areas of steep slope, and other areas of concern. Facilitators integrated initial proposals from the subgroups into a "single negotiating text." This text underwent a series of changes before nearly all working group members endorsed it.

Consensus View

The resulting "consensus view" requests that the Forest Service manage the general area for a diversity of forest types, emphasizing native species, and for a range of traditional recreation uses. It distinguishes between the general forest area and "special" areas, where unique resources may require special attention. Special areas include situations where appropriate management techniques are already available and those where additional research is needed to develop management alternatives. Some situations where appropriate management is already known may be managed without timber harvest (e.g., Chauga Scenic Area, visual retention areas); some may require special harvesting techniques (e.g., steep slopes) or limitations on amount harvested (e.g., stream buffers). Situations where appropriate management is not yet known include some rare plant habitats and areas to be managed for "old-growth" characteristics.

The consensus view promotes further efforts in recreation, research, and ongoing public involvement. Under recreation, there are suggestions for small-scale developments to improve access by the handicapped and elderly, as well as an expanded education program by the Forest Service and citizen groups on nontimber as well as timber uses of the forest. Research suggestions include short-term surveys and longer-term research. Short-term surveys of rare plant and older stand locations will help delineate areas to providing old-growth habitat and a socioeconomic study will examine the community consequences of both timber and nontimber uses of the forest. Longer-term research will identify management for rare plants and for areas in the old-growth network, specifying appropriate types of timber management. Other research will examine the impacts on timber and nontimber resources of alternatives to clearcutting. Unlike many calls for research, this one is well-focused to address the concerns raised by a broad constituency, so that resources can be protected without undue delays and uncertainties for the timber program. In both recreation and research, the consensus view contains specific plans for ongoing participation by citizen committees and volunteers.

The consensus view was forwarded to the Forest Supervisor. He and his staff responded with proposals for items that could be undertaken immediately, those that required additional planning or funds, and those that would be considered in the upcoming revision of the forest plan. Although it is too soon to judge the long-term implementation of the consensus view, these activities have taken place: improvements were made to a rifle range in the study area; the Forest Service is working with citizens to site a scenic trail; the Forest Service held a Saturday public open house; research projects have been initiated on management of smooth coneflower habitat; use of remotely sensed data has been used to identify uneven-aged management and characteristics of old-growth; and timber sales are being prepared that will provide both commodity outputs and opportunities to test uneven-aged harvest techniques.

This collaborative problem-solving process required a substantial investment by citizens, the Forest Service, and the facilitators. The working group met nine times over a g-month period, with additional work between meetings. It is possible that additional technical analysis might have made the consensus view more specific and more responsive to the goals of all parties, but the need to achieve closure and begin implementation precluded further refinement. The use of DA/DR methods did not eliminate all the tensions among interest groups or settle all disputes about Forest Service actions on the Pickens District. But the ability of the people to work together to identify common ground and to clarify goals and differences, stands as evidence of the potential usefulness of collaborative efforts.

Conclusions

We have presented a brief overview of social science research and American values, and discussed an application of DA/DR techniques on the Sumter National Forest in South Carolina. Numerous social science disciplines can contribute in some fashion to improved national forest/ecosystem management applications, as reviewed here. When using these scientific applications, it is important to remember that American values differ widely among individuals and groups, so not all methods will yield the same results, and even the same method is likely to yield different results in different locations.

Social science research differs from the biological sciences that foresters are most familiar with; it relies on secondary data about people and their behavior rather than primary data derived from controlled experiments. However, by using social science methods to improve forest planning and resource management, the Forest Service could make substantial improvements in social welfare in a relatively short time, rather than waiting decades for results as is often the case with biological/forestry research implementation.

Increasing social science research would take a sincere commitment by the Forest Service of allocating dollars and personnel to live up to the research needs identified in all their strategic planning documents. It also would take a commitment by the national forests to try and to adopt new methods developed. And last, it probably would require revision of some of the existing planning laws and regulations (NFMA, NEPA) to allow more flexibility and creativity in public input methods and in implementation. None of these changes will be easy, or perhaps even likely. But this type of substantial change and an increased focus on the people, not just the trees, or the plants, or the wildlife, are what will be required to sustain and enhance the mission, image, and success of the National Forest System and of Forest Service Research. These prospects certainly can provide a challenge for us in the future.

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Building National Forests Research Partnerships

Technology Transfer at the Heart of a Research/Management Partnership

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Abstract

We describe a technology transfer program that forms the basis for a strong research/management partnership. The research team conducts annual training sessions for managers. The sessions contain an equal mix of classroom lecture, forest demonstration tours, and practice exercises. These sessions ensure that forest managers and researchers share a common understanding of the forest ecosystem, know each other personally, and have frequent opportunities to adapt management practices, research guidelines, and research plans to address the latest research results and emerging management problems. Examples of adaptive management activities that have grown out of the training sessions are given.

Introduction

One of the important components of ecosystem management is "Land manager/scientist partnership" (Robertson[1]). This paper describes such a partnership, and shows how annual training sessions form the heart of that partnership. The training sessions foster a sense of community and partnership by ensuring a common foundation of ecosystem knowledge, providing a format for translating research results to management guidelines, building personal relationships, and ensuring that feedback from managers reaches researchers.

Background

Like much of the eastern hardwood forest, the forests of the Allegheny Plateau region of northwestern Pennsylvania are the result of landscape-scale harvesting operations at the turn of the present century (Marquis 1975). At the time of these harvests, deer (*Odocoileus virginianus virginianus* Boddaert) populations were nearly extirpated, so advanced regeneration was abundant and diverse after partial cuts, and regeneration successful after complete removal cuts. By the 1960's, as the oldest of the second growth forests neared maturity, forest managers attempted to duplicate turn-of-the-century cutting practices and were met by a high proportion of regeneration failures (Marquis 1981). After a 1969 regional symposium, concerned foresters appealed to the USDA Forest Service, Northeastern Forest Experiment Station, to increase staffing at the Warren Forestry Sciences Laboratory and to focus the attention of those researchers on solving regeneration problems.

In one early study of regeneration problems, fences to exclude white-tailed deer were erected inside clearcuts. Regeneration developed successfully inside the fences in 92 percent of the study areas, but developed successfully outside in only 38 percent of the areas. Of the areas that failed to regenerate outside the fence, 87 percent regenerated successfully inside the fence-so deer browsing was responsible for 87 percent of the failures (Marquis 1981). Further research showed that the key to regeneration success was abundant advance regeneration before final harvest (Grisez and Peace 1973), and that such regeneration could be developed through a shelterwood sequence (Marquis 1973).

Transferring Technology

Researchers at the Warren Laboratory considered management implications as they designed and implemented their studies. The key question was, "What factors needed to be measured in an inventory to identify those stands that had a high probability of regeneration success?" Research results were published as management guidelines (Grisez and Peace 1973, Marquis and Bjorkbom 1982, Marquis and others 1984, 1992), but researchers realized that more than publication was needed. Changes in day-to-day field procedures would take hold only if both agency heads and field personnel understood exactly what was required and what benefits they could expect from implementing new, and perhaps more costly, procedures. So, in 1977, personnel from the Warren Laboratory and the Cooperative Extension faculty of the Pennsylvania State

Research Forester and Forester, respectively, USDA Forest Service, Northeastern Forest Experiment Station, Warren, PA; and Silviculturist, USDA Forest Service, Allegheny National Forest, Marienville Ranger District, Marienville, PA.

[1] Robertson, Dale. June 4, 1992. 1330-1 Memo to Regional Foresters and Station Directors.

University instituted a series of l-day workshops. These were intended to teach the results of the research conducted by the staff of the Warren Laboratory and the procedures necessary to use these research results.

From the beginning, the sessions were more than illustrated lectures. Participants learned in the forest on training plots carefully prepared by Laboratory staff and tried the methods the researchers were suggesting. The researcher who developed the advanced regeneration guidelines and the inventory procedure for determining the adequacy of advanced regeneration in stands was present to tell participants whether a particular seedling was countable, and why. Similarly, researchers were present to hear participants' comments about the new procedures. Those early sessions built a strong framework for sharing knowledge and building community. They contained a balanced mix of lecture, field tours, and practice exercises to support a systematic approach to forest inventory, analysis, and prescription development. They also built on the strong sense of community that already existed in forestry in the Allegheny Plateau region, with each session. The session participants always included a balanced mix of public, industrial, and nonindustrial private forest managers, and fostered an atmosphere of dialogue and exchange.

Personnel involved in forest management at the time describe these sessions as a revelation. The idea of basing regeneration prescriptions on an inventory of understory conditions was a new concept in the seventies, and is still not a standard teaching practice at forestry schools and colleges.

Training Sessions Today

There was more than technical revelation at those early sessions. Researchers learned whether the technologies they were proposing could really be implemented. They also learned about emerging management problems. Agencies found that the sessions had unexpected benefits. They oriented new employees to a complex forest ecosystem. They fostered personal and professional relationships between managers and researchers. They provided continuing education to long-term professionals. And the sessions were a good forum for drawing research attention to important current problems.

The originators of the sessions believed that a few sessions over a few years would satisfy the demand, and that another round of sessions might be required every 5 to 10 years. However, the sessions have been given at least twice annually for 17 years to more than 1,000 foresters and related professionals from at least 7 States and 4 foreign countries. At present, the sessions last from noon on Monday through noon on Friday, with each day a busy eight-and-a-half-hour mix of lecture, field tour, and practice exercises. Each session is attended by foresters and related professionals from a balanced mix of public (State, provincial, and Federal) agencies, industry, and private consultants. Several people have attended two or more sessions over the years to keep up-to-date with current research results.

The approach presented in the sessions is an integrated system of inventory, analysis, and prescription. Each major topic in the sessions (regeneration of tree species, intermediate culture of stands undergoing even-aged management, and uneven-aged management) is presented in two related lectures, a field demonstration, and a practice exercise. For each topic, there is one lecture highlighting basic ecological principles that apply to that topic in this forest ecosystem, a second lecture addressing the practices that have been developed on the basis of those principles, a field tour demonstrating both principles and practices, and a classroom, forest, or forest-classroom exercise that allows participants to test the practices.

Lectures and field tours are presented by the researchers who conducted the research, and they remain present for the informal exchanges and the associated exercises. Exercises range from collecting inventory data through analysis and prescription development to marking stands for a treatment developed in the exercises. In addition, lectures and field tours highlight current knowledge concerning key topics like wildlife habitat manipulation, the impact of deer on forest resources, the characteristics of natural disturbance patterns and old-growth in this forest system, biological diversity, and landscape ecology.

Participants provide a detailed evaluation of the sessions as they end, and researchers make fine adjustments to the schedule and the presentations between every session. In addition, there have been major updates to the sessions about every 3 years, as new research results accumulate and are worked into the fabric of guidelines and ecological background.

The systematic approach to inventory, analysis, and prescription taught in the training sessions is known as the SILVAH system, for **SILViculture** of Allegheny Hardwoods. There is a computerized implementation of the system (Marquis and Ernst 1992), but it is not a focal point of the training sessions. The primary goal of this systematic approach is to ensure consistency in prescription among stands and prescribers when management goals are similar. This is achieved by building a common base of ecological knowledge among those who work in this forest ecosystem, and by designing efficient standard inventory, analysis, and prescription procedures that are widely used in the region. The standards and guidelines of the Allegheny National Forest Land and Resource Management Plan (Allegheny National Forest 1986), for example, institutionalize many of these procedures, and they also are used by several industries, State agencies, and private consultants.

The prescription process is built around a family of decision charts (fig. 1) that trace the factors that drive forest stand development and regeneration (Marquis and others 1984, 1992).

In addition to the formal portions of the training sessions, there is time for the all-important socializing that builds a sense of community-coffee breaks and lunches, often in the woods, and the famous Wednesday night steak fry. The sessions are offered now in a forest classroom built through donations from agencies and foundations associated with participants over the years, complete with Allegheny hardwood paneling.

It is during these informal interactions that the researchers find out what is and isn't working in the woods, and learn of new management challenges. It also is in these informal times that participants learn from one another how other agencies are facing common challenges, and it is not unusual for new opportunities for collaboration or new ideas for studies to originate during the social times at these sessions.

Building on the Training Sessions

Several years ago, foresters from the Allegheny National Forest began using area fencing as a management tool to promote successful regeneration where seedlings existed, but in small numbers. At the training sessions, foresters from the districts that were using this practice expressed their concerns about it. Researchers reexamined data from small enclosure studies to show that fences could improve the probability of regeneration success in stands where neither light nor an abundance of interfering plants limited the establishment and growth of seedlings. These results were translated into guidelines for identifying stands with low overstory density and low proportions of interference as candidates for a fence-regeneration prescription (fig. 1).

However, the best outcomes of the training sessions are opportunities for collaborative research and adaptive management. Researchers and managers involved in the development and implementation of herbicide prescriptions for vegetation management on the Allegheny National Forest cooperated together with concerned citizens to design a study of the effects of herbicide use on several representative groups of nontarget species, including songbirds, small mammals, reptiles, and amphibians.

An adaptive management opportunity developed from conversations at the training sessions and elsewhere concerning the impact of white-tailed deer browsing on forest resources (Tilghman 1987, deCalesta[2]). A lo-year study showed that deer impacts were a function not only of deer density but also of available browse, created by thinnings and regeneration cuts. In the deer study areas, successful regeneration of timber species was obtained at very high deer densities because the level of cutting, and hence browse production, was twice that found on typically managed compartments in most ownerships in the region.

Ted Beauvais and Lois DeMarco, of the Marienville Ranger District on the Allegheny National Forest, asked Dave deCalesta, Jim Redding, and Russ Walters of the Warren Laboratory staff to help them try the strategy that had worked in the deer study

[2] deCalesta, David S. Impact of deer on interior forest songbirds in northwestern Pennsylvania. Report on file at the Forestry Sciences Laboratory, Warren, PA.

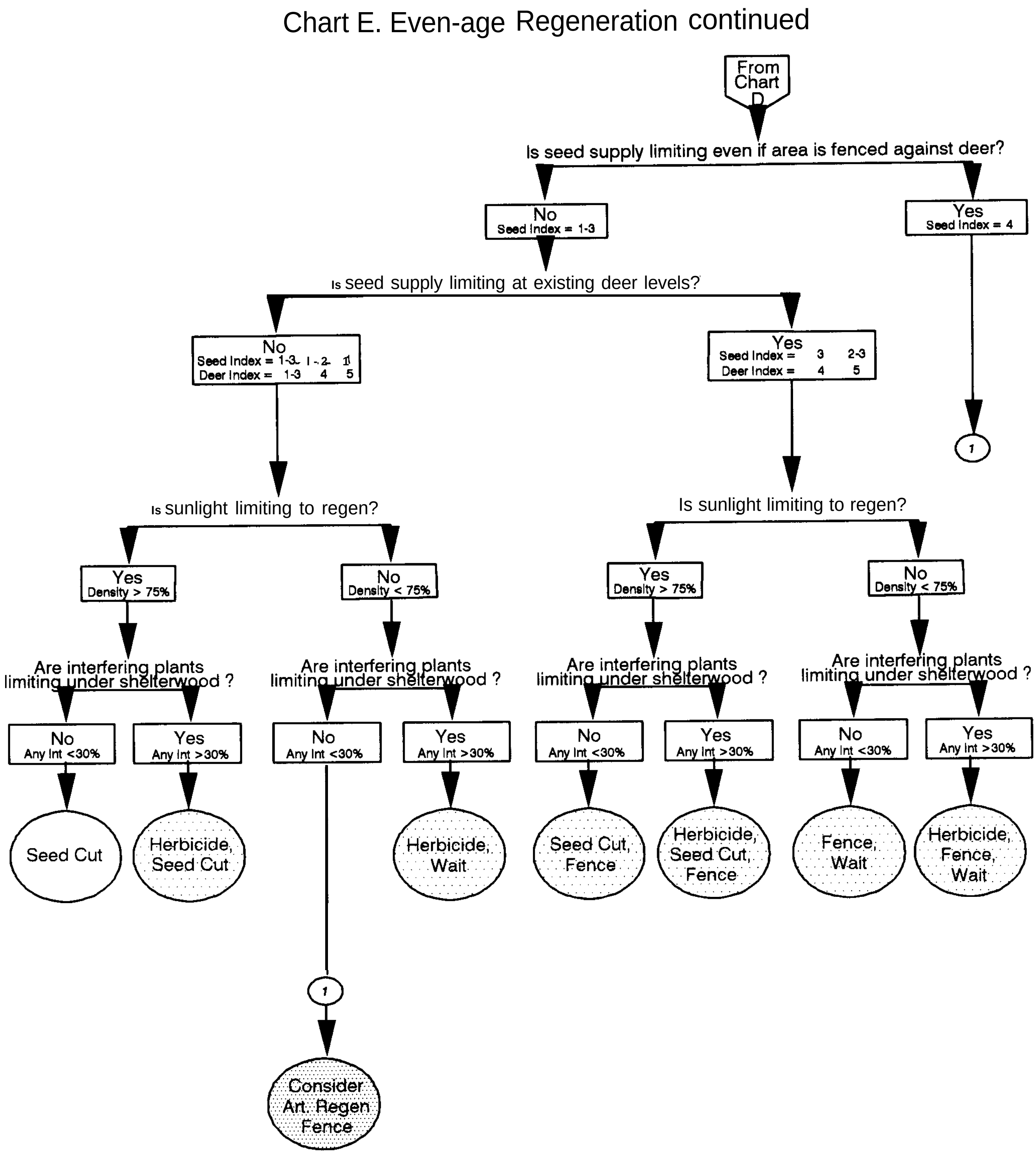

Figure 1-A sample of the decision charts used to select appropriate silvicultural prescriptions during the Allegheny hardwood silviculture training sessions (Marquis and others 1992).

on an operational basis on a district compartment. The compartment they chose, known as Porter's Prize, had not been managed for at least 30 years due to lack of right-of-way access.

This 1,100-acre compartment was located in Management Area 3.0, the portion of the Allegheny National Forest designated under the Forest Plan (Allegheny National Forest 1986) to provide a sustained yield of high-quality Allegheny hardwood and oak sawtimber through even-aged management. An additional objective is to provide a variety of age and size class diversity from seedling to mature forest in a variety of forest types. One of the greatest challenges to achievement of these objectives in Management Area 3.0 has been the lack of advance regeneration and the presence of high proportions of interfering plants in the understories of forest stands, due to the impact of deer over a 50- to 70-year period.

In the face of these problems, compartments like Porter's Prize have traditionally been managed with a mix of intermediate thinnings in all stands that qualified for a treatment, with overstory removals planned for only about 3 to 4 percent of the area. The more traditional approach to Porter's Prize would have resulted in thinnings or shelterwood seed cuts on approximately 47 percent of the area. There would have been no overstory removal cuts as there were no stands with the appropriate levels of advanced regeneration stocking at the time of project planning.

Working with Lab personnel, the District instead chose an alternative with 152 acres of clearcutting, 139 acres of shelterwood seed cutting, and 228 acres of intermediate thinning, or 14 percent clearcut, 33 percent partial cuts, and 53 percent uncut. These proportions are very similar to the 10 percent clearcut, 30 percent thinned, and 60 percent uncut design used in the deer density study. The idea behind this alternative for Porter's Prize was that the high amount of forage produced would reduce deer impact and allow successful regeneration of harvested stands. Lab personnel adopted the compartment as a study site and helped with monitoring and evaluation.

The sale was sold in June 1988, and cut over the next 3 years. A cutting pattern was included in the sale contract that required the operator to remove units in clusters. In each cluster, the partial cutting units were to be cut first and the clearcuts removed last. This was intended to draw deer off harvest units by providing an abundance of fresh tops in the adjacent partial cuts.

By the summer of 1993, Lab personnel completed after-harvest stocking surveys in all of the partial cut and clearcut units. Based on these preliminary surveys and visual observations, District personnel expect to certify stand establishment in all final harvest units within the 5-year requirement of the National Forest Management Act.

In addition to this success, understory development in the partially cut stands is surprising. Seedlings and forbs dominate the understories of these stands, rather than a few ferns and grasses. More woody species than we have come to expect in traditionally managed compartments are surviving and growing in the understories of both these stands and the partially cut stands.[3]

The apparent success of the Porter's Prize compartment provides a natural transition as the members of this community of researchers and managers scale up from stand to stand aggregate, ecosystem, and landscape scales for ecosystem management. Plans are underway to follow up on the developments at Porter's Prize with more complete ecosystem inventories and with additional silvicultural manipulations to take advantage of the diverse and desirable regeneration developing in partially cut stands. Additional plans call for replications of the Porter's Prize experiment in other compartments, and a careful look at developments in uncut stands within compartments producing large amounts of forage.

These developments also point the way for the next major update to the training sessions. The results of this successful cooperative effort of researchers and resource managers will thus be shared with others in the community. Through the information-sharing at the training sessions, we will lay the groundwork for more adaptive management projects. The training sessions and related technology transfer and adaptive management projects enable us to undertake the challenges of ecosystem management confident that our research-management partnership is strong.

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[3] Walters, Russell S. 1993. Progress/final report for Study 94: Intensified cutting within a forest compartment. Report on file at the Forestry Sciences Laboratory, Warren, PA.

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A Long-Term Management and Research Partnership Facilitates Ecosystem Management Opportunities in a Montana Western Larch Forest

Raymond C. Shearer, Peter F. Stickney, James H. VanDenburg, and R. Steven Wirt

Abstract

The Miller Creek Demonstration Forest on the Tally Lake Ranger District, Flathead National Forest, was formally established in 1989 to capitalize on 23 years of research in this western larch forest and to apply the knowledge to ecosystem management projects. Cooperation from 1966 to 1989 created a close management/research partnership. Research showed the effects of quantified fires conducted over a range of fuel and environmental conditions on air quality, plant succession, conifer regeneration, water quality, erosion, and small animal populations. Brochures and signs show visitors the results of research and ecosystem management projects.

Introduction

Fire is the most dramatic ecological force in western larch forests. Prior to the 1960's, prescribed fire was being used to emulate the natural role of fire, but we did not know how, when, and where to burn effectively. Consequently, results were usually unpredictable. Also, we had only limited knowledge of the effects of prescribed fire on physical and biological factors. This led to the initial cooperative efforts to fill these knowledge gaps. In the mid-1960's, Beaufait (1966) determined that more use of prescribed broadcast burning and extension of the burning season into the spring and summer period would be necessary if natural regeneration objectives were to be met on the national forests of the Intermountain and Northern Regions of the USDA Forest Service. Both land managers and research scientists recognized the need to improve the results of prescribed burning. In June 1966, a memorandum of understanding, signed by the Regional Forester of the Northern Region and the Director of the Intermountain Research Station, committed Forest Service researchers and managers to cooperate to solve this problem. Western larch forest type was deemed the highest priority for study (*Larix occidentalis*) (Society of American Foresters 1980), growing on sites where subalpine fir (*Abies lasiocarpa*) was climax. In 1966, Miller Creek, a 5,000-acre watershed (Tally Lake Ranger District, Flathead National Forest, near Whitefish, MT) was selected for study. In this relatively uniform, cool, moist environment, the *Abies lasiocarpa/Clintonia uniflora* habitat type (Pfister and others 1977) predominates. Three phases of this habitat type were represented: *Menziesia ferruginea* on upper, cooler, moister slopes; *Xerophyllum tenax* on warmer and dryer slopes; and *Clintonia uniflora* on the remaining mesic sites. Sixty lo-acre units (15 each on slopes facing each of the 4 cardinal directions) were marked for clearcut and broadcast burn treatments; 53 units were within the Miller Creek drainage and 7 were within the Martin Creek drainage. These units were logged from January 1967 through January 1968. Prescribed fire treatments were applied in July, August, and October 1967 and from May through October 1968. A wildfire on August 23, 1967, burned eight clearcut and five uncut units. Although unexpected, the wildfire provided a unique opportunity to compare regeneration and plant succession on wildfire and prescribed burned areas.

Excellent cooperation between scientists and land managers enhanced the amount and quality of data collected and improved management practices. In June 1989, the Flathead National Forest designated this area as "Miller Creek Demonstration Forest" and signed a memorandum of understanding with the Intermountain Research Station to protect existing study areas and promote future research.

This paper outlines research conducted on this area and discusses the value of this database to understanding the effects of timber harvest and fire treatments on ecosystem functions, such as vegetation and small mammal succession, soil

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erosion, water quality, and conifer regeneration (fig. 1). Results of this research provide a database to evaluate effects of contemporary management practices, not only on this area, but also on comparable sites within the natural range of western larch.

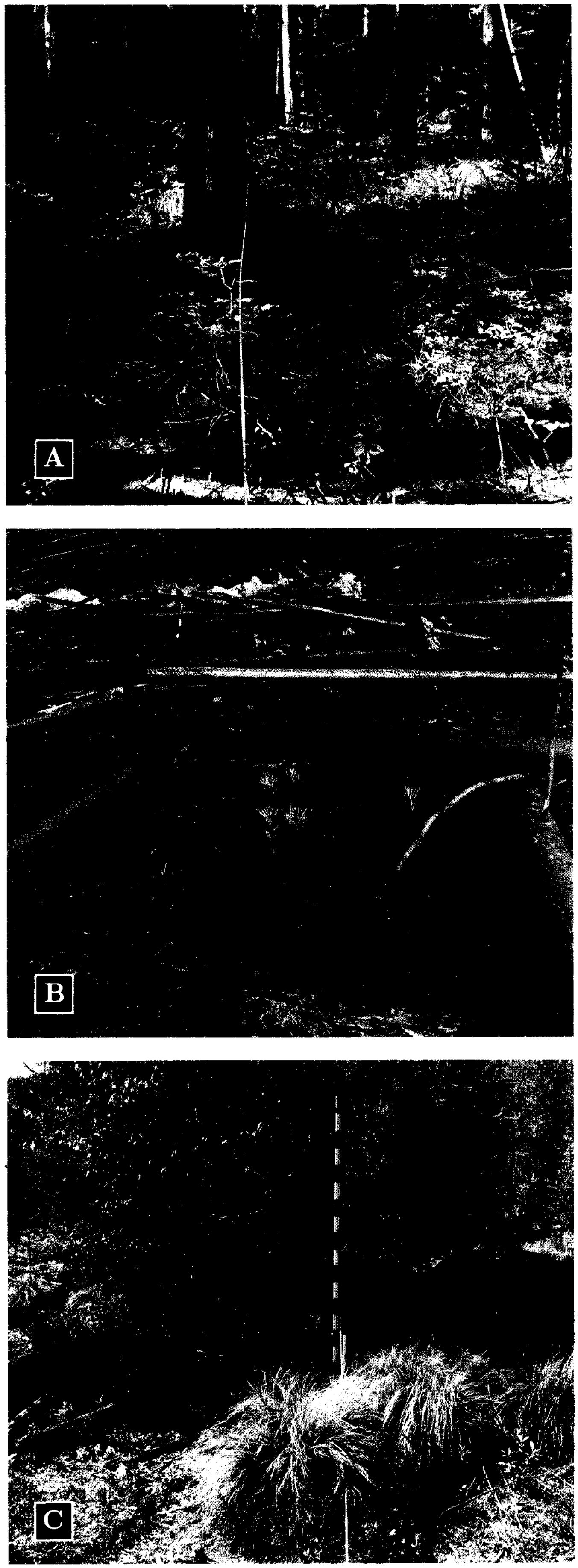

Figure 1—Changes in vegetation on a south-facing slope harvested and slashed in June 1967 and prescribed broadcast burned on May 18, 1968: (A) September 8, 1966 (preharvest); (B) September 12, 1968 (one growing season after fire); and (C) July 20, 1992 (25 growing seasons after fire).

Research

In 1966 and 1967, the effects of treatments (clearcutting, ground-lead skidding, and broadcast burning of slash) within Miller Creek's old-growth forests were studied from several perspectives. DeByle (1981) summarized: "Fire behavior and amount of fuel and duff consumed were related to fuel and weather variables by fire scientists; smoke production and dispersion were studied by air quality engineers; seedbed preparation and establishment and growth of conifer seedlings were measured by silviculturists; successional development and amount of cover afforded by vegetation growing on the burns were traced through several years by plant ecologists; numbers and species of small mammals on treated and on control areas were quantified by a wildlife biologist; and physical and chemical impacts on soil and on runoff waters were determined by watershed and soil scientists." Most studies had ended by 1974. But, plant succession studies continued until 1992 and forest development research will continue indefinitely.

A multidisciplinary team of scientists from seven research units worked closely with Forest Service managers through a coordinator on the Tally Lake Ranger District to locate plots and make measurements before, during, and after harvest and prescribed fire treatments. The large mass of data resulting from these studies were reported in symposium proceedings, journal articles, and Forest Service publications, and during field trips and workshops.

The objectives of the studies (Beaufait and others 1977) and a brief summary of results published by DeByle (1981) illustrate the nature and extent of research accomplishments.

Fire Behavior and Effects

Objectives-(1) Correlate fuel and weather conditions with the amount of duff reduction and mineral soil exposure. (2) Identify indices characterizing fuel and weather conditions that produce a burn of a specific quality. (3) Predict prescribed fire smoke column height from fuel conditions and environmental factors. (4) Provide a basic design and field layout for studies by other research groups.

Results-Data from this and similar studies in western Montana provided information leading to the development of guides for use of fire as a management tool. Managers can predict and control prescribed fire's effects on smoke dispersal and air quality, site preparation, early succession of plants and small mammals, and water and soil resources (DeByle 1981). Quantification of the effects of fire on these resource values ranged across a broad spectrum of fire intensity and effectiveness of slash and duff reduction (Norum 1977). Results show that fire can be used with precision to accomplish many management goals (Beaufait 1971).

Air Quality and Smoke Management

Objectives-(l) Determine the range of combustion product emissions from a series of prescribed burns conducted under varying fuel moistures and meteorological conditions. (2) Monitor the movement and dispersal of the emissions.

Results-Fires in 1967 and 1968 at the Miller Creek Demonstration Forest produced about 30 pounds of airborne particulate per ton of fuel consumed (Adams and others 1976). Managers can control the timing and quantity of emissions from prescribed fires and the ratios and location of polluted air (DeByle 1981). This research showed the value of local forecasts of wind direction and velocity because fire intensity can override the influence of the prevailing height of free air convection (vertical transport of particles) and the velocity and direction of surface winds (Norum 1974). Ground-level effects of fires on air quality downwind were detectable on burning days, but not afterward.

Small Mammal Populations

Objectives-(l) Identify species composition and relative abundance on uncut and on clearcut and burned areas. (2) Relate successional patterns of mammals to plant succession after treatments.

Results-From 1967 to 1974, rodent populations increased greatly on areas with clearcut and broadcast burn treatments, especially populations of rodents that eat conifer seeds and can drastically limit tree regeneration (DeByle 1981). Changes in deer mouse (*Peromyscus maniculatus*) composition changed the most: from an average of 10 percent of the total small mammal population in undisturbed forests to an average of 74 percent in burned clearcuts. Conversely, composition of redback voles (*Clethrionomys gapperi*) decreased from 44 percent of all small mammals on forested sites to 2 percent within treated areas. During the same period, chipmunks (*Eutamias* spp.) decreased from 25 percent of all small mammals to 8 percent on treated units. During these 7 years, the number of deer mice increased 69 times on burned clearcuts in comparison to the uncut forest. Also, the number of redback voles decreased by half and the number of chipmunks nearly tripled on the burned clearcuts.

Soil Erosion

Objectives-(l) Determine which vegetal, soil, and topographic factors affect overland flow and soil erosion. (2) Measure the effect of varying intensities of broadcast burning on overland flow and erosion. (3) Develop means for predicting expected overland flow and erosion after burning under selected prescribed conditions.

Results-Broadcast burning slash and other woody debris neither induced unacceptable water repellency nor did it reduce organic matter unacceptably in the surface mineral soil (DeByle 1981). Recovery of vegetation quickly reduced the probability of soil erosion from all the sites. Even during the first year after burning, only a few hundred pounds of soil per acre moved by water into collection tanks; an amount that easily can be kept from streams by buffer strips (Packer and Williams 1976). However, complete consumption of the surface organic horizon by fire may promote surface soil erosion from intense summer rainfall on slopes averaging 55 percent or greater. We also learned that lower intensity fires should be used on south-facing slopes where soil and vegetation were impacted the most by fire and where vegetation recovered more slowly.

Water Quality

Objectives-Determine the changes in soil chemistry and fertility, the quality and nutrient content of overland flow, and the plant nutrient losses as a result of treatments.

Results-Changes in the nutrient status associated with clearcutting and fire treatments at Miller Creek should not adversely alter site quality (DeByle 1981). Nutrient cycling rapidly returned to pre-burn conditions with the robust recovery of vegetation on these sites. Burning volatilized a third of the nitrogen in the surface organic horizon (DeByle 1976). After burning, a layer of debris and ash was deposited on the surface of unburned duff and bare soil; the debris and ash leached and eroded during the next 2 years, temporarily reducing the nutrient content of this layer (DeByle and Packer 1972). Phosphorus, potassium, sodium, calcium, and magnesium nutrients were held within the rooting zone, while nitrogen was leached below the rooting zone.

Plant Succession

Objectives-(1) Describe quantitatively the development of seral forest communities after clearcutting and broadcast burning. (2) Determine the influence of pre-logging vegetation and the different treatments on vegetal development patterns.

Results-As heating increased at the soil surface during the fires, more resident plant species died, making the site more favorable for off-site colonizers to establish (DeByle 1981). Units with the driest lower duff at the time of burning produced site conditions most favorable to pioneer species such as: the herb, fireweed ***(Epilobium angustifolium)***; shrubs, shinyleaf ceanothus (***Ceanothus velutinus***) and Scouler's willow (***Salix scouleriana***); and trees, western larch and lodgepole pine (***Pinus contorta***). The potential for changing vegetation composition is greatest after severe fires that remove most of the duff layer and least after fires that leave much of the litter layer and logging residues intact (Stickney 1985). For example, on south-facing slopes, a midsummer wildfire that removes most of the duff layer under an uncut forest can be compared with a midspring prescribed fire that removes less than half of the duff layer. Pioneer species made up a high percentage of the plant community after a stand-replacing wildfire (Stickney 1980, 1990), but constituted a lower percentage of the initial postfire community after the spring fire. Without fire or other disturbance, clearcutting by itself causes little change in species composition (Shearer and Stickney 1991).

Silviculture

Objectives-(1) Determine how regeneration of selected conifers was influenced by seedbed condition and other site factors following treatments. (2) Contrast these results with nearby uncut areas burned by wildfire or slashed but unburned clearcuts.

Results-Greatest duff reduction and soil heating, with their associated root mortality, occurred when the water content of duff and upper soil was the lowest (Shearer 1975). Slash must be burned when the duff is dry to significantly reduce the organic mantle of the litter and duff layers. Early regeneration of conifers was greatest on sites where most of the duff layer was removed by fire (Shearer 1976). More seedlings germinated on bare soil than on sites with more than a half-inch of unburned duff (DeByle 1981). Successful site preparation on north-facing slopes may only be possible in midsummer to late summer. Factors contributing to seedling mortality were birds, fungi, moisture stress, and high surface temperature. Pioneer tree species such as western larch and lodgepole pine rapidly grew in height, overtopping shrubs 7 years after treatment; shade-tolerant species required much longer to overtop shrubs (Shearer and Stickney 1991). The percentage of conifer cover increased slowly; conifer cover usually required at least 20 years to equal shrub cover. On clearcuts without fire, trees were composed mainly of shade-tolerant advanced regeneration (mostly Engelmann spruce and subalpine fir and their shrub and herb understories). On burned sites, plantations of larch, Douglas-fir, and Engelmann spruce were still taller than natural regeneration 15 years after treatment (Shearer 1988).

Management

Because the research effort for the burning study was nearing completion, Flathead National Forest sought to maintain the research contribution to future management decisions by creating the Miller Creek Demonstration Forest in June 1989. Prior to this designation, we made several visits to the site and discussed future management options for the area. We agreed that all future projects should build on the knowledge gained from experience and from research conducted there since 1966. This designation strengthens and reinforces the partnership between research and management. Past research focused on fire behavior, air quality, small mammals, soils, water quality, plant succession, and silviculture; new management practices will emphasize ecosystem management. The results of past and ongoing studies will be used to help evaluate its performance.

Examples of projects planned for implementation at Miller Creek and their objectives are:

1. Determining the role of precommercial and commercial thinning in biodiversity and ecosystem management.

- What species composition and spacing will lead to desirable conditions in a given landscape?

- What are the desirable/undesirable effects of shade-tolerant understory trees within a stand of intolerant crop trees?

- What are the results of varied tree spacing within an area?

2. Managing two-storied, even-age stands with and without a fire treatment.

- How do such stands develop with and without fire?

- Will additional treatments create desirable attributes within two-storied stands at an earlier age?

- What are the results of wildfire on two-storied stand structures?

3. Identifying desirable attributes of old-growth that can be enhanced through management of young stands.

- What are the results of a range of treatments on development of old-growth?

- Can desirable attributes be obtained earlier through silvicultural practices?

- What effect do management practices have on wildlife species that prefer old-growth conditions?

4. Blending past harvest practices (principally clearcutting) and new harvest or thinning practices into ecosystem management.

- How can past stand management be incorporated into ecosystem management at the landscape level?

- Can the patterns of block stand management be modified through silvicultural practices in adjacent stands?

- What role will prescribed fire play in ecosystem management?

Past, current, and future research at Miller Creek provides baseline information to evaluate new ecosystem management practices. This information can aid the manager in judging the degree of success of different practices. Mapping with Geographic Information Systems will help managers use ecosystem management principles at the landscape level. Results from Miller Creek will be applied to other areas within the western larch forest type.

In addition to the expanding database documenting past and current treatments, Miller Creek has an important role in informing and educating the public. Objectives of this Demonstration Forest are to show results of past and current practices (including ecosystem management) and to encourage public participation in the forest's management. At the Miller Creek Demonstration Forest, visitors can view a wide range of successional responses to treatments and compare them to current and future management. Signs along roads and trails, brochures, and knowledgeable personnel will explain the projects to visitors.

Summary

The Miller Creek Demonstration Forest offers a unique opportunity to apply the results of past research to future ecosystem management treatments and add to the database to compare our progress over time. It also provides an atmosphere in which the public can be encouraged to learn more about this area and ecosystem management and to become involved in their futures.

The Flathead National Forest and the Intermountain Research Station are committed to continuing the strong partnership between management and research developed during the past 27 years. We look forward to using the past experience and information to improve our management practices in the future.

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Research and Demonstration of Ecosystem Management Principles in Ponderosa Pine/Douglas-Fir Forests: Lick Creek, Bitterroot National Forest

Clinton E. Carlson, Rick Floch, and Carl Fiedler

Abstract

Selective harvest and fire exclusion in the northern Rocky Mountains during the last century have significantly changed forest structure and species composition. Current research and management activities will develop future forests that will be more in harmony with fire ecology. These activities are expected to benefit wildlife, recreation, wood products, and other resources. Specific studies and progress through 1993 are described.

Introduction

Coniferous forests of the northern Rocky Mountains in the United States have changed substantially in the last 100 years. This is especially true for the lower elevation, semiarid montane forests (Arno 1980, 1988; Gruel1 1985). Prior to the 1900's, these forests were dominated by parklike stands of old-growth ponderosa pine (*Pinus* ponderosa Dougl.), western larch (*Larix occidentalis* Nutt.), and interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco; the understory was grassy with scattered shrubs and occasional thickets of young conifers. Wildfires were frequent; fire-free intervals averaged 5 to 15 years. The old-growth seral ponderosa pines, highly valued as timber, were for the most part removed from the landscape by the early 1970's. Frequent fire was removed too. The combination of these two management actions-preferential removal of the seral species and effective fire prevention/suppression, set the stage for a change of species composition across the landscape. Shade-tolerant grand fir and Douglas-fir in great part replaced the old-growth ponderosa pine forests. These new forests, besides being far more susceptible and vulnerable to insects (Anderson and others 1987; Carlson and Wulf 1989), disease, and stand-replacing wildfires, are much less esthetic and may be less hospitable to many types of wildlife. Forest managers, researchers, and concerned publics agree that a change in management perspective is in order; that we must take an ecosystem approach to future management rather than focusing mainly on the timber resource (Gillis 1990). How can we accomplish this job? Integrating and optimizing multiple resource outputs over landscapes is a significant challenge. Clearly, we need to conduct studies that will guide future management.

Lick Creek, northwest of Darby, MT, manifests many of the problems caused by selective harvesting and fire exclusion and is a good area to study remedial activities. Lick Creek is a minor drainage located *on* the east slopes of the spectacular, rugged, Bitterroot Mountains in Montana. The drainage is about 20 km^2 in area and ranges in elevation from 1,600 m in the foothills of the Bitterroot Valley to 2,380 m in the Selway/Bitterroot Wilderness to the west. Frequent wildfire was common; pre-1900 fire-free intervals were estimated to average 7 years (Gruel1 and others 1982). The area contains a diversity of resource values. It is adjacent to a high-use recreation area at Lake Como. An off-highway loop road through the area provides users with a scenic forested drive to and from this recreation area. At lower elevations, the Lick Creek drainage provides excellent winter range for deer and elk. The Bitterroot Valley is developing rapidly, and this winter range will become ever more critical. Lower elevation sites in Lick Creek are also relatively productive. Besides providing wildlife habitat and recreation amenities, the area can provide high quality ponderosa pine timber.

History of the area also offers a unique opportunity for interpretation. A large natural salt lick for which Lick Creek is named was probably a kill site used by Native Americans. Lower elevation forests at Lick Creek comprised

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the first ponderosa pine timber sale in the Forest Service's Northern Region in 1906. This original sale was logged with horses and steam donkeys, and many of the original railroad beds are still evident.

Photo points established in 1909 after this early sale have been photographed several times since the sale, providing a rare opportunity to document forest succession in managed stands of ponderosa pine over 80 years (Gruel1 and others 1982), and for another decade to the present. Harvest records and growth data are also available for this area. This information, combined with the unique values that the Lick Creek area provides, make it an excellent candidate for a demonstration/research forest.

Soon after the forest plan for the Bitterroot National Forest was completed in 1987, the ideas and principles of New Perspectives (precursor to the concept of ecosystem management) moved to the forefront of national forest resource management. Faced with the challenges of New Perspectives, employees of the Darby Ranger District initiated an Integrated Resource Analysis to implement the forest plan in the Lick Creek area. Focusing at the landscape level of analysis, and in partnership with research scientists, county officials, concerned publics, including leaders of special interest groups, public meetings were held during the fall and winter of 1989. At these meetings, public issues were identified, resource information was collected to respond to these issues, and forest plan goals and direction were reviewed. Significant issues included: a concern that past logging and road building had resulted in a current watershed condition that was at the adjusted sediment threshold for fish; road densities were not meeting forest plan standards for elk habitat effectiveness; and several areas were not meeting forest plan standards for old-growth habitat. Forest plan objectives for this area included optimizing elk winter range, producing wood products, and maintaining the visual quality objectives.

At the completion of these meetings, planners developed a desired future condition for the Lick Creek area and a list of management activities that would begin moving the Lick Creek landscape toward that goal. This integrated resource analysis fulfilled the requirements of the National Forest Management Act and once the list of projects was developed, environmental analysis and alternative development as required by the National Environmental Policy Act were initiated.

During the meetings to identify issues for the Lick Creek area, the idea of making the Lick Creek area a demonstration/research forest took shape. The historic records of the 1906 timber sale, growth response data recorded some 35 years later, and the photo point historical sequence provided an interesting story of how the area had changed since the first harvest. The present condition of vegetation at lower elevations showed that logging and fire control in the Lick Creek area since the early 1900's had caused major changes in stand structure and species composition. Stands probably were uneven-aged and highly productive. Today, second growth ponderosa pine and Douglas-fir occupy most of the landscape. Despite the several harvests and thinnings since 1900, stands are overstocked with conifers, and wildlife forage (grasses) is much reduced compared to pre-1900 conditions. Insects and disease are impacting forest health, and risk of severe wildfire concerns land managers, particularly as more and more homes are built in the low-elevation forests of the Bitterroot Valley.

The challenge that was identified during the public meetings was to guide the Lick Creek area on a trajectory toward stand structures that would enhance wildlife habitat, improve esthetics, and enhance tree growth and development. To this end, the Bitterroot National Forest, the Intermountain Research Station, and the University of Montana entered into cooperative agreements to conduct studies that will provide a sound basis for ecosystem management in Lick Creek and similar landscapes. This cooperation is formalized in a memorandum of understanding between the Bitterroot National Forest and the Intermountain Research Station, and in Research Joint Venture Agreements between the University and Research Station. The Research/Demonstration Forest was officially established in February 1991 with the focus on demonstrating valid operational approaches to ecologically sustainable and environmentally sensitive long-term forest stewardship.

Demonstration Projects

To date, the demonstration projects identified during the Integrated Resource Analysis that are being implemented include:

1. Demonstration of the effects of different harvesting/fire regimes on regeneration and growth of ponderosa pine, on bitterbrush (*Purshia tridentata* (Pursh.) DC), on bird use, and on public perceptions. All harvests retain an overstory of the most vigorous ponderosa pine available.

2. Timber harvesting to improve views from the loop road through Lick Creek.

3. Timber harvesting and fuels disposal to reduce dwarf-mistletoe (*Arceuthobium douglasii* Engel.) infections in Douglas-fir, reduce risk of intense wildfire in the nearby forested residential zone, and to reduce the risk of mountain pine beetle (*Dendroctonus ponderosae* Hopkins) epidemics in lodgepole pine (*Pinus contorta* var. *latifolia* Engelm.).

4. Watershed rehabilitation through road reconstruction, road and area closures to motorized vehicles, and off-road vehicle trail rehabilitation.

5. Development of a self-guided interpretive auto tour and historic district in the Lick Creek area.

These projects are close to being fully implemented at this time.

Research Projects

Ecosystem management is a broad topic with many themes. For Lick Creek, which in principle represents a significant area of the northern Rocky Mountain landscape, we elected to conduct a series of studies that focus on a return to stand structures that are sustainable considering the fire ecology of the area. In these studies, we feature management of ponderosa pine, the principal seral species extant at Lick Creek in pre-settlement times. The idea is to develop stands that have a significant component of large diameter pine, along with younger age classes, too, and to maintain a large diameter class indefinitely through time. Prescribed light surface fires will be scheduled periodically to regulate the Douglas-fir and grand fir regeneration.

Timber harvests will be scheduled coincident with the burning and will be tailored to develop uneven-aged stand structures through time. To accomplish this, selection and irregular shelterwood silvicultural systems will be used. The timber harvest and burning will be the dominant vegetation management activities undertaken. This action should benefit wildlife habitat, esthetics, timber production, recreation, and forest protection (fire, insects, and disease) by maintaining vigorous tree growth dominated by seral species. In short, it should have a stabilizing influence on the treated areas. Effects of this management on nutrient flow, shrubs, forbs, and grasses, wildlife use, and public perceptions of our activities will be measured, analyzed, and documented.

At Lick Creek, ecosystem management includes timber harvest. Manipulation of the vegetation must, in large part, deal with the conifer resource, perhaps giving the research a look of "just another timber sale." However, this simply is not the case at Lick Creek. Timber must be harvested to reduce stand densities, favor seral species, and prepare the sites for prescribed surface fires, especially since fire has been excluded for nearly a century.

Methods

All of the ecosystem management and research at Lick Creek is being conducted under the general guidance of Intragency Agreement No. INT-91567-IA between the Intermountain Research Station and the Bitterroot National Forest. This Agreement assigns responsibilities to the Station and the Forest such that the integrity of the ecosystem management/research is assured.

The following studies have been designed to meet our objectives at Lick Creek. The objectives of these studies are listed here: details are given in the study plans on file at the Forestry Sciences Lab in Missoula, MT.

1. Evaluation of shelterwood cutting and prescribed burning for enhancing multiresource values of second-growth ponderosa pine stands. Study Plan No. INT-4403-120. Principal Scientist: Stephen F. Arno, Research Forester, RWU-INT-4403; 1991.

Objectives

This study tests prescribed underburning in moist and dry duff, applied in conjunction with shelterwood cutting, as methods for maintaining and perpetuating seral ponderosa pine stands that have high values for wildlife habitat and esthetics as well as value for timber production and other resources. Specific questions are:

a. How effective are these underburning regimes in killing unwanted understory trees (primarily Douglas-fir and grand fir (*Abies grandis* (Dougl.) Forbes) without damaging the overstory?

b. How effective are different underburning regimes in preparing seedbeds for natural regeneration of ponderosa pine?

c. How do the different underburning regimes affect composition of undergrowth vegetation, including wildlife forage plants?

It is recognized that even if efforts to obtain regeneration of ponderosa pine on these sites are successful, accompanying regeneration of fir is virtually inevitable and is desirable to maintain stand diversity. The silvicultural goal and challenge, however, is to perpetuate pine as the principal stand component.

2. The impact of different fire treatments on survival and growth of thinned, immature ponderosa pine. Study Plan No. INT-4403-119. Principal Scientist: Mick Harrington, Research Forester, RWU-INT-4403.

Objectives

The general goal of this study is to test the effects of three contrasting fire treatments on subsequent mortality and growth of immature trees in a recently thinned stand of ponderosa pine poles. Frequently, thinning slash and natural fuels are either left untreated or are treated with fire under moist conditions such that only the fine fuels are consumed. In addition to these two treatments, a burn resulting in much greater fuel reduction will be tested. Specific objectives are:

a. Determine the impact of different fire treatments (levels of fuel consumption) on overstory injury including crown scorch, bole char, and root damage.

b. Determine the effect of different levels of heat injury on tree survival.

c. Determine the effect of different levels of heat injury on subsequent tree diameter and height growth.

d. Determine the effect of the general fire treatments on subsequent diameter and height growth of uninjured trees.

e. Determine the effect of the fire treatments on soil nutrient availability.

f. Determine the effect of the fire treatments on soil moisture availability.

3. Evaluation of uneven-aged silviculture and underburning for managing ponderosa pine/Douglas-fir forests in Montana. Principal Scientist: Carl Fiedler, School of Forestry, University of Montana. (Research Joint Venture Agreement INT-91616-RJVA with U of M; INT ADOR: Clinton E. Carlson.)

Objectives

This study uses uneven-aged, regulated silviculture to develop stands composed mostly of ponderosa pine, with significant age, diameter, and height structure. Prescribed fire will be invoked to reduce fuels and prepare seedbeds for regeneration of ponderosa pine. Specific objectives are:

a. Compare density and stocking of natural regeneration under the individual tree selection method using alternative residual density levels and site preparation treatments.

b. Develop a small-tree height/age model for ponderosa pine growing in uneven-aged stands.

c. Evaluate angle count (Bitterlich), angle summation (Spurr), zone count (Opie), and multiple-BAF (Zeide) as measures of point density for determining the competition environment of individual trees.

d. Compare stand volume increment (cubic foot and board foot) under the individual tree selection method using alternative residual density levels and site preparation treatments.

e. Compare P-inch diameter class volume increment (cubic foot and board foot) under the individual tree selection method using alternative residual density levels and site preparation treatments.

The stand structures, residual densities, and forest floor conditions created in this study will also provide experimental material for other aspects of the overall Lick Creek research effort. Among-treatment comparisons of proposed associated studies include: (1) species composition and biomass of shrubs, forbs, and grasses; (2) causes and amount of annual tree mortality; (3) scenic beauty estimation, and (4) nutrient composition of tree foliage and soils.

4. Public perceptions of New Perspectives forestry: Lick Creek, Bitterroot National Forest Principal Scientist: Robert Benson, Systems for Environmental Management, Missoula, MT. (Research Joint Venture Agreement INT-91622-RJVA with SEM; INT ADOR: Clinton E. Carlson.)

Objectives

This study determines public response, in terms of visual preference, to several types of partial stand harvesting and underburning methods (studies 1, 2, and 3 above) at Lick Creek and determines costs associated with this level of ecosystem management. Specific objectives are:

a. Evaluate and compare how viewers respond to different treatments in terms of their visual preferences.

b. Document and compare effectiveness of treatments in terms of visual characteristics through photographic records and related vegetative and other data.

c. Analyze specific management treatments in terms of how they add or detract from the visual resource.

d. Determine costs associated with this level of ecosystem management.

5. Evaluating growth and yield from 35 years of silvicultural partial cuttings with multiple entries in seral ponderosa pine stands of western Montana. Principal Scientist: James Menakis, School of Forestry, University of Montana. (Agreement No. INT-92656-RJVA; INT ADOR: Clinton E. Carlson.)

Objectives

The objective of this work is to remeasure a system of existing permanent plots installed in 1948 and 1954 and determine effects of varying levels of basal area on growth and development of the residual stand and subsequent ingrowth. Reasonably good records were kept on data taken from the permanent plots. This provides a standard against which to compare current measurements of height and diameter growth of ponderosa pine and Douglas-fir under varying amounts of competition.

6. Avian abundance and foraging behavior in relation to retention shelterwood harvest and surface fire. Principal Scientist: Sallie Hejl, RWU-INT-4201, (Exploratory study, formal study plan to be written in winter, 1994.)

Objectives

This study will determine the influence of retention shelterwood harvest and prescribed light surface fire on diversity, abundance, and foraging behavior of avian fauna.

7. Response of willow and bitterbrush to shelterwood cutting and underburning treatments in a ponderosa pine forest. Principal Scientist: Donald Bedunah, School of Forestry, University of Montana, Missoula. (Research Joint Venture Agreement No. INT-92684-RJVA. INT ADOR: Michael Harrington, IFSL, Missoula, MT.)

Objectives

This study will determine the effects of alternative silviculture and fire treatments on wildlife habitat. Specific objectives are:

a. Determine effects of a shelterwood cut and prescribed fire treatments on survival and seedling establishment of Scouler's willow (*Salix scouleriana* Barratt) and bitterbrush.

b. Determine effects of a shelterwood cut and prescribed fire treatments on leaf and twig production and nutritive value of bitterbrush and Scouler's willow.

8. Influence of prescribed underburning under a retention shelterwood cut on survival and growth of planted western larch and ponderosa pine. Study plan No. INT-4151-033. Principal Scientist: Clinton E. Carlson, RWU-INT-4151.

Objectives

a. Compare and contrast growth and survival of western larch *Larix occidentalis* Nutt.) planted barely outside its natural range to growth and survival of planted ponderosa pine.

b. Determine the effects of partial canopy cover (shelterwood cut) and prescribed surface fire on growth and survival of planted western larch and ponderosa pine seedlings.

Analyses and Publication

All of these studies are active and will be for the foreseeable future. From time-to-time we will prepare a synthesis document to integrate results among the various studies. Copies of formal reports, publications, and other documents concerning this collective research will be maintained by the Intermountain Research Station, Research Work Unit 4151, Forestry Sciences Laboratory, Box 8087, Missoula, MT. These studies, either individually or collectively, will generate data and inferences that will guide future management on similar sites throughout the northern Rocky Mountains. They will be available on request.

Current Status

All prescribed burns are complete in the retention shelterwood and selection units and most are done in the thinning unit. All pre-treatment data have been recorded for all units; some post-treatment data have been taken in the burned units. The timber harvest caused minimal impact to the ecosystem, and met the spirit and intent of the silvicultural prescriptions. The retention shelterwood harvest truly is a shelterwood, with the best of the pine trees left uncut at basal area of about 100 ft^2 per ha. The selection cutting also met treatment objectives; the best quality trees were left in all diameter classes (including many large diameter ponderosa pines). The stand structure is now diverse in terms of age and size. This should set the stage for a continuous flow of resource outputs, not the least of which will be wildlife and visual amenities. The thinning also was done well, releasing not only the residual pines but also the understory vegetation.

In the summer of 1994, we will have the first full set of post-treatment data and we look forward to the results. Thus far, public response to the Lick Creek effort has been favorable. In a more general sense, public land management on the Bitterroot is gaining favorable support.

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Building National Forest System-Research Partnerships for Ecosystem Management of East-side Oregon and Washington Forests

Andrew Youngblood, Richard Everett, and Matt Busse

Abstract

Formation of partnerships to achieve shared goals, a guiding principle of the Forest Service *mission,* is actively being pursued at the Pacific Northwest Research Station. Strong working relations between the National Forest System and Forest Service Research are essential if we are to address priority resource issues, develop new technology needed by resource managers, and expand the frontiers of science to meet future resource challenges. Examples of formal and informal partnerships between the Pacific Northwest Research Station and east-side forests in Oregon and Washington include the Rare Plant Consortium, long-term site productivity studies, the High Desert Learning Center, and landscape-scale adaptive management.

Introduction

Central and eastern Oregon and Washington comprise a vast and diverse geographic region containing roughly two-thirds of the total land area of the two States. From elevations of about 3050 m at the crest of the Cascade Range, the diverse landscape to the east includes mountain range, near desert, and high plateau environments. Physiographic and geological provinces of greatest interest in east-side forests include the Okanogan Highlands, Northern Cascades, Southern Washington Cascades, High Cascades of Oregon, and the Blue Mountains.

USDA Forest Service research units of the Pacific Northwest Research Station (PNW) in Bend and La Grande, OR, and Wenatchee, WA have a history of contributing to the understanding of resource management and productivity in forests east of the crest of the Cascade Range in Oregon and Washington. Research emphasis at the Silviculture Laboratory in Bend, OR, for the past two decades has included wildland fire behavior, fire effects, and the silviculture, growth, and yield of key tree species. Domestic livestock-wild ungulate relations, forest insect ecology, and avian species habitat requirements have been studied at the Forestry and Range Sciences Laboratory in La Grande, OR. Scientists at the Wenatchee Forestry Science Laboratory in Washington have investigated hydrologic recovery after wildfire and regeneration of high elevation forest stands.

Recently, insect outbreaks, disease epidemics, and wildfires have increased in the forests of central and eastern Oregon and Washington, especially in forests altered over several decades by timber harvesting practices and successful fire control. Increasing hazards of additional insect outbreaks, disease epidemics, severe fire, and possible changes in species diversity have caused people to question management practices in east-side forests. Changing priorities for wildlands research and resource issues of regional and national concern, and recent direction from the Chief of the Forest Service to practice ecosystem management in national forests, provide an opportunity to refocus and integrate PNW's east-side research capabilities for assessing east-side forest health and implementing ecosystem management.

Ecosystem Management

Public demand for consideration of nontimber forest values and a growing concern for forest health in the late 1980's led the PNW Station to review and reassess its research priorities. Much of this review coincided with Forest Service-wide efforts to initiate new approaches to resource management and culminated in a policy of ecosystem management for national forests and grasslands. Ecosystem management means using an ecological approach to achieve multiple-use management of national forests and grasslands by blending the needs of people and environmental values so that national forests and

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grasslands represent diverse, healthy, productive, and sustainable ecosystems (USDA Forest Service 1992a). This philosophy and policy is "the skillful, integrated use of ecological knowledge at various scales to produce desired resource values, products, services, and conditions in ways that also sustain the diversity and productivity of ecosystems."[1] It is the means by which the Forest Service will meet society's needs in ways that also restore and sustain healthy, diverse, and productive ecosystems. Regional Foresters and Station Directors were directed to develop a joint strategy for making ecosystem management an integral part of the organization and its decisions, tasks, and dealings with the public.

The ecosystem management strategy for the Pacific Northwest Region and PNW Station is built on six principles (USDA Forest Service 1992b):

- Sustaining the vitality and resilience of ecological systems.
- Recognizing ecosystem dynamics, complexity of processes, and the need to retain management options for the future.
- Clearly identifying desired land and resource conditions to be expected if management goals and objectives are achieved.
- Cooperating and coordinating goals and plans across jurisdictional and ownership boundaries.
- Integrating data and tools for analysis that transcend traditional disciplines.
- Integrating research and monitoring with management.

Ecosystem management carries with it four important aims previously recognized in the PNW Strategic Plan (USDA Forest Service 1991):

- The Forest Service must take care of the land by continuing to restore and sustain the integrity of its soils, air, water, biological diversity, and ecological processes.
- The Forest Service must renew its commitment to public involvement and actively seek and incorporate people's views in management decisions.
- The Forest Service must expand partnerships with local and regional governments, the private sector, conservation organizations, and others having a shared interest in management of the national forests and grasslands.
- The Forest Service must strengthen partnerships among managers and scientists to close the gap between scientific knowledge and its application in day-to-day management.

In response to this new direction for increased emphasis on ecosystem management, PNW scientists in eastern Oregon and Washington have altered their research programs. Scientists in Bend have joined forces on an Eastside Ecosystem Management Research Team to conduct integrated research for enhanced understanding of the health and functional processes in east-side forests. Scientists in La Grande work closely with the associated Blue Mountains Natural Resources Institute and stakeholders in developing local constituency for management decisions. Scientists in Wenatchee now focus on forest health through characterization and description of landscape attributes and the conservation of biodiversity.

One central tenet of ecosystem management, as embraced by the Forest Service, is establishing and expanding conservation partnerships with agencies, universities, and private organizations that share an interest in resource management. The PNW Station actively seeks partners in the public and private sector to help support research in areas of mutual interest. Developing cooperative ties with east-side national forests is essential if we are to address priority resource issues, develop new technology needed by national forest resource managers, and expand the frontiers of science to meet future resource challenges.

Examples of several formal and informal partnerships between east-side national forests and the PNW Station are discussed below.

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[1] U.S. Department of Agriculture, Forest Service, Memo (1330-1) dated June 4, 1992. On file with Bend Silviculture Laboratory, 1027 NW Trenton Avenue, Bend, OR 97701.

The Rare Plant Consortium

Public focus on wildlands is changing from an emphasis on commodity production to an emphasis on resource conservation. Timber harvesting, grazing, and recreation-induced disturbances resulting from multiple use management of range and forest lands affect rare plant species. Preservation of rare plants and their habitats is increasingly important as vegetation diversity declines on a local, regional, national, and global scale. Invasion of noxious weed species and fire suppression have created plant communities unlike those in the past, yet little is known of the reproductive biology of most rare plant species: Previous efforts to define the ecology and management of rare plant species have been piecemeal, with many agencies, institutions, and organizations working independently. A more unified approach, involving a partnership between the National Forest System, Forest *Service* Research, and cooperators, is proving efficient.

The Rare Plant Consortium was created as a forum for land managers to present their priority rare plant issues and for scientists to study rare plants, resolve current issues, and develop the scientific basis for management of rare plants. Specific objectives are to:

- Promote, facilitate, and conduct basic and applied research on rare plants.

- Develop a better understanding of rarity in plants and associated insect and animal species through research and monitoring.

- Provide recommendations and strategies for the preservation of rare plants and associated ecosystems.

- Provide educational opportunities to participating organizations and the public on the concepts of rarity and species preservation.

- Provide a forum and thereby create a multidisciplinary approach to understanding the nature of rarity.

- Provide managers access to basic biological data to assist them in making management decisions.

The Rare Plant Consortium started in 1990 at a meeting of the Wenatchee National Forest, the Wenatchee Area Office of the Bureau of Land Management, the Washington Natural Heritage Program, and the PNW Station to discuss rare plant issues. From this local effort, the Rare Plant Consortium has grown to over 60 members from universities, Federal and State agencies, private organizations from across the United States and Canada, and satellite locations in Europe. All national forests in the Pacific Northwest Region are members of the consortium and most have active cooperative research projects with the consortium. Actions of the consortium are conducted under a memorandum of understanding signed by participating partners.

The underlying theme of consortium activities is the integration of rare plant management with management of associated ecosystems, such that species viability and ecosystem sustainability are assured and listing of species as threatened or endangered becomes unnecessary. Information is lacking on biology of, ecology of, and response to common management practices by rare plant species. Conservation of rare plants and associated habitat is required by law (U.S. Laws, Statutes, etc.; Public Law 93-205), but the taking of species and habitat can result from both custodial and intensive management unless more is known of the species habitat requirements. Effective and cost-efficient monitoring strategies for rare plants are lacking. Procedures are needed to safeguard the genetic resource and increase plant numbers to viable levels for those species having minimal numbers or those at immediate risk. Cooperative research on priority rare plant issues by consortium members provides information required by land managers for species management guides.

Products from the Rare Plant Consortium partnership include information on species biology and ecology, monitoring strategies, and associated habitat management guides for maintaining or enhancing viability of the species. Recent work has involved response of Thompson's clover (*Trifolium thompsonii* Morton) to fire and response of Wenatchee larkspur (*Delphinium viridescens* Leiberg) to changes in canopy closure. Monitoring strategies have been developed for Chelan rockmat (*Petrophytum cinerascens* (Piper) Rydb.), a species that may serve as a bioassay for global climate change. Partners are developing micropropagation techniques to facilitate establishment of new populations and increase species viability of showy stickseed (*Hackelia venusta* (Piper) St. John), known from only a single population of less than 1,000 plants.

Long-term Site Productivity Research

The central Oregon Deschutes National Forest, like several other east-side national forests, began a program of extensive intermediate harvests in young ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) during the mid-1980's. Most of these sites were logged by railroad early in the 20th century, and stands were approaching maturity at the same time. Over 80 km^2 supporting this stand type were threatened by mountain pine beetle (*Dendroctonus ponderosae* Hopkins). Efforts to improve tree vigor and protect the resource from infestation centered on thinning to a wider spacing. Concurrently, the use of more efficient harvest systems and changing markets for forest products resulted in increased interest in whole-tree removal and complete use. Previous work in this portion of central Oregon indicate that these pumice soils are young, poorly developed, and infertile (Cochran 1972, Youngberg and Dyrness 1965). Fertilization trials with nitrogen, phosphorus, and sulfur resulted in increased annual volume, basal area, and bole area growth in ponderosa pine (Cochran 1978). Other work shows reduced foliar nitrogen and diminished growth rates after prescribed underburning (Landsberg and others 1984). During a study that quantified energy and nutrient pools in actively growing ponderosa pine stands, PNW scientists recognized that results provided only a static understanding of nutrient capital in these stands. Little was known of the long-term effects of intermediate harvests combined with whole-tree removal and increased use of logging residues on the nutrient capital of these infertile pumice soils, and of resulting changes in overall forest productivity and ecosystem dynamics.

A partnership was established that included the Pacific Northwest Region, Deschutes National Forest, Oregon State University, and the PNW Station to design, install, monitor, and report significant findings from a study of ponderosa pine ecosystem processes. The goal was to improve understanding of ponderosa pine ecosystems by monitoring the response of these systems to various silvicultural practices, including thinning with three levels of usage (no removal, bole only, and whole tree), fertilization, and three forms of slash treatment (broadcast burning, pile and burning, and crushing). The underlying scientific question and management concern was whether different rates of organic matter removal significantly alter biological, physical, and chemical processes in ponderosa pine ecosystems.

National Forest System participation in this partnership extends beyond the usual and customary assistance in research plot installation and supports funding for materials and equipment. In this example, ecologists within the Pacific Northwest Region area ecology group, assigned to the Deschutes, Fremont, Ochoco, and Winema National Forests in central Oregon, actively participated in designing and implementing research. These same ecologists have responsibility for determining wood and litter decomposition rates, quantifying nitrogen fixation by various undergrowth shrub species, monitoring response of herbaceous species to harvesting and slash disposal treatments, and developing shrub biomass equations. Ecologists also augment PNW Station efforts to put knowledge created through research into the hands of National Forest System resource managers: ecologists are direct liaisons between national forest staffs and PNW scientists involved in the long-term site productivity research.

The High Desert Learning Center

Management of Pacific Northwest forest ecosystems and resources has never before received the current degree of public scrutiny, and Forest Service managers in the Pacific Northwest have never before confronted the potential of such sweeping changes in management direction as they do now. In May 1993, the "Eastside Forest Ecosystem Health Assessment" was completed.[2]

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[2] Everett, Richard L., Team Leader. Eastside forest ecosystem health assessment. Wenatchee, WA: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, 5 Vol Administrative report. On file with: Forestry Sciences Laboratory, 1133 N. Western Avenue, Wenatchee, WA 98801.

This scientific assessment involving more than 100 scientists and managers outlines a new direction of management for east-side forests of Oregon and Washington: management based on ecosystem dynamics and maintenance of regional and landscape scale patterns and processes. This effort was followed in July by release of the interagency Forest Ecosystem Management Assessment Team (FEMAT 1993) report, commissioned by President Clinton. The FEMAT report on management of both west- and east-side forests within the range of the northern spotted owl (Strix occidentalis caurina) forms one of three major components of President Clinton's "The Forest Plan for a Sustainable Economy and a Sustainable Environment."[3] Most recently, major multiagency efforts at resolving Pacific Northwest fisheries issues have concluded with recommendations for riparian buffers. Greater public participation in these assessments and more extensive efforts to develop public understanding of the complex biological and social issues involved are needed to ensure acceptance of management decisions based on these assessments. The Forest Service must renew its commitment to public involvement and actively seek and incorporate people's views in management decisions.

Learning centers in the Pacific Northwest Region provide a unique opportunity to renew and practice Forest Service commitment to public involvement. These centers provide a focal point for adaptive management, testing of new ideas and concepts, research, education, and technology transfer. Each of the five learning centers in the Pacific Northwest Region have a distinctive focus and function: the Olympic Natural Resources Center accents adaptive management of the Olympic rainforest; the Columbia Cascades Learning Center highlights long-term productivity and health of ecosystems, including landscapes created by stand-replacement fire and volcanic eruption; the Cascade Center for Ecosystem Management features development and adaptive management of west-side, old-growth forests; the Learning Center of the Blue Mountains Natural Resources Institute showcases ecosystem management of natural resources through a network of demonstration areas; and the High Desert Learning Center emphasizes public education.

The High Desert Learning Center is a partnership designed to provide leadership in forest ecosystem management east of the crest of the Cascade Range, through public education, management development, and research. It is comprised of the High Desert Museum, four National Forests (the Deschutes, Fremont, Ochoco, and Winema), and the PNW Station. The mission of the learning center is to inform and educate the public and resource professionals on forest ecosystems, natural resource issues, and management tools and techniques, and to improve understanding of high desert ecosystems. Specifically, the High Desert Learning Center strives to:

- Provide opportunities for dialogue with the public on human and natural resource issues.
- Present and display the dynamics of ecosystem processes within the concept of adaptive management.
- Increase awareness of the methods and tools used in the management of ecosystems based on established practices, while continuing to research, improve, and develop new management approaches.

The four participating National Forests and the PNW Station, in particular, and the Forest Service, in general, benefit from collaboration with the High Desert Museum. The High Desert Museum is a nonprofit, regional museum located on the outskirts of Bend, OR, State Highway 97. It is a "living," participation-oriented museum of the cultural and natural history of the arid Intermountain West. Attendance is about 200,000 annually and growing. With an outreach program for over 40 Oregon public and private schools, and numerous traveling exhibits in addition to its 61-ha site, the museum offers an outstanding opportunity for public education in ecosystems, natural resources issues, and ecosystem management through a nonadvocative approach.

Current efforts of the High Desert Learning Center emphasize design and fabrication of a new 335-m^2 forest ecosystem exhibit on the grounds of the High Desert Museum. Focus of this exhibit is past

[3] Various briefing papers from the White House Office of Communications, President William J. Clinton and Vice President Albert Gore, Jr. July 1, 1993. Washington, DC. On file with: Bend Silviculture Laboratory, 1027 NW Trenton Avenue, Bend, OR 97701.

and present roles of humans and the importance of societal values in forest management. The learning center also will capitalize on demonstration and adaptive management opportunities at the nearby Lava Lands National Monument and Pringle Falls Experimental Forest. In the future, it may be possible to link the High Desert Learning Center with the Siuslaw National Forest in western Oregon and the Cascade Center for Ecosystem Management, managed jointly by the Willamette National Forest, Oregon State University, and the PNW Station. This network would provide a unique opportunity to develop and showcase examples of new management approaches along a transect extending from the Oregon coast to the high desert.

Landscape-Scale Adaptive Management

When the Forest Service Chief issued his June 4, 1992 (see footnote 1), decision to integrate the policy of ecosystem management and its general principles into the actual management of the national forests and grasslands, he included several elements that proved successful under the New Perspectives program. He challenged the Forest Service to develop stronger land manager-scientist partnerships to ensure that management decisions reflect the best and most current science. The teaming together of land managers and scientists was endorsed through the "Eastside Forest Ecosystem Health Assessment" (see footnote 2) by recognizing ecological and socioeconomic uncertainty that will cause management decisions to be made in the context of active adaptive management experiments where needed information is developed through experimentation.[4] The concept of adaptive management was further refined in the FEMAT report (1993) as the process of implementing policy decisions as scientifically driven management experiments that test predictions and assumptions in management plans, and using the resulting information to improve the plans. This feedback of information to correct and reassess is critical because of the ecological system complexities and socioeconomic intricacies we face.

Land managers from various east-side national forests and PNW Station scientists at all three east-side laboratories have recently entered into partnerships to address questions of landscape-scale adaptive management. The Cherry Canyon Demonstration Project in the Wenatchee National Forest addresses the integration of coarse-filter landscape level ecosystem management with fine-filter management of northern spotted owl habitat. The goal is to develop sustainable forest ecosystems while emphasizing improved habitat for northern spotted owls. This dry ponderosa pine and Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) site represents one of the least productive forest types occupied by northern spotted owls. Our ability to maintain the current range of the owl is hampered by the biological capacity of the site to produce required canopy closure, while maintaining low insect, disease, and fire hazards. Project objectives are to develop techniques to create, enhance, and protect the arrangement, quality, and amount of suitable habitat for a breeding pair of northern spotted owls; develop management techniques that reduce the risk of fire or insect-caused stand replacement in northern spotted owl habitat; and manage the landscape to meet current guidelines for northern spotted owl dispersal habitat. Much of this work will be based on analysis of compositional and structural attributes of owl nest-site neighborhoods.

In the Deschutes National Forest, efforts are underway to implement ecosystem management within various watersheds near the crest of the Cascade Range. Key resource issues to be considered in one such watershed, Jack Creek, include:

- The watershed is within a larger basin designated for special management because of unique quality and diversity of natural resources and spiritual values.

- Fish populations and unique hydrologic features have resulted in special streamside buffers and setbacks.

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[4] Everett, R.; Olver, C.; Saveland, J. [and others]. Adaptive ecosystem management. In: Jensen, M.E.; Bourgeron, P.S.; eds. Volume II: ecosystem management principles and application. (Everett, Richard L., Team Leader; Eastside Forest Ecosystem Health Assessment). Administrative report. On file with: Forestry Sciences Laboratory, 1133 N. Western Avenue, Wenatchee, WA 98801.

- Exclusion of natural fires and changes in stand composition and structure now favor insect-caused canopy defoliation and stress-related root rots.

- Risk of stand-replacement fires exceeds the range of natural variability.

- Current stands conditions favor and support nesting pairs of northern spotted owls.

- The watershed includes several commercial and public developed recreation sites, dispersed recreation sites, and provides access to the Mount Jefferson Wilderness Area.

Active adaptive management in the Jack Creek Ecosystem Management Demonstration Project will include a comprehensive analysis of the broader regional context within which the subwatershed is located, in addition to indepth analysis of ecological relations within the subwatershed. The objectives of research in this project will be to develop a better understanding of the effect of management activities on ecological processes, to refine our understanding of spatial and temporal patterns on the landscape; and to develop practical and ecologically meaningful statements of desired future condition to guide land management activities.

Conclusions

The Pacific Northwest Region and PNW Station have entered a new era of increased cooperation in defining resource issues, refining research approaches, and incorporating research findings into land management practices. The PNW Station research agenda has undergone dramatic changes in recent years to make it more responsive to societal needs and expectations and the needs of the National Forest System.

Scientists at PNW Station laboratories in Bend, La Grande, and Wenatchee have redirected their research programs and joined with Pacific Northwest Region national forests in developing information required to implement ecosystem management on public lands. Existing formal and informal partnerships between national forests and the PNW Station, such as the Rare Plant Consortium, the High Desert Learning Center, and long-term site productivity research, demonstrate the kinds of partnerships possible in resolving priority resource and socioeconomic issues. These partnerships extend from developing needed basic research information, to refining its application, to implementing the information in improved management practices. These partnerships also demonstrate means to involve and educate the public on management by the Forest Service.

Pacific Northwest Region national forests and the PNW Station have joined forces to start an adaptive management approach to ecosystem management where we design together, evaluate together, and learn together. The Cherry Canyon Demonstration Project and the Jack Creek Ecosystem Management Demonstration Project are only two examples of ongoing cooperative efforts in landscape-scale adaptive management for creating and maintaining sustainable ecosystems and resource flows. The road to sustainable ecosystem management will be built on cooperative bridges like these between the National Forest System and Forest Service Research.

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Implementation—Personnel, Budget, Organization, and Training

Ecosystem Management Approach of the Helena National Forest

Sam Gilbert and Lois Olsen

Abstract

The Helena National Forest has developed, within regional guidance, a midscale analysis process to integrate ecosystem management principles into forest plan implementation. The interdisciplinary team describes (1) the range of natural variation for all the resources: (2) existing conditions for the resources; (3) desired conditions for the landscape (considering biological, economic, and social factors); and (4) management practices to move toward the desired conditions. The public is informed about the process and involved in the desired conditions. The results include a program of work, integrated data collection and monitoring plans, and the basis to move on to NEPA analysis of specific project proposals.

Introduction

Like other national forests, the Helena National Forest has been working on processes to integrate ecosystem management principles into our daily management activities.

We have developed a midscale analysis process that breaks our Forest into four landscape analysis units that range from 65,000 to 148,000 hectares in size. To date, we have two of the areas basically analyzed and are starting analysis on the third. Our goal is to complete the last, unit by the spring of 1996.

Setting the Stage

The Helena National Forest is located in central Montana. Portions of the Forest occur on each side of the Continental Divide. The Blackfoot and Little Blackfoot Rivers are the major drainages to the west and the Missouri River is the major drainage to the east. The Missouri River has three reservoirs that are on or adjacent to national forest land. The Forest is located between the steeper mountains with V-shaped valleys and predominantly conifer cover to the west and the rolling grasslands to the east. Much of the Forest is characterized by wide U-shaped valleys and distinctly separated mountain ranges.

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Conifer vegetation is often interspersed with extensive nonforest openings. Our tree composition is relatively simple with seven conifer species and two hardwood species. Shrub, forb, and grass species composition are much more complex. The sensitive plant list contains 26 species.

Elk is the primary big game species. Threatened, endangered, or sensitive species include grizzly bear. gray wolf. bald eagle, peregrine falcon, and bull trout. There are numerous species of songbirds, waterfowl, raptors, rodents. fur bearers, reptiles, and amphibians. Some of the species that were here historically are now absent, (bison) or exist, in local populations (prairie dogs).

Evidence of Native Americans indicates that they lived in the area as long as 10,000 to 12,000 years ago (right after the ice age). The Lewis and Clark Expedition passed through here in 1805 and 1806. They were followed by trappers and adventurers. About 1850, miners and settlers began permanent, occupancy of the area. Our local economy is primarily government and agriculture. Mining. ranching, and logging are historic activities that continue today. Tourism continues to increase in importance.

Landscape Analysis Process

A process has been developed that takes us through most of the National Forest Management, Act (NFMA) analysis procedure. It provides a great deal of the background for the various National Environmental Policy Act (NEPA) analyses that will follow. The nine steps are segregated into four phases: (1) Preparation for the Analysis, (2) Gathering Background Information, (3) Developing Integrated Desired Condition, and (4) Irnplementation to Meet the Desired Condition.

Phase 1: Preparation for the Analysis

Step l-Identify the analysis area. The area is delineated based on the biological resources and social considerations to be analyzed. Emphasis is on the biological resources and physical conditions that occur rather than political boundaries (districts, forests. counties. Bureau of Land Management, etc.). Landscape features that, are valuable in the delineation are isolated mountain ranges, fourth- or fifth-order watersheds, geologic composition, etc. As mentioned before, we have divided the 395,000 hectares in the Forest, into four analysis areas.

Step 2—Identify available tools. Determine which tools are available that, will help identify the natural range of variation, existing condition and that will help you decide on a desired condition. These might include the following: Lewis and Clark Journals, Forest Reserve Reports, archaeological reports, pollen analysis from bog samples. early and current maps and aerial photos, and other historical documents of all types. Current infornation sources include the forest plan. resource inventories. current scientific literature, existing databases, GIS, and the professional wisdom to pull it all together.

Step 3—Develop Ecological Landscape Units (ELU's). ELU's are hierarchical polygons based on the interaction of landscape features, local climatic regime, and response to natural processes.

Task 1-Delineate landtype associations (LTA's), which are physical landscape polygons that interact with ecosystem processes and produce similar biological responses. They are identified by similar bedrock geology, geomorphic influence, broad climatic breaks. landform/vegetative pattern and position. and habitat type groups.

Task 2—Describe the processes that influence the flora and fauna on the landscape. Generally, local climatic regime, fire, insects, and flooding are the most significant for this Forest.

Task 3-Integrate the products of the first, two tasks to produce the ELU's. It is important, to stay broadscale in this step. For example, we have four ELU's in the Big Belts Integrated Resource Analysis Area. They represent the areas where grasslands, ponderosa pine, Douglas-fir. or subalpine conifers are the dominant vegetative expression.

Socioeconomic units are also developed to reflect the social and economic issues for the area. They are organized locally by school district boundaries and at broader levels to reflect, State and national concerns.

Phase 2: Gathering Background Information

This phase involves the gathering, verification, and analysis of information to describe the pre-European conditions and conditions up to the present time.

Step 1-Describe the range of natural variation. This is done for each ELU. It is a description of the biotic and abiotic characteristics which are a result of natural process influences on the landscape. Natural processes include the activities of Native Americans. The full range of natural variation would include anything which is likely to occur on some sort of cyclic basis over time. Extreme events such as volcanic deposits, glacial advances, and 500-year floods are described as shaping the area, but are not included in our description of the range of natural variation.

Task 1-Identify the specificity of information needed. This is usually based on the needs of the resource with the most detailed information requirements.

Task 2—Quantify the parameters. They are usually expressed as a range of percentages rather than precise units. For example. aspen occupied 5-10 percent, of the Douglas-fir ELU.

Task 3--Identify appropriate time frames. The most recent ice age left this area about 12,000 years ago. European people became permanent residents of the area starting in 1850. (It is recognized that Europeans had an indirect effect many years before that, particularly by introduction of the horse. However, 1850 will be considered as the date of direct effects.) Therefore. we will consider the period between 12,000 and 150 years before present. Because of data and knowledge limitations, we will emphasize the 300-year period prior to 1850 for the vegetation and wildlife resources.

We have fairly detailed information about fire effects on conifer vegetation from 1870 to the present. Dates of timber stand origination and fire scar infornation allows us to project occurrences back in time. We can map nonconifer vegetation by species beginning in 1923. Using the above information, and knowing the response of various plant species to these processes, we can make assumptions to describe vegetative conditions. Wildlife occurrence and distribution are based on the habitats available during the period.

Vegetative descriptions include composition (species, age. sizes) and structure, horizontal and vertical arrangement. patch sizes, etc.

In the Big Belts Area. we have determined that low intensity fires had an occurrence frequency of 5 to 40 years. depending on the ELU. Stand replacing fires had a frequency of 100 to 150 years. Stand replacing fires occurred on a major scale. It is common for 60 to 90 percent of a third-order watershed to be in a single age class. Average patch sizes range from 140 hectares in the Douglas-fir types to 470 hectares in the lodgepole pine types. Structure was usually two-storied on the high energy aspects and single story on the low energy aspects.

It is very important, to identify and document the assumptions that, the resource specialists use, and the logical thought process they go through to reach their conclusions. This will help a great deal with credibility and any adjustments in thinking that might occur due to new information that becomes available later.

Step ‘L-Describe the existing condition. Existing condition should relate to the ELU boundaries and forest plan management, areas. The level of specificity described by each resource may vary.

The forest plan standards. guides, and outputs. and the assumptions that, led to their development must be understood. They are analyzed in this step to determine their validity and any need for possible adjustment. Socioeconomic concerns are also analyzed here.

Data needs and gaps are also identified at this step. Note: Some resources will find it easier to do the existing condition first and then work backwards to range of natural variation and then forward to desired condition.

In the Big Belts, the major change from the past is the reduced role of fire. The elimination of Native American-caused fires, the increased consumption of fine fuels by domestic herbivores, and finally the control of fire by the various land management agencies have contributed to that condition. Major stand-replacing fires occurred in the 1870’s and 1890’s, but have been relatively minor until the 1980’s. Timber harvest has affected less than 10 percent of our forested area. The stands are denser now than during periods when underburns were more frequent. In many cases, the understory of two-storied stands has caught up with the overstory co appear as single-storied stands. Conifers have been able to become established in areas that were formerly maintained as grasslands by the frequent fires.

Phase 3: Developing Integrated Desired Condition

The time frame to reach the desired condition (DC) is the next 50 to 200 years, depending on the resource and objective. Sustainability over time is the ultimate goal. DC statements are developed for all the biotic. abiotic, and social resources in an area.

The DC must take into account the forest plan goals. objectives, guides, and outputs: and must also consider the capability of the land to meet them. The statements need to be specific enough to quantify and interpret forest plan direction, but not so specific as to eliminate decision space or management flexibility.

The range of natural variation is a logical place to start, if it is based on land capability. We may choose to operate outside that range, but we need to evaluate the consequences (cost and risk) of doing so.

Step l-Individual resource areas develop DC’s for their resource.

Step 2-Conflicts are identified in accomplishing or failing to accomplish each DC. For example, to improve elk security, we would need to close some of the roads in the area. This would reduce existing opportunities for motorized recreation. If we fail to improve elk security, then more elk will be killed than desired or it will be necessary to use a permit system or shorten the hunting season.

Step 3—Conflict resolution is used to create an integrated DC. The integrated DC is a consensus of all resources.

Step 4—Prioritize the various DC’s. The purpose is to gain an integrated perspective of which DC’s are most important to achieve. This doesn’t mean that they have to be done in sequence. Priority setting is based on the recommendations of the interdisciplinary team and the decision of the line officer.

When the DC's have been developed, the broadscale, landscape analysis portion of the process is "complete." This means that we can move on to the next, more refined step. However, it is never really done, as we anticipate that, we will be updating it as new information becomes available. The Helena National Forest, has chosen to package the document in a three-ring binder rather than a bound document to emphasize that, it is subject, to update.

Tables 1 through 3 show a brief summary of the historical, existing, and DC's for one of the ELU's. The first two tables are helpful in developing the DC and the comparison of the second and third tables are helpful in developing management opportunities as described in the next phase.

Phase 4: Implementation to Meet the Desired Condition

Step 1—Identify implementation areas. In this step, we are moving from the landscape level to a more site-specific area. These are units where management actions will be applied to achieve the integrated DC. They are always defined by watershed boundaries, usually third or fourth order. Other boundaries such as elk herd units might also be helpful. To date, our implementation areas have ranged from 8,000 to 16,000 hectares.

Step 2-Identify management opportunities. Development of the management opportunities is done in a brainstorming session. The existing condition is compared to the DC. Where differences exist, a management opportunity should be developed to move the existing condition closer to the DC. More than one management practice is often identified to accomplish a DC goal; for example, reduction of conifer cover by fire or by timber harvest.

This step is designed to utilize the collective knowledge of the analysis team to develop opportunities which implement the DC. This process should give the NEPA interdisciplinary team ideas for tools, prioritization factors, data needs, prior requirements, and monitoring needs.

A vegetation management proposal has been developed for the Wagner-Atlanta Implementation Area within the Big Belts Analysis Area. That implementation area is 10,930 hectares in size.

The District Ranger requested that, the proposal include a single entry in the area within a 25-year period. Based on that, time frame and the DC, we propose to treat 2,835 hectares. This will include 1,175 hectares of prescribed burning on nonforest lands, 810 hectares of prescribed burning or timber harvest on high energy aspects containing primarily Douglas-fir, and 850 hectares of timber harvest on low energy aspects containing lodgepole pine or Douglas-fir. Treatment areas will average 100 hectares in size, although more than one treatment will be applied within each area (except the prescribed burns). The magnitude of the proposal is based on the range of natural variation as modified by current social acceptability and rconornic constraints. The area of nonforest and high energy aspects to be treated is half the area represented by each condition. (In effect. a 50-year disturbance cycle compared to the 25-year historic cycle.) The area of low energy aspects to be treated is based on a reduction of thr area by 10 percent. to provide assurances for old-growth and then taking one-sixth of the remainder of the area (150-year stand replacement cycle divided by 25-year entry cycles). Entries are planned in only four of the six major watersheds mvolved to better simulate the magnitude of disturbance that historic fires produced and to help maintain elk security.

During the NEPA process, other alternatives are being developed to respond to issues that were identified. These include no treatments within roadless areas; assigning treatment, priorities based on existing or expected forest health problems: emphasizing elk security; maximizing present, net value and keeping openings created by even-aged harvest, treatments under 16 hectares. In all cases. the 2,835 hectare treatment. goal will apply unless a constraint is found that cannot be mitigated.

Step 3—Products of the analysis. As a result, of the analysis, we obtain an integrated program of work, an integrated data collection plan; an integrated monitoring plan, and information to validate or begin the amendment of the forest plan.

The Elkhorns analysis cost us about $0.36 per hectare and the Big Belts analysis about $0.12 per hectare. The difference in cost is due to the larger size of the Big Belts Area and to our being further along on the learning curve. Based on current, budget levels, our goal is to have a process that does not. cost us more than SO.32 per hectare.

TABLE XI HISTORICAL

ELU #I-LT'S 42,60 (ELU is 10% of the Analysis Area)

PONDEROSA PINE ON GENTLE SLOPES

VEGETATION	% ELU	MAJOR SPECIES	CANOPY CLOSURE	STRUCTURE	PATCH SIZE	PRODUCTIVITY
Grassland	40-55	Agsp, Kocr, Feid-10096	>50%	Two layer	4-500 141 Ac	
Aspen	1-5	Syal, Rowo,Spbe Potr- 80-90% Pipo 20-10%	>70%	Single storied	4-75 26 Ac	
Grassland 60%/ Ponderosa Pine Mosaic 40%	1-5	Agsp, Feid, Kocr SO-SC% Syal, Rowo, Spbe Pipo 20-40%	50% >50% in patches	Two Layer Single storied	loo-243 174Ac	15-20 cu.ft/ac/yr
Ponderosa Pine 60%/ Grassland Mosaic 40%	1-5	Agsp, Feid, Kocr Syal, Rowo, Spbe Pipo	>50% MO96 in patches	Two layer Single storied	20-300 100 Ac	20-30 cu.ft/ac/yr
Savannah	3545	Agsp, Kocr, Feid SO-70% Shca Pipo 20-30%	>50% 25-40%	Three Layer Single Storied	16-4485 652 Ac	10-20 cu.ft/ac/yr
Dense Ponderosa Pine	1-5	Shca Pipo 90-100%,Psme O-l 0%, Pien-T, Piil-T	>70%	Single storied (multi-aged)	3-63 29 Ac	40 cu.ft/ac/yr
Dense Ponderosa Two-storied	1-5	Pipo 90-100%, Psme 0-10% Shca Pien-T, Pifl-T	>70%	Two storied	74 74 Ac	40 cu.ft/ac/yr
Old Growth	1-5	Shca Pipo 90-100 Psme-T	> 50%	Two storied	20-250 50 ac	2535 cu.ft/ac/yr

TABLE #2 EXISTING

ELU **#1-LT'S 42,60** (ELU is 10% of the Analysis Area)

PONDEROSA PINE ON GENTLE SLOPES

VEGETATION	% ELU	MAJOR SPECIES	CANOPY CLOSURE	STRUCTURE	PATCH SIZE	PRODUCTIVITY
Grassland	16	Agsp, **Kocr,** Feid-90% Pofr **Pipo-1**8%	**>50%**	Two layer	l-158 39Ac	
Aspen	T	Pofr, **Syal,** Rowo, **Juco,** Spbe Potr **50%, Pipo 30%,** Psme 15% **Pien 5%,**	**>70%**	Two storied	2-47 16 Ac	
Grassland **60%/Ponderosa** Pine Mosaic 49%	3	Agsp, Feid, **Kocr** Pofr, **Syal,** Rowo, **Juco,** Spbe **Pipo**	50% **>70% -** patches	Two layer Two storied	5-152 **60** Ac	**15-20 cu.ft/ac/yr**
Ponderoea Pine **60%/Grassland** Mosaic **40%**	3	Agsp, Feid, **Kocr** Pofr, **Syal,** Rowo, **Juco,** Spbe **Pipo**	59% **>70%in** patches	Two layered Two storied	**16-85 39 Ac**	**20-30 cu.ft/ac/yr**
Savannah	0					
Dense Ponderosa Pine	47	**Syal,** Rowo, Spbe, **Juco,** Bere, Aruv Pipo-80% **Psme-15%, Pien-3%, Pifl-2%**	**>70%**	Single story (multi aged)	3-1256 **580 Ac**	**40 cu.ft/ac/yr**
Dense Ponderosa Two-storied	18	**Syal,** Rowo, Spbe, **Juco, Bere,** Aruv **Pipo-80% Psme-20%, Pien-T, Pilf-T**	**>70%**	Two storied	lo-174 51 Ac	40 **cu.ft/ac/yr**
Old Growth	13	**Syal,** Rowo, Spbe, **Juco,** Bere, Aruv **Pipo -** 98% Psme **-** 18%	**>50%**	Two storied	12-235 85 **ac**	25-35 **cu.ft/ac/yr**

TABLE X3 DESIRED

ELU #1-LT'S 42,60 (ELU is **10%** of the Analysis Area)

PONDEROSA PINE ON GENTLE SLOPES

VEGETATION	% ELU	MAJOR SPECIES	CANOPY CLOSURE	STRUCTURE	PATCH SIZE	PRODUCTIVITY
Grassland	**15-20**	Agsp, **Kocr,** Feid 100% **Pipo** 0%	**> 50**	Two layer	5-150 50 Ac	
Aspen	1-3	Potr **80-90%** **Pipo 10-20%**	> 70	Single story	5-75 25 Ac	
Grassland/Ponderosa Pine Mosaic	1-5	Agsp, **Feid, Kocr** Pofr, **Syal,** Rowo, **Juco,** Spbe **Pipo**	**> 50** **> 50**	Two layer Two storied	20200 **100 Ac**	**15-20 cu.ft/ac/yr**
Ponderosa Pine/Grassland Mosaic	**30-50**	Agsp, Feid, **Kocr,** Pofr, **Syal,** Rowo, **Juco,** **Spbe,** **Pipo**	**> 50** 50-70	Two layer Mufti-storied	20200 **100 Ac**	**20-30 cu.ft/ac/yr**
Savannah	510	Agsp, **Kocr,Feid 70-80%** **Shca** **Pipo** 2030%	**> 50** **25-40**	Three layer Single story	20-100 70 Ac	1 **0-20 cu.ft/ac/yr**
Dense Ponderosa Pine	**10-20**	**Syal,** Rowo, Spbe, **Juco, Bere,** Aruv Pipo-SO%, **Psme-15%, Pien-3%, Pifl-2%**	> 70	Single story	**20-150 70 Ac**	**35-40 cu.ft/ac/yr**
Dense Ponderosa Two-storied	**10-20**	Spbe, **Juco, Bere,** Aruv, **Pipo-80%, Psme-20%, Pien-T, Pflt-T**	**>70**	Two storied	20-150 **70 Ac**	**35-40 cu.ft/ac/yr**
Old Growth	**10-15**	**Syal,** Rowo, Spbe, **Juco, Bere,** Aruv **Pipo-90%,** Psme-10%	**>50**	Two storied	20-250 **100 Ac**	2535 **cu.ft/ac/yr**

Phase 4, Step 2 is the final step of the NFMA process, but is not the end. As mentioned before, we will be revisiting the analysis whenever there is significant new information to be considered. We are now ready to move into the NEPA process.

The two analyses that have been done to date have provided the background and basis for environmental effects for the following projects now planned for fiscal years 1994 through 1996: twelve allotment management plan NEPA analyses (identified projects include water developments, fencing, prescribed burning, timing, and distribution of grazing); two travel management plans (road management, road obliteration, access needs, and signing); stream restoration relative to past mining activity and current erosion of a streamside road; old-growth maintenance and protection via prescribed burning on 100 hectares; vegetative diversity on forested and nonforested sites through prescribed burning on 2,500 hectares: and four timber sales on 1,000 hectares. More projects will be proposed as we complete additional implementation areas within the analysis areas.

Public Involvement

Public involvement has two significant purposes. First, since this is a new process, we are spending quite a lot of time visiting with people about what we are doing and why. Second, we are asking for their informal participation in developing the desired condition and the management, opportunities that will help to achieve it.

Public involvement has occurred one on one, in group presentations, through the news media. and through interagency coordination.

Summary

A major benefit of the process is that we have a relatively detailed picture of the landscape (what it was, what it is. and what we want it to be). This is something that we haven't had before. The picture is integrated and recognizes the opportunities and tradeoffs for each resource to achieve the desired condition. The expected outputs are based on the capability of the land and are sustainable over time. In those cases where we are choosing to operate outside the range of natural variation. we have considered the costs. risks, and tradeoffs that are involved.

The process has created a truly interdisciplinary environment, with a high level of respect among our workforce. Although we expect fine tuning of the process to continue, we believe that ecosystem management is here to stay on the Helena National Forest.

Continuing Education in Ecosystem Management (CEEM) An Interdisciplinary Approach

Barry L. Bollenbacher, Fred Samson, and Kevin O'Hara

Abstract

Past and present continuing education available to mid-career professionals has had a strong functional tie and has successfully provided many employees with an educational background to assist them in managing individual resource challenges in the national forests. With the evolution of the management philosophy embodied in the themes of ecosystem management, a more integrated interdisciplinary continuing education program is being developed to help prepare natural resource professionals for the challenge of integrated analysis and management of ecosystems in the northern Rocky Mountain forests and grasslands. The organization and format of the program is being designed to provide flexibility in times of decreasing budgets, while providing a common educational reference point for professionals that will be working in an interdisciplinary climate of ecosystem management in the future. Current cooperators in this continuing education effort are: USDA Forest Service; Bureau of Land Management; Bureau of Indian Affairs; U.S. Fish and Wildlife Service; Idaho Department of Lands; Montana Department of State Lands; Montana Department of Fish, Wildlife and Parks; Potlatch Corporation; Champion International; University of Idaho; Montana State University; and the University of Montana.

Introduction

During the past **20** years, continuing education programs such as Continuing Education in Forest Ecology and Silviculture (CEFES) have been very successful in providing a solid educational base for silviculturists working on resource management challenges in the field. The primary focus of past and current continuing education programs has been rather functional in approach. As an example, the CEFES program has focused mainly on stand or individual tree interactions and processes with the local environment. Several aspects of other resource interactions have been included in the curriculum, however, a more inclusive, integrated approach to teaching and learning about the ecosystem functions in the northern Rocky Mountains has not been undertaken.

These continuing education programs in the past have helped us to be quite successful with our management at the stand or site level. However, often we have been less successful at integrating multiple resource objectives and values within the context of larger ecosystems. We have struggled to perform in an interdisciplinary mode due in large part to a narrow understanding of ecosystem functions, and limited integration of a full complement of expectations and desired conditions related to sustaining ecological systems at various scales.

Based on the premise that as our natural resource professionals learn together and work together, we will make better decisions together, an integrated continuing education program in ecosystem management has been designed and will be offered in the spring of 1994. The program will be available to the various land management and wildlife agencies in the geographic area in addition to members of the general public. This program builds on some of the functional strengths of programs like CEFES, while expanding to an integrated approach to understanding and managing the ecosystems that society depends on.

Since the inception of the CEFES program in 1973, 461 natural resource professionals have attended the program, and of that, 230 have been Region 1 employees. During the first 12 years of the program, approximately 15 Region 1 employees participated each year out of an average class size of 28. However, for various reasons, including declining budgets, participation in the program beginning in 1985 has declined to approximately five Region 1 employees on an annual basis. This reduced demand by Region 1 foresters for this type of continuing education opportunity, has led to difficulties in the universities' ability to offer this program each year, as was the case prior to 1985. Considering this recent trend, the viability of continuing education opportunities similar to the past CEFES program may rest with an integrated approach that will draw candidates from a wider array of disciplines.

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Evolution of Continuing Education in the Northern Rocky Mountains

Goal, Scope, and Target Audience

Within the past 2 years, the concept of ecosystem management has included emphasis to increase cooperation between government agencies and public groups to achieve a better understanding of how to manage ecological systems in a sustainable manner. To provide a continuing educational background for resource professionals who will implement ecosystem management in the future, a necessary change in the format, organization, and content of current programs was proposed in the fall of 1992, by a steering group composed of natural resource professionals from various State and Federal government agencies, forest industry, and universities.

The goal of the Continuing Education in Ecosystem Management (CEEM) program is to provide an understanding of ecosystem dynamics and management philosophy that will foster an interdisciplinary focus on ecosystems and their management at multiple scales.

Beginning in 1994, this continuing education program will provide an interdisciplinary continuing education program at the graduate level focusing on the conceptual and the technical application of ecosystem management. Included in the program will be course material directed at program and policy issues like: legal mandates, resource policy, economics. and other aspects of the human dimension. A capstone course for CEEM will address application of ecosystem management principles at multiple scales, and will follow a set of prerequisite courses, that would be foundations or building blocks.

The intended audience are natural resource professionals from any discipline concerned with forest, aquatic. or grassland ecosystem management. All or portions of the program could be attended by professional level employees, within and outside the agency regardless of the student's functional resource background. This continuing education program would also be open to professionals from industry and to members of the general public such as educators or others wishing this type of educational experience.

CEEM includes sufficient course material to provide a foundation for educational requirements for such Forest Service programs as silviculturist certification, and to keep resource specialists current in the area of ecosystem ecology and in the interdisciplinary nature of ecosystem management.

Structure

The program will involve a modular approach, and will include courses taught in an interdisciplinary way to an interdisciplinary audience. Modules will be grouped into one of four types: (1) Basic Ecological, Evolutionary Concepts; (2) Ecosystem Dynamics; (3) Integrated Ecosystem Inventory and Analysis; and (4) Ecosystem Management Implementation. The length of each module will be I to 3 weeks, depending on the topic. A set of four "core courses" will be taken as an interdisciplinary base durmg two successive years, with additional "required courses" to satisfy various "in service" program objectives such as the silviculturist certification program, the capstone paper in the fisheries, wildlife, and rare plant continuing education program, or the range management continuing education program. Other modules will be termed advanced, or specialized courses, and could be taken to supplement an individual's educational background, or as an update to the continuing education process.

Geographic Location

The CEEM program could be taught in various geographic areas such as the Northern Rocky Mountain Ecosystem or the Central/Southern Rocky Mountain Ecosystem. These areas could be defined by associations of ecoregions such as Bailey's 1993 delineations. Some of the course work is being developed to address the local ecosystems, such as core modules 2 and 4, while some is more generic with similar content related to many other geographic areas as in core modules 1 and 3. Modules of the northern Rocky Mountain CEEM would be offered at various host universities including the University of Montana, University of Idaho, and Montana State University. Modules taken at other CEEM programs in other geographic areas may well satisfy some of the educational requirements of programs like the silviculturist certification process.

Module Organization and Content

Basic Ecological, Evolutionary Concepts Core Module

During a 3-week period. this module covers a basic overview of ecological concepts that will deal with vegetation. landform, soils, hydrology, climate, succession, photosynthesis. autecology, and genetics. The basic ecological section will follow a biogeographic perspective. 'This module would then describe the environmental setting that influences the distribution and abundance of wildlife and fish and continues with a discussion of historical events and ecological interactions with other organisms that have influenced distribution and abundance. The module will treat current concepts and theory relative to ecological interactions and ecological processes that influence distribution and abundance, and will discuss the way historic events, ecological interactions among organisms, and ecological processes interact to influence past and present distribution and abundance. The module integrates what often appear to be divergent concepts and information to focus on important questions facing resource specialists. In addition. integrated into all of the above. the module will cover the topic of conservation biology. This portion of the module will include discussions of rare and sensitive plants and vertebrates.

This module also tracks human values and needs people have in relation to the northern Rocky Mountain ecosystem from the last retreat of the glacier period until the present day. Focus would include past effects pre-European humans had on the ecosystems and how present day values may affect the management of these ecosystems. This would include any aboriginal rights that exist today in the various ecosystems.

This module will precede the following core module.

Ecosystem Dynamics Core Module

During a 2-week period, this module focuses on synecology (ecosystem scale) and associated fauna and habitat relationships. Included in this module would be discussion of structure and composition and function (both past and present) of major ecoregions at multiple scales across the northern Rocky Mountain landscape. The module will relate landform, climate, and ecosystem disturbance regimes such as fire. forest insect and disease, and historic herbivory. to ecosystem composition and structure in the major ecoregions. Forest health in both the historic and the current ecosystems will be integrated as a major topic. The module will include the topic of stand dynamics and will relate the stand level scale to the broader landscape scale. The module will also include how various silvicultural system treatments and resulting structures are important at both the stand level and landscape scale. The session will also include rare and sensitive plant and animal communities, and exotic species as they occur in the ecosystems.

Also included are discussions of the dynamics of social values and beliefs, including such things as (but not limited to) economic considerations and how visual quality objectives at the landscape scale given a particular characteristic landscape are important now and into the future.

Integrated Ecosystem Inventory and Analysis Core Module

This 2-week module includes the components of analysis: data availability, inventory and sampling, statistical analysis, characterization and analysis techniques, and modeling.

This includes use of deductive models to predict effects of land management activities, establishing the need to conduct biological evaluations for TES, and evaluating in a systematic way those environmental attributes most important to species distribution and abundance. It will address current, specific issues in resource management, such as consideration of neotropical migrants, landscape linkages, barriers within river/stream reaches, etc. It will include exploring the opportunities to detect and describe important aspects of the landscape pattern with the use of indices, providing an opportunity to demonstrate and use models at both the stand level and landscape level to project vegetative composition and structure change over a large scale, given various assumptions including types of disturbance regimes.

The module also includes instruction on current Resource Policy, and Law established due to society's values

Ecosystem Management Implementation Core Module

Using the concepts learned in previous modules, an overview of analysis techniques at various scales of hierarchy, and given set of data available for a landscape, teams will develop, over a 2-week period, an integrated plan to move the landscape toward the DFC while providing a full range of goods and services through concepts of ecosystem management. This includes structures that could be implemented through silvicultural prescriptions at the stand and landscape scale to sustain the ecological system over time.

Additional Specialized Modules

A number of these basic and advanced modules have been developed and offered in the past several years and will be updated where needed. Some of these could be taken during the sequence of core modules, or completed later to continue to strengthen a student's knowledge or expertise in specific areas.

Concept Modules

1. (Advan) Range Ecology. 1 week

2. (Advan) Riparian Ecology. I week

3. (Basic) Habitat Types of Montana. 1 week

4. (Basic) Habitat Types of Idaho. 1 week

5. (Advan) Cultural Values. I week

Landscape/Ecosystem Analysis Modules

1. (Advan) Integrated ecosystem mapping/analysis. 1 week

2. (Advan) Remote sensing for ecosystem mapping. 1 week

3. (Advan) GIS/GPS Analysis Tools. 1 week

4. (Advan) Vegetative Measurements, Inventory, and Modeling at both the landscape and stand scale for forested ecosystems. Inventory of insect and disease and modeling would be included. Effects of implementing various historic ecosystem compositions and structures on forest regulation would be addressed. 1 week (Required in addition to the core modules for silviculturist certification in Region I.)

5. (Advan) As above for Range Ecosystems. I week

6. (Advan) As above for Riparian Ecosystems. I week

7. (Advan) Cost and Compromise in Inventory and Monitoring of Wildlife. Biological information and inventory are needed for land use decision-making and to resolve land use conflicts. The information needed centers on which species are present and how many may or may not be in a particular area, and how distributions and numbers change over time or in response to land management activities. This module discusses the need for careful planning (asking the right questions), what ecological theory (including scale) can contribute to effective inventories, inventory design (unbiased samples are key to any effective inventory and analysis) and data analysis. and compares different inventory designs and sampling strategies in terms of compromise, e.g., cost versus acceptable error in inventory and data analysis. Success in inventory and monitoring will likely rest with concepts and approaches that describe changes in species composition and distribution for a broad array of species and that are amenable to spatial issues in land management. 1 week

8. (Advan) Benefits and Costs of Fish, Inventory and Monitoring, similar to the wildlife module above. 1 week.

9. (Advan) Ecological Classification and Data Analysis. 1 week

10. (Advan) Landscape/Ecosystem Characterization/Analysis. I week

11. (Advan) Threatened and Endangered Species. 1 week

Ecosystem Management Implementation Modules

1. (Advan) Interdisciplinary Team Building. 1 week

2. (Advan) Effective communication internally and with various stakeholders. 1 week

3. (Advan) Reforestation. (Required in addition to the core modules for silviculturist certification in Region 1.) 1 week

4. (Advan) Stand Culture, Applied Stand Dynamics. 1 week

5. (Basic) Genetics (GENE). 1 week

6. (Advan) Management of Natural Areas and Wilderness. I week

7. (Advan) Managing Fire for Sustainable Ecosystems. 1 week

8. (Advan) Maintaining Forest Ecosystem Health. 1 week

9. (Basic) Insect and Disease, Identification and Management. 3 days

10. (Advan) Management of Exotic Species. 1 week

Summary

Today's challenge of ecosystem management provides us with direction and the responsibility to look at our ecosystems in a more holistic sense with the human dimension being a very important component of these systems. We must be able to recognize our past successful management at the stand level, while moving ahead to also be successful in the larger ecosystems at the landscape scale and beyond. An integrated continuing education program, such as CEEM, will provide the flexibility and the interdisciplinary educational environment to develop and maintain necessary knowledge and skills for our natural resource professionals to successfully implement ecosystem management in the future.

Visualizing Management Objectives: Turning the Numbers into Trees using GRAFGYM, A Graphic Projection System for Growth and Yield Output

Wayne D. Shepperd

Abstract

GRAFGYM is a computer program that illustrates the forest conditions predicted by the central Rockies and southwest growth and yield model GENGYM. It reads tabular diameter class output produced by the model, then draws a profile of the side of one acre of the modeled forest on the computer screen. GRAFGYM runs on any PC with a VGA display and is capable of illustrating a variety of tree species in a single stand. An explanation of the program logic and examples illustrating a silvicultural prescription are presented.

Introduction

Anyone who has ever studied the myriad of stand tables produced by a modern growth and yield model can appreciate the difficulty of visualizing these computer-grown forests. Experienced users may gain some appreciation of what the modeled stand might look like, but until recently, rates of growth, culmination of yield, and net rates of return were of more concern than the physical appearance of the projected forest. However, times have changed. With the advent of ecosystem management, professionals of all disciplines are beginning to use growth and yield models to predict the consequences of natural and human-caused disturbances to forest ecosystems as well as evaluate management alternatives to create specific habitats for animals or humans. Tabular output is inadequate to meet the needs of these new model users. They need to view the consequences of natural disturbance or see the forest that might result from management intervention or deferment. This paper describes a personal computer program that can be used with a growth and yield model to meet these needs.

Background

The popularity of an earlier graphics program designed to illustrate plot data collected in old-growth forests (Shepperd 1992) prompted the development of a similar program that could be used in conjunction with the central Rockies and Southwest growth and yield model GENGYM (GENeralized Growth and Yield Model, Edminster and others 1990). The GENGYM model utilizes a variable density stand table projection system to project expected stand conditions in pure and mixed species stands with even-aged, uneven-aged, or irregular stand structures. The program uses stand examination data summarized by species and l-inch diameter classes to simulate either even-aged or uneven-aged management. Even-aged management can be projected with cutting from either below or above (e.g., concentrate harvest in smaller or larger trees). Uneven-aged management is simulated using user-specified balanced diameter distributions. The impacts and intensification of dwarf mistletoe can also be simulated. Growth and yield data are output by diameter class, species, or whole stand level.

GENGYM has been calibrated for mixed-conifer and ponderosa pine stands in the Southwest (Edminster and others 1990), Black Hills ponderosa pine, Engelmann spruce-subalpine fir, and lodgepole pine types in the central Rocky Mountains. Work is currently underway to incorporate the aspen and Front Range ponderosa pine forest types. GENGYM is available in personal computer and Forest Service Data General versions, and GENGYM relationships have been implemented in the individual-tree based Forest Vegetation Simulation (FVS) system maintained by the Washington Office Timber Management staff. Input data for the GENGYM model include the site index of the predominant species growing on a site, the number of trees per acre by species, d.b.h. and height classes, and the average crown ratios, dwarf mistletoe ratings, age, lo-year radial bole growth, and 5-year height growth for each class.

The graphics program described here is named GRAFGYM. It is a free-standing program that extracts data from the GENOUT.DBH diameter class output file created by every GENGYM run. This information is then used to draw a "wire-frame"

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profile of the stand on the computer screen for each growth period projected by the growth and yield model. Source code for GRAFGYM was written in GWBASIC, then converted to an executable file capable of running without proprietary graphics software on any IBM compatible personal computer with a VGA color monitor.

Program Description

GRAFGYM execution begins by displaying an introductory screen and warning the user that file GENOUT.DBH must be present in the current directory. If the user elects to continue, a random number generator is seeded with the computer clock and GENOUT.DBH is read. Height, crown ratio, and stem density data for each diameter class and species in all growth projection periods are extracted and written to a temporary storage file in a compact format (this greatly reduces the time to repeatedly find and plot data on slower computers). Header and site descriptive information is also read and stored in a separate temporary file.

Growth projection periods present in the GENOUT.DBH file are displayed on the screen and the user is asked to choose the year to display. The temporary data file is then searched until the desired year's data are found. The number of trees in each species, d.b.h., and height class listed for that year are read and used to generate a file of individual tree dimensions that will be plotted. A uniformly distributed random number between 1 and 210 (the dimension in feet of the side of an acre) is also generated for each tree that will appear in the plot.

Not all trees in the projected stand will appear in the plot, however. Initial tests with dense stands revealed that a profuse jumble of lines resulted if a side-profile of an entire acre of trees were drawn. Further trials revealed that drawing a 1/5-acre strip gave a good representation of a side view into a dense stand. Therefore, only the first 42 feet looking into the side of the acre is drawn. Trees with a randomly selected position greater than 42 feet away from the viewer do not appear in the plot.

The plotting routine reads an individual tree's dimensions from the temporary file and translates them into screen pixel units. Once tree dimensions have been converted, a species-specific subroutine is called to draw the tree on the screen. Each species' subroutine draws the main stem of the tree surrounded by a "wire frame" diagram of the crown. Diameter, height, and length of the crown are scaled according to the data read from the model output. Crown width is arbitrarily set as a percentage of the tree height, since the growth model does not provide crown width data.

The crown shape and color are determined by tree species. Firs are blue with a triangle crown, spruces are green with a five-sided crown, pines are green with a six-sided crown, and aspen are plotted with a white stem and circular green crown. This color scheme and crown dimensions are modified slightly for some southwestern species, so all species in a stand can be differentiated.

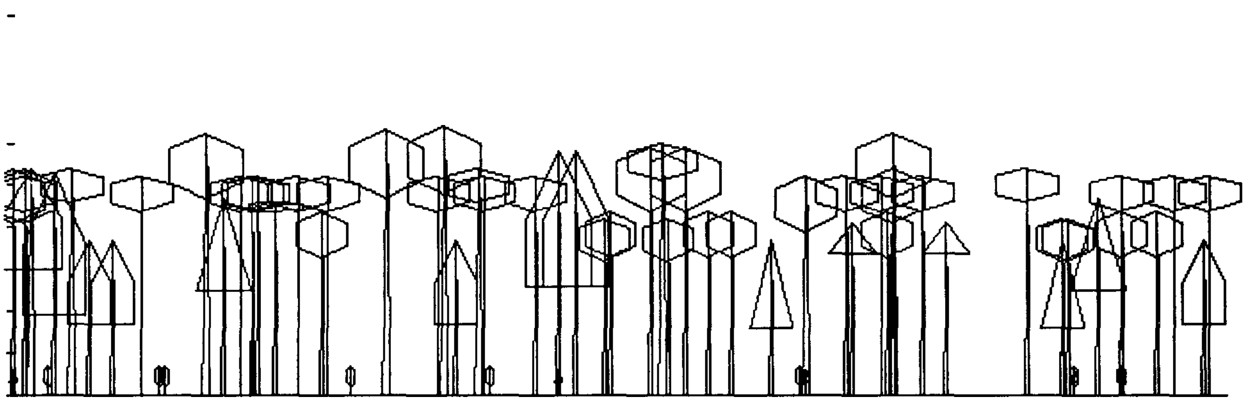
Plotted trees are positioned along a line across the center of the screen representing the 210-foot side of an acre. The growth model does not provide data on the spatial position of each tree, so random numbers assigned earlier are used to position trees along the line in a naturally appearing pattern. Because a new temporary tree data file with associated random numbers is generated each time a growth period is selected, no two diagrams will appear exactly alike, even if the same period is drawn twice in succession.

After the trees are drawn, the temporary header information file is read and a summary of stand data is displayed around the diagram on the screen. A color key of species appearing in the diagram is also shown. Finally, the user is asked whether another plot is desired.

An Example

Data from the Lexen Creek Watershed on the Fraser Experimental Forest were used in this example. The GENGYM model was used to simulate a two-step shelterwood prescription applied to a mature lodgepole pine (*Pinus contorta* var. *latifolia* Engelm.) forest containing some Engelmann spruce (*Picea engelmannii* [Parry] Engelm.) and subalpine fir (*Abies lasiocarpa* [Hook] Nutt.). The existing forest is illustrated in figure 1. The same stand appears after the seed cut in figure 2 and prior to the overstory removal in figure 3. Figure 4 shows the newly regenerated stand at the end of the growth projection period.

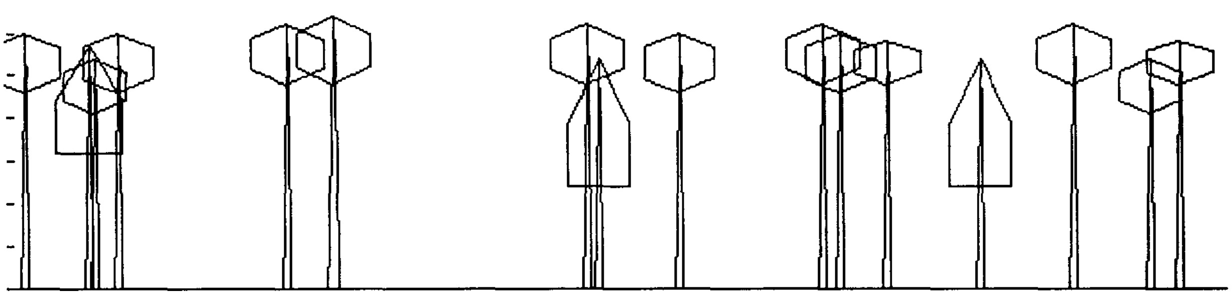
GRAFGYH PROFILE OF THE SIDE OF ONE ACRE, LOOKING 40FT. INTO THE STAND
COLOR CODES: SPRUCE, DF = Φ PINE = Φ FIR = Φ ASPEN = Φ
STAND DATA: YEAR= 0 TPA(1in+)= 318 TCF= 4289 MCF= 3612 BFS= 14132
BA= 152 QMD= 9.5 SDI= 288
- 100 FT.



210 FT.
REGION 2 FOREST 99 DISTRICT 0 SITE INDEX = 43. SPECIES 108
LPP915 SHELTERWOOD 12 DECADES 1617040004
GRAPH ANOTHER? (Y OR N)

Figure 1-GRAFGYM illustration of a mature lodgepole pine stand containing some spruce and fir from the Fraser Experimental Forest in central Colorado.

GRAFGYH PROFILE OF THE SIDE OF ONE ACRE, LOOKING 40FT. INTO THE STAND
COLOR CODES: SPRUCE, DF = Φ PINE = Φ FIR = Φ ASPEN = Φ
STAND DATA: YEAR= 11 TPA(1in+)= 62 TCF= 2286 MCF= 1996 BFS= 9859
BA= 77 QMD= 15.2 SDI= 120
- 100 FT.



210 FT.
REGION 2 FOREST 99 DISTRICT 0 SITE INDEX = 43. SPECIES 108
LPP915 SHELTERWOOD 12 DECADES 1617040004
GRAPH ANOTHER? (Y OR N)

Figure 2-The same stand following a simulated shelterwood seed cut projected by the growth and yield model GENGYM.

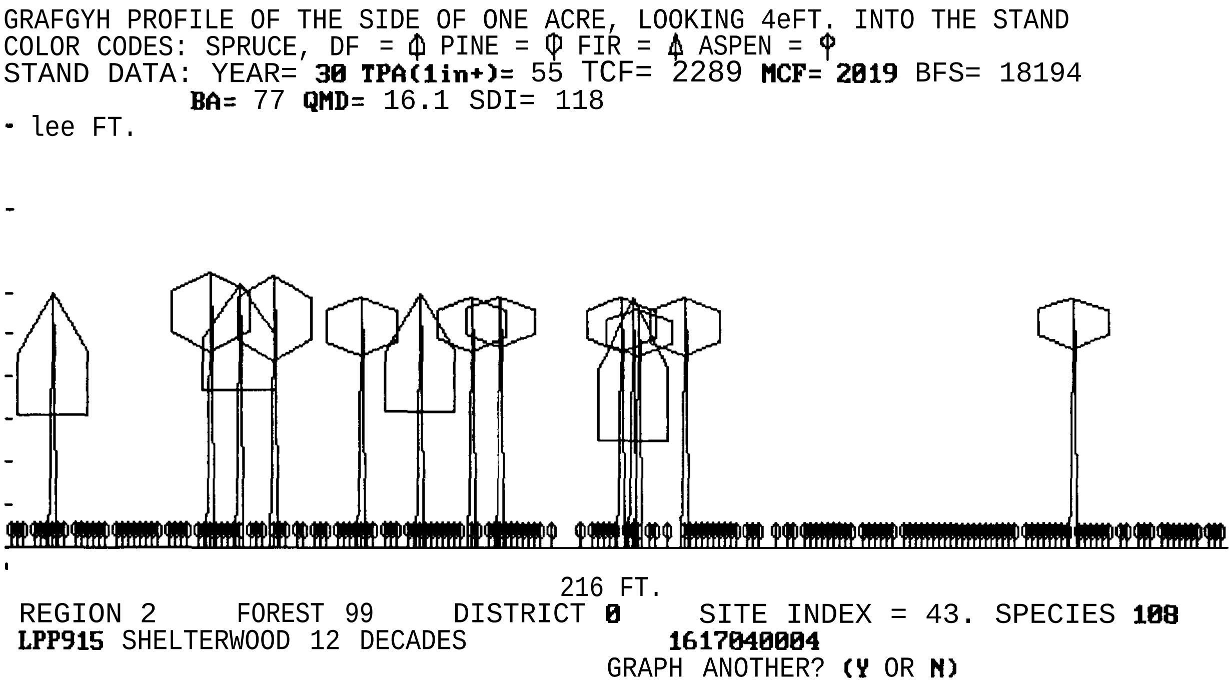


Figure 3—The same stand prior to the overstory removal. Note the dense stand of young pine regeneration.

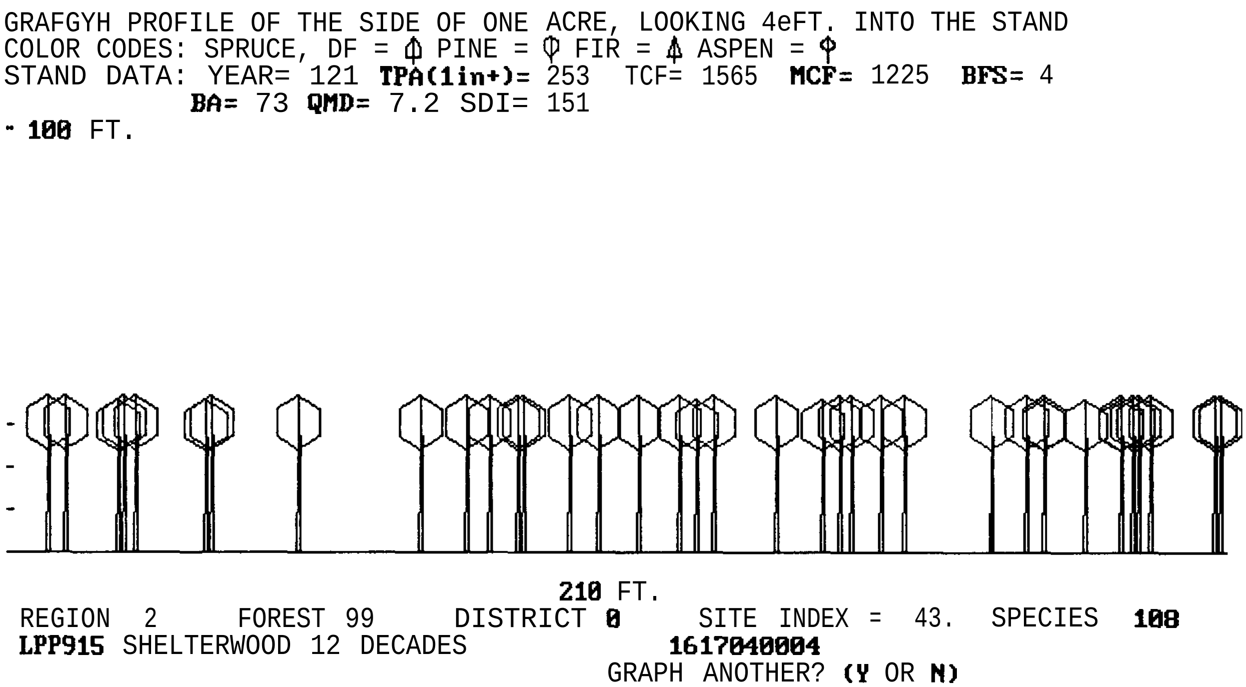


Figure 4-The regenerated lodgepole forest at the end of the GENGYM growth projection period in year 121, following a commercial thinning.

Several advantages of the GRAFGYM program are apparent from these illustrations. First, the viewer may appreciate the subtleties of species and size variation in the original stand as well as the changes that will occur after the stand is harvested. Growth of new regeneration can be seen as well as some of the limitations of the model. For example, the regenerated trees in Figure 4 appear exactly the same with none of the size variation we all have observed in young stands. This is not the result of any limitation in the GRAFGYM program, but rather merely illustrates the results of projecting growth by average size classes of trees. The model is not capable of producing a truly naturally appearing stand that is a result of many stochastic processes acting over time. Model projections are only estimates, not truth. GRAFGYM provides a means of visually emphasizing this point to the user that is not readily apparent from tabular output.

Future Development

Currently, GRAFGYM is available for use on DOS-based PC's equipped with a VGA monitor, and in conjunction with the GENGYM growth and yield model. Conversion for use with the PC version of the FVS system is underway. The Central Rockies Southwestern Mixed Conifer variant of GRAFGYM has been completed and is being tested. Conversion to other FVS variants is planned, but integration into the Data General platform has been stymied by lack of a suitable high resolution graphics capability.

A modified version of GRAFGYM has also been developed that can display output files saved from a number of different GENGYM runs. This program is useful in preparing computer demonstrations of various management alternatives, or to illustrate different stand conditions. All of the GRAFGYM programs as well as the GENGYM model can be obtained by sending a formatted high density diskette to the author at the following address:

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240 West Prospect
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303-498-1259

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Vegetation Management: A Key Part of Ecosystem Management

Gary 0. Fiddler and Philip M. McDonald

Abstract

The USDA Forest Service established a national administrative study to develop alternatives for releasing conifers in plantations. A system of study sites was established in order to test these alternatives in California. Results indicate that release from competing vegetation is needed in order for conifers to grow to the capacity of the site. Methods for achieving this release include manual, mechanical, chemical, grazing, and mulches. Release must be done early in the life of the plantation and often needs to be repeated. Data from this study will provide valuable information concerning vegetation manipulation in implementing ecosystem management. Ecosystem management will require vegetation manipulation; results from this study show the consequences of this manipulation.

Introduction

Despite all the talk and promises of new forestry, New Perspectives, biodiversity, and ecosystem management, the United States faces an increasing need for more wood products. This need is a direct result of demand for wood products by a rapidly growing population. More people will mean more demand. A case in point is California. California ranks third, behind Washington and Oregon, in terms of wood production, yet it produces only about 40 percent of the lumber and wood products its population consumes. To meet this demand, more wood is going to need to be produced on lands still available for growing this resource.

The environment in California is not the best for growing trees. In that part of the State where the majority of wood products are produced, climatically controlled conditions of temperature and moisture combine to limit the growing season. Often in the spring, soil temperatures warm enough for plant growth are reached, only to be followed in a relatively short time by inadequate soil moisture due to lack of precipitation from May to September/October. Many growing seasons are only 2 months long.

Forester, USDA Forest Service, Pacific Southwest Region, Redding, CA; and Research Forester, USDA Forest Service, Pacific Southwest Station, Redding, CA (respectively).

Combined with this naturally occurring shortage of resources, especially moisture, is another factor which contributes greatly to the problems of producing wood in California. In many instances, the lands that grow trees also are host to numerous plant species other than those that produce usable wood products. These species are direct competitors for the limited resources necessary for wood production. Table 1 illustrates the densities of these competitors on some study locations in California. The facts of life are: competitors are almost always present; they are well adapted to growing on timber sites; and they severely limit conifer growth. In order to produce wood products, these competitors must be controlled.

Table 1-Representative densities of competing plant species on national administrative study sites in California, 1993

Location	Species	Density
		(No/acre)
Stanislaus NF	Bearclover	205,000
	Grasses	241,000
Eldorado NF	Bearclover	198,000
Shasta NF	Shrubs	41,000
	Grasses	18,000
Klamath NF	Deerbrush	45,500

Methods

Until the 1970's, the common control method for these competitors was the use of herbicides. This method was effective, economical, and widely used. But, increasing public concern over the effects of herbicides on the environment led to the loss of this release method on Federal lands in the Pacific Northwest in the late 1970's. This loss was decreed through court decisions or, as was the case on California national forests, a self-imposed moratorium on herbicide use.

In response to this loss, the Forest Service started a national administrative study on alternative methods for releasing conifers in plantations. This study was designed to promote conifer growth, not just survival. It was a cooperative effort in California between the National Forest System and Research. The study had four main objectives:

1. Evaluate manual, chemical, animal, mechanical, and mulches as release methods.
2. Quantify treatment costs.
3. Determine tree growth/competitor quantity relationships.
4. Determine "best" treatment in terms of cost, survival, and growth.

The study was to last for 10 years and was concentrated in young conifer plantations. Measurements of conifer seedling growth and survival were originally envisioned as the primary variables, but as the study progressed, measurements of various parameters of competing species became increasingly important and useful. To date, 40 study sites on national forest, Bureau of Land Management, State of California, and private industry lands have been installed.

Treatments

The following are examples of release treatments applied:

Untreated control-measure all vegetation present; no treatment applied; all vegetation allowed to develop naturally.

Radius-manually cut or grub all competing vegetation from around conifer seedlings to predetermined radii; repeat as needed; radii tested were from 2 feet to 6 feet.

Free-to-grow-manually cut or grub all vegetation competing with conifers in treatment plots; repeat as needed.

Cut and spray-manually cut all competing vegetation from around conifer seedlings to predetermined radii and chemically treat stubs with a herbicide; repeat as needed.

Directed foliar spray-apply herbicide to all competing vegetation from around conifer seedlings to predetermined radii; repeat as needed.

Simulated aerial-manually apply herbicide to all competing vegetation in treatment plots; apply same volumes/acre as would be applied by aerial methods; use pressurized boom fitted with nozzles similar to those used with aerial systems.

Mechanical-use large masticating equipment, mechanically cut all vegetation competing with conifers in a treatment plot. In some instances, herbicide will be applied to the treated vegetation after l-2 years.

Grazing-utilize grazing animals (sheep or cattle) to control vegetation competing with conifers.

Mulches-use various types of material, apply around conifers to predetermined radii; materials include woven polyesters, polypropylene/polyester sandwiches, newsprint, and asphalt/kraft paper sandwiches.

Timing-of-Release

Not only were various release treatments tested, but the timing of application of these treatments was also part of the administrative study. The objective was to determine the best time to apply release treatments in order to realize the most effect on conifer growth. If plantations cannot be kept competition-free until establishment, when is the best time to lessen competition?

To help answer this question, six study sites on national forest and private industry lands were established. Treatments common to all sites included:

Control-similar treatment as described earlier.

First years, free-to-grow-for the first 3 years following planting, the conifers were kept competition-free. After the end of the third growing season, no more release treatments were applied for the life of the study (10 years).

Later years, free-to-grow-in this treatment the plantation developed naturally for the first three growing seasons with no release treatments. During the fourth-sixth growing seasons, the conifers were kept competition-free.

Following the sixth growing season, no more release treatments were applied for the remainder of the study.

Free-to-grow-similar treatment as described earlier.

Results/Discussion

General Findings

In young conifer plantations, competition becomes intensive when foliar cover of competing vegetation exceeds 10-20 percent on poor sites and 20-30 percent on good sites. The first year and probably the first 3 years are critical for conifer seedlings. Proper vegetation management the first few years usually eliminates the need for further treatments. Growth losses of conifer seedlings in early years are not made up in subsequent years. For release, at least a 5-foot radius is necessary. Smaller radii do not give the conifer seedling enough competition-free space for rapid growth. Diameter growth is consistently the best indicator of release. Height growth seems to be competition-independent.

Manual Release

Manual release can be effective on nonsprouting woody and herbaceous plants (not grasses) but is expensive. Costs of $500 to $600 per acre are common for the larger radii when release treatments need to be applied more than once. If harvesting and planting continue at present levels, the shortage of workers willing to do this type of release will adversely effect manual release projects in the future. Average production rates of 1/4-acre per man-day require a large work force in order to complete the release needed in California. Indications are that this work force will not be available.

Chemical Release

Nonphenoxy herbicides like Velpar, Garlon, and Roundup give good results. Herbicides are biologically effective, most cost-effective of the five treatment methods tested, give statistically significant results earliest, and have the longest-lasting effects. The release job that costs $500 to $600 per acre if done manually costs about 1/10 of that if done with herbicides.

A side benefit has been noted on the study sites using herbicides. As the herbicide takes out the target species, less competitive species appear. No detrimental effects have been noted on conifer growth from the presence of these species, and equally important, no bare ground remains.

Mechanical Release

After 5 years, mechanical release plus the addition of a herbicide to treated vegetation 1 year following cutting, significantly improved conifer stem caliper, height, and volume increment. Mechanical release alone did not significantly improve conifer height or volume over counterparts in the control. Inclusion of the herbicide increased release costs by 25 percent over mechanical release alone. This increase in cost resulted in significant increases in conifer growth. Without the herbicide, the mechanical release alone bought nothing. Total costs for mechanical release plus herbicide was $189 per acre.

Grazing

To date, after 9 years of grazing, no significant gain in conifer seedling diameter or height has been found in spite of big reductions in shrub cover. It is common for the grazing animals to consume up to 70 percent of the competing vegetation on a study site. But, the grazing does not effect the roots of the competitors, so they quickly resprout. Net result is no gain for the conifers relative to control plots. Manually released plots showed significantly higher conifer growth compared to grazed or control plots.

One early fear concerning damage to the conifer seedlings by the grazing animals has not materialized. In one study, conifer survival after 9 years was 100 percent; damage was minimal and not significant.

Mulches

Mulches of durable polypropylene effectively controlled most herbaceous plants and shrub seedlings. Large mulches (10 x 10 feet) show promise for enhancing conifer seedling growth.

Installation and maintenance of the mulches, especially the larger ones, is expensive. Costs approaching $2,000 per acre are common. Smaller paper mulches will cost one-third that, but do little for conifer growth.

In summary, the best release treatment is one that prevents competing vegetation from getting started. The next best treatment is that which minimizes the effects of the competing vegetation. To prevent and minimize means that the best time to treat is before planting or just as soon as most propagules of competing species have committed to growth.

Vegetation Management/Ecosystem Management

So what has all this got to do with ecosystem management? Like it or not, ecosystem management is the big issue for silviculture today.

In California, one of the basic stepping stones into ecosystem management is a change from managing vegetation in large openings (clearcuts) to manipulating vegetation in small openings, usually less than 2 acres in size. Will our knowledge of vegetation management gleaned from large openings be of value as we turn to small openings?

There is every reason to believe that current vegetation management data will be valuable in ecosystem management. Our studies show that small openings contain just as complex a plant community as do larger openings. Plant density may not be the same, but overall diversity certainly is.

There is a lot of talk about how weed species growing in small openings are not very thrifty and will not be a challenge to more desirable species such as conifers and hardwoods. We are not finding this to be true in California. In fact, small openings appear to be more easily taken over by weed species, to the detriment of preferred species. Here again, our knowledge on vegetation management comes into play. Based on results from our studies, we will know which release treatment to use to control this unwanted vegetation without lessening the diversity of desirable species.

We need to know the value of species that, up until the era of ecosystem management, were considered noneconomic. What better source of data for this than the untreated controls in our vegetation management studies. In these controls, all vegetation has been left to develop naturally without treatment of any kind. The data from these controls provides valuable information for noneconomic species. On the other hand, data from the plots that received some method of release treatment will show how various species, conifer and otherwise, respond to manipulation.

Knowledge in vegetation management is critical to implementing ecosystem management. I believe we still have to manipulate and manage vegetation to make ecosystem management work. This does not mean sitting back and accepting whatever comes along. Studies in vegetation management are still vitally needed-their objectives have just changed.

Ecosystem management is the latest challenge silviculturists are facing. Our knowledge in vegetation management will carry us through this change just as it has with past changes in management direction.

Harmonizing the Effects of Multiple Landowner Decisions-The SAMAB Experience

Charles Van Sickle and George Martin

Abstract

Implementing ecosystem management on our national forests will require careful assessment of the conditions and context surrounding the national forests. In the Southern Appalachians, the regional Man and Biosphere cooperative (SAMAB) is becoming a useful mechanism for coordinating the actions of Federal and State agencies. The paper briefly describes SAMAB and gives an illustration of how the management context can be used to define management objectives.

Introduction

When the USDA Forest Service (Forest Service) began to think about ecosystem management, one of the most challenging aspects to surface was the expanded scale of management. Some foresters resented the suggestion that past management ignored landscape-level planning; others questioned whether such planning was even feasible. In reality, we have long recognized landscape-level implications of forest management but our application of principles has been inconsistent and contradictory. Past management activities that did recognize landscape-scale effects include measuring cumulative watershed effects, recovering endangered species, monitoring air quality, and maintaining high-quality scenic vistas. And today, as land managers address the expanded scale of ecosystem management, they need to evaluate the total context in which management decisions are made.

As already mentioned, ecosystem management on national forests requires that we consider the surrounding landscape. At this conference, several good illustrations of the physical and biological context have already been presented. Our paper deals primarily with the social and institutional factors within a specific geographic context. These factors help define the management goals and the silviculture treatments to achieve those goals.

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A recent and instructive example of how ecosystem management is affected by geographic context is provided by experiences of the Southern Appalachian Man and Biosphere program (SAMAB). In this paper, we present those social and institutional factors affected by geography, describe SAMAB and how it relates to ecosystem management, and give an illustration of how context helps define management objectives.

Ecosystem Management

Landscape-scale perspectives were echoed repeatedly at the recent conference, "Creating a Forestry for the Twenty-First Century" in Portland, OR. While some still criticize landscape ecology, ample evidence shows expanded scale is gaining acceptance. First, the Forest Service Chief has emphasized the need to take human and social values into account-not social values defined in some abstract way but those defined by the local setting. Second, managing ecosystems is based on protesting values that are affected by the aggregate actions of numerous management decisions. These values include water quality, visual quality, wildlife habitat, and recreation experiences. Third, the most credible challenges to our management of the national forests have come from those who claim we have not considered the consequences of our actions-consequences that go beyond the limited scope of a specific timber sale or silvicultural treatment.

Ecosystem management is designed to overcome some of the limitations of previous management approaches. Nevertheless, ecosystem management may be easier to mandate than to implement. One factor hindering implementation is the uniqueness of each management unit or ecosystem. In the West, ecosystem management may require the close coordination of Federal and forest industry landowners. In the East, national forests are often part of mosiacs that include farms, small communities, resort developments, heavy industry, and other varied land uses. Private landowners are extremely sensitive to the possible threat of regulation or restriction, but actions on private tracts directly affect the conditions managers may wish to achieve on public lands.

For example, favoring migratory birds may require maintaining late-successional habitat on public land because little or no such habitat is available on private land. Consequently, as demonstrated in the reintroduction of the red wolf, actions on public lands might directly threaten values on private lands.

SAMAB

In the Southern Appalachians region, Federal land and resource management agencies have become increasingly aware of the interdependence of their management decisions. In 1988, they developed a plan to more effectively share information and coordinate their efforts using the framework of the international Man and Biosphere (MAB) program. Eight agencies’ signed a cooperative agreement establishing SAMAB. Under guidelines of the U.S. Man and Biosphere program, SAMAB was the first integrated regional program in the global network. The mission of SAMAB is to foster harmonious relationships between people and their environment while applying scientific knowledge and setting an example for others within the region to follow.

The Southern Appalachian Mountains region is one of the most biologically and culturally diverse areas in the United States. It is also undergoing rapid economic development and social change. The people who live in this highland area are proud of their homeland and are concerned about its future. Most of them want economic development; however, the sensitivity of mountain ecosystems to the stress of development makes careful planning essential. SAMAB’s goal is to encourage the desired economic development while preserving open space, scenic quality, air and water quality, plant and animal diversity, and many other natural and cultural resources. Community planning, an activity that might have been scoffed at a few years ago, is gaining recognition and acceptance.

As the largest land manager in the Southern Appalachians, the Forest Service is a key player in the SAMAB cooperative. Management decisions on national forest land directly affect the welfare of large numbers of people. Thus, SAMAB has become a means of examining management actions in a broader, interagency context. The National Park Service and the Tennessee Valley Authority (TVA) which have extensive common boundaries with the Forest Service, are also large land management agencies in the SAMAB cooperative.

Through SAMAB, the Forest Service, National Park Service, and TVA have addressed many issues of common interest. More importantly, the agencies have found ways to resolve questions that might arise from conflicting agency objectives or mandates. One way involved establishing different classes of land management units, which follow:

1. Biosphere Reserve Unit
2. Varied Harmonious Landscape
3. Modified Landscape

Each classification has been patterned after similar classes defined by the international MAB program. The SAMAB Resources Management committee carefully studied these management units and adapted the UNESCO (United Nations Educational Cultural and Science Organization) nomenclature and criteria to the Southern Appalachian region. These classifications represent different levels of land use and protection. Biosphere Reserve Units are largely protected from environmental degradation. These units might be considered “control” areas, where management actions that might risk degradation are excluded. Congressionally designated wilderness areas could become Biosphere Reserve Units although none have yet been designated. However, one wilderness area has been proposed to UNESCO as a Biosphere Reserve Unit, and the following five areas have been designated as Biosphere Reserve Units within the region: Great Smoky Mountain National Park (Park Service), Coweeta Hydrologic Laboratory (Forest Service), Walker Branch Watershed (Department of Energy), Mt. Mitchell State Park (State of North Carolina), and Grandfather Mountain (private ownership).

The two remaining unit classifications recognized by SAMAB represent management and economic development demonstrations and focus on sustaining high-quality ecosystems-all key objectives of SAMAB. Varied Harmonious Landscapes are areas managed to provide both amenities and economic benefits. These areas demonstrate that economic benefits may be achieved with practices that protect

[1] The signatories are National Park Service, U.S. Forest Service, Tennessee Valley Authority, U.S. Department of Energy, U.S. Fish and Wildlife Service, Economic Development Administration, U.S. Environmental Protection Agency, and the U.S. Geological Survey.

or even enhance environmental values and conditions. A farm or forest that utilizes the State's best management practices provides an example of a Varied Harmonious Landscape.

Finally, a Modified Landscape is actively managed to restore conditions degraded by past practices. Logically, corrective actions should eventually result in converting the area from a Modified Landscape to a Varied Harmonious Landscape. Conversion is accomplished by using the natural principles which occur in the Biosphere Reserve Units.

We hope the following example will further your understanding and appreciation of these land management classifications.

The Ocoee Varied Harmonious Landscape

In a Varied Harmonious Landscape (VHL), silviculture is used to accomplish specific management objectives, such as creating income or improving wildlife habitat. The Ocoee VHL demonstrates how a variety of landowners and interests, cooperative efforts, and unique arrangements serve the public and provide economic benefits. Management involves Forest Service, TVA, the Tennessee Department of Environment and Conservation, the Tennessee Wildlife Resources Agency, the Tennessee Department of Transportation, Special Use Permittees, Challenge Cost-Share Partners, Atlanta Committee for the Olympic Games, Ocoee Region Canoe and Kayak Association, the Ocoee Development Organization, and numerous other support and promotional organizations. Planning decisions have been coordinated across jurisdictional lines on a landscape basis.

Area recreational facilities developed by the Forest Service include Parksville and Thunder Rock campgrounds, Mac Point Swimming Beach and Picnic Area, Parksville Boat Ramp, and Parksville Beach. The Forest Service administers these facilities for public use and charges user fees at some sites. In addition, the Forest Service administers numerous dispersed sites for public use such as foot trails, secondary gravel roads, and a shooting range, where user fees are not charged.

The Ocoee VHL contains several privately developed recreational facilities on national forest lands. Administered by the Forest Service through special use permits, these facilities meet many needs. Some, such as the Ocoee Inn, simultaneously provide services to the public and profits for the permittees. Others, such as the 67 summer homes adjacent to Ocoee Lake, provide recreational opportunities for permittees and minimal visual impacts on anyone using the lake and adjacent facilities. Illustrating the compatibility of uses is the backyard of one of the summer homes which serves as a colony site for the only known red-cockaded woodpecker (an endangered species) in the Cherokee National Forest. Habitat enhancement, through the application of appropriate silvicultural treatments for this species, is aimed at protecting both the woodpecker and the recreational sites. Other special use permittees within the VHL include the Young Men's Christian Association (YMCA) and several churches that run camps for group users.

A unique arrangement is the Kings Slough Boat Ramp on the south side of Lake Ocoee. This facility funded by a private developer for a cabin development nearby was donated to the Forest Service for public use. This Challenge Cost-Share agreement met the needs of the private developer and provided public boat access for lake users.

The Ocoee Scenic Byway, consisting of U.S. Highway 64 and Forest Service Route 77, was designated as the Nation's first national forest scenic byway in 1988. These routes, in the heart of the VHL include a shore and riverside drive and an ascending hard surface road with overlooks of the Ocoee River Gorge. Forest management practices are interpreted along the byway. The Ocoee Ranger District Office, located adjacent to U.S. Highway 64 near the entrance to Forest Service Route 77, provides additional interpretive information, and houses an interpretive association sales outlet.

Most of the recreational sites and opportunities in the VHL are associated with facilities developed in the Ocoee Gorge by the TVA in the 1930's. Ocoee Lake is impounded by TVA Dam Number 1. Through a "stick dam" impoundment on the Ocoee River, water is diverted through a 4½-mile flume line to turbines in TVA Ocoee Power Plant Number 2 to generate electricity for local communities. In cooperation with the Tennessee Department of Environment and Conservation, which manages the whitewater use activities and the "put in" and "take out" facilities on the Ocoee River, TVA provides periods of water release from the stick dam for commercial rafting and public kayaking and canoeing. These activities generate revenue for over 15 rafting companies, provide tax benefits to Polk County, and rafting fees reimburse TVA for power lost during flow periods.

Upstream from the stick dam, is a section of the Ocoee River where water flow has been diverted through tunnels to produce power, another TVA power plant. This section of the river has been selected as the sight for the Whitewater Venue of the 1996 Olympic Games. TVA will flow water through this section for the games and possibly pre- and post-Olympic events.

In conjunction with these closely coordinated activities and facilities, a portion of the VHL is classified as suitable for timber management. Silvicultural systems are designed to blend timber management with recreational and scenic values while generating revenue and taxes in the VHL.

In the Ocoee example, management of the national forests is a cooperative venture that includes TVA, several State agencies, numerous user groups, and private landowners and developers. All these groups influence the landscape and the management objectives. The Ocoee management unit demonstrates the importance of including man in the ecosystem. Development is inevitable. But management can help guide development and channel its impacts in ways that minimize adverse consequences.

Conclusions

The Ocoee River VHL illustrates the need to factor many considerations into the land management equation. Within the Southern Appalachians region, SAMAB can become a powerful force that assists land managers in understanding and shaping the management context. The current Federal administration's emphasis on interagency cooperation should further enhance the role of SAMAB as a facilitator for resource management.

Implementing ecosystem management will require considerable art and skill in applying silviculture to manage our national forests. Determining the character of the landscape the Forest Service wishes to achieve must be done in a dynamic context both within and adjacent to the national forests.

The Role of Low Impact Herbicide Treatments in Ecosystem Management

Charles K. McMahon, James H. Miller, and David F. Thomas

Abstract

Environmentally safe, selective herbicide treatments can be adapted to manage habitats and direct succession toward desired future conditions within the principles of ecosystem management. Six roles for herbicide treatments in ecosystem management are suggested: create and maintain desired habitats; create mixed and uneven-aged stands; restore damaged landscapes; control exotic, noxious, and poisonous plants; maintain recreational areas, trails, and scenic vistas; and manage rights-of-way for multiple use. Low impact, selective herbicide treatments include tree injection, cut-stump sprays or wipes, basal sprays or wipes, directed sprays, and soil spot sprays. Selective control can also be achieved using broadcast (aerial and ground) applications of selective herbicides. Currently less than 0.1 percent of national forest lands are treated with chemical herbicides in a typical year. The six roles and treatment methodologies are consistent with the desire of the current administration to decrease pesticide use, to use safer pesticides, and to emphasize integrated pest management programs.

Introduction

As the debate on the initial concept of New Perspectives and the current concept of ecosystem management for national forests began a few years ago, some of our public and private sector colleagues would raise the question ... "Will there be a role for herbicides in this new ecological approach to multiple-use management of the national forests?" Some would quickly answer their own question and say, "probably no role for herbicides" .. because of the widespread disapproval of herbicide use on public lands. Others would say .. "probably no role for herbicides" ... when new regulatory issues dealing with threatened and endangered species, water quality, State Best Management Practices, etc., are factored into ecosystem management strategies. Others would say ... "probably no role for herbicides" ... because they see herbicides as only benefiting commodity production .. "and there would be little room for that" ... based on their limited understanding of ecosystem management goals. And finally, some environmental organizations would say ... "probably no role for herbicides" ... because they pose unnecessary risks to human and ecosystem health and safety, and they are socially unacceptable.

Our own response to the "herbicide question" involved more careful deliberation and was brought to a head by our research mission review process that took place this year within the USDA Forest Service, Southern Station. From that review and from other reviews of Forest Service programs at the regional and national level, it became obvious to us that the Forest Service will need a carefully-devised and publicly-accepted integrated vegetation management program to meet many ecosystem management goals. Access to the full menu of vegetation management alternatives (biological, chemical, manual, mechanical, and prescribed burning) would be required to reach desired future conditions related to the structure, composition, and function of ecosystems and their aesthetic acceptance. Moreover, as we sorted fact from fiction, and real needs from rhetoric, we concluded that low impact selective herbicide treatments would often be the most cost-effective, environmentally sound, efficacious, and timely option for meeting many of the multiresource needs of forest and grassland ecosystems.

Conceptually, we see a continued role for chemical herbicides in ecosystem management with a decrease in the amount of active ingredient used per acre in most situations. Keep in mind that many newer herbicide formulations coupled with low impact selective application technology now permit effective treatment with only ounces of active ingredients per acre. Also, keep in mind that less than 0.1 percent of our National Forest System lands currently receive a herbicide treatment in any one year (USDA 1993a). Positive control, a high degree of selectivity, and cost-effectiveness are what make modern herbicides ideal for meeting many ecosystem management needs. Clearly, further research will be required to refine prescriptions for all situations, but usable techniques and approaches could be applied today.

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Role of Herbicides in Ecosystem Management

Ecosystem management is the operating philosophy of the Forest Service for stewardship of lands and resources to achieve environmentally sensitive, socially responsive, economically feasible, and scientifically sound multiple-use management of the National Forest System. Ecosystem management means using an ecological approach to achieve the multiple-use management of National Forests and Grasslands by blending the needs of people and environmental values in such a way that National Forests and Grasslands represent diverse, healthy, productive, and sustainable ecosystems (Bartuska 1993). Conceptual uses of low impact forest herbicides which are consistent with this operating philosophy will be outlined in this paper.

Low impact, selective herbicide treatments include tree injection, cut-stump sprays or wipes, basal sprays or wipes, directed foliar sprays, and soil-spot sprays. These methods are described by Kidd (1987), Miller and Mitchell (1988), and Williamson and others (1989), except for the innovative wipe techniques that can further minimize application rates. These treatments have the potential to control or suppress the full range of sizes and species of plants when the appropriate individual herbicide or tank mixture is used. Selective control can also be achieved using broadcast applications of selective herbicides with aerial and ground systems. Selectivity can often be enhanced by changing application rate, timing, additives, and herbicide formulation.

These proposed roles are logical extensions of current uses and silvicultural practices that have been reported elsewhere (USDA 1983, 1988, 1989, and 1992; Cantrell and others 1985) and will not be reviewed in this paper. Our primary focus is to describe roles that enhance noncommodity values, while still supporting wood and forage production. The discussion of these roles and ideas for specific treatments represent research inputs into adaptive management and will warrant experimental and operational monitoring and testing to refine these uses.

1. Create and maintain desired plant and animal habitat

Herbicides in concert with other vegetation management treatments, such as prescribed fire, can play a vital role in creating and managing habitat for threatened, endangered, and sensitive plants and animals. Wildlife and game animal habitat can also be created and maintained with selective herbicide treatments.

The structure of old-growth stands can be mimicked to some degree in younger stands by midstory control, gap formation, and creation of standing and down coarse woody debris for the assemblage of species dependent on older forests.

In the South, herbicides are being used to selectively remove midstory and understory hardwoods from older pine stands to develop the parklike nesting habitat required by the endangered red-cockaded woodpecker. This practice is being used operationally in the USDA Forest Service, Southern Region and has been approved by the U.S. Fish and Wildlife Service.

Periodic creation of standing and down woody structure through tree injection can also improve stand composition while benefiting a wide array of organisms from bark-foraging birds, raptores and hole-nesters, to arthropods and microorganisms (McComb and Hurst 1987).

Food plants for game and nongame wildlife can be encouraged by their release from plant competition using selective herbicide treatments. Food plots created for animal species can be managed by removing woody invaders with single stem herbicide treatments so that costly reestablishment procedures will not be required. Woody browse can be created by basal sprays that deaden tops and yield resprouts. Fruiting shrubs can be released from low-value midstory and understory components. Woody plant encroachment into traditional grassland habitat of elk and antelope can be suppressed with selective control treatments to perpetuate critical wildlife populations as a supplement to the natural role of fire in these ecosystems. Additionally, on some landscapes forest livestock grazing can be enhanced with increased forage production by controlling species composition to favor more desirable plants.

2. Create mixed and uneven-aged stands

Regeneration of a variety of stand types, including both mixed conifer-hardwood, hardwood, and uneven-aged stands is the challenge facing Forest Service silviculturists, wildlife biologists, and other resource managers. Completely new silvicultural systems will have to be developed to meet these challenges, which is underway at several ecosystem management research sites across the United States. Natural regeneration will play an increasing role, which will require innovative vegetation control strategies for establishment and management through succession.

Through selective removals by herbicides of individual and component plants early in the regeneration phase, successional development can be positively directed, releasing desired conifer and hardwood species, and other desirable components. Wood and fiber outputs cannot be overlooked in ecosystem management and can be optimally produced using selective application technology. The management of stand structure, composition, and even function (e.g., increasing nitrogen fixers) can be accomplished through removals by selective cutting and selective control with forest herbicides.

Chemical herbaceous plant control will be needed in lieu of burning treatments in smoke sensitive zones to prepare seed beds for fire subclimax conifer species. Also, uneven-aged mixed stands will probably not tolerate periodic burns, thus herbaceous control treatments can be efficiently applied in single-tree gaps or larger openings to foster both conifer and hardwood regeneration.

Edges between adjoining stands, streamside management zones, and wildlife openings can be blended from early successional (low-stature) species, to shrubs, and to arborescent species by using selective periodic removals. These blended edges of harvest units will create a more favorable aesthetic appearance, provide more habitat options for wildlife, and higher recreational values.

3. Restoration and rehabilitation of damaged landscapes

A full array of natural and human induced factors have resulted and will result in extensive areas of damaged landscapes and ecosystems. Pest epidemics, wildfires, hurricanes, ice-snow storms, and widespread drought cause different patterns of perpetual disturbance to forest and range landscapes. Human induced factors such as fire exclusion and overgrazing can also contribute to damage and loss. Some past harvesting practices and reforestation efforts also have resulted in undesirable monocultures, and off-site genotypes, some of which may require restoration to natural vegetation.

Landscape rehabilitation will demand a full array of forest vegetation management tools including herbicides. Broadcast applications of selective herbicides may be required for extensive landscape restorations to accelerate forest canopy development to protect fragile sites, reverse or prevent invasion of exotic species, enhance aesthetics, and reclaim critical habitat.

4. Control of exotic, noxious, and poisonous plants

The Office of Technology Assistance in the U.S. Congress recently published a comprehensive report which describes the current and future threat to the United States from 4,500 harmful nonindigenous plant and animal species (U.S. Congress 1993). The report indicates just 15 potentially high-impact plants, insects, and aquatic invertebrates could cause as much as $134 billion in losses over the next 50 years. This is a growing economic and environmental burden for the entire country, and a major concern on many forest and grassland ecosystems.

There is much discussion and desire to use biocontrol measures to address these concerns. We also see the need for expanding research efforts for the development of biological pesticides and biocontrol programs for exotic plant species. However, these methods are generally not available at this time and will require years to develop and at very high costs. The need to suppress or eradicate nonindigenous species in some areas calls for immediate action with tools that are readily available. Selective chemical herbicide treatments are often the only effective means to meet this urgent national need.

Forest Service strategic plans for both landscape restoration and management of introduced forest pests have been recently presented in "Healthy Forests for America's Future-a Strategic Plan" (USDA 1993b) and the "Strategic Plan for Pesticide Use, Management and Coordination" (to be published in 1994). While the primary focus in these plans is on insect pests, plant pests are noted as serious problems on most national forests. Because of the unrelenting aggression of these exotic plants with no endemic predators, herbicides must be a part of any cost-effective integrated pest management approach. In most cases, there is no substitute for herbicide's positive control of these persistent and spreading pests. Some of the most pervasive imports are purple loosestrife, knapweeds, salt cedar, and kudzu-each dominate millions of acres. Exotic pests, besides detracting from forest development and recreational uses, often represent severe threats to native plant and wildlife diversity in critical habitats.

Poisonous plants represent continued threats to human and animal health. Poison ivy and oak in campgrounds and recreation sites place severe restriction on recreational opportunities for sensitive individuals. Poisonous plant control has been a long-term activity on national grasslands to prevent livestock mortality and these integrated pest management programs will require herbicides to play a continuing role.

5. **Maintain recreation areas, trails, and scenic vistas**

Woody regrowth that hinders recreational activities or impairs vistas in high-use sites can be controlled with herbicide treatments that minimize unsightly brownout and yield long-term control. Slow-acting herbicides and selective application techniques can be used in this role. Maintenance on the expanding Forest Service trail system, which already exceeds 120,000 miles will demand low-cost innovative treatments.

Resprouting woody species immediately adjacent to trails are typically manually cut each and every year. They could be selectively treated once after cutting with a very small amount of herbicide, eliminating the need for successive treatments. The cost savings would be dramatic and the environmental impacts negligible.

Creation and maintenance of vistas can greatly enhance the recreational value of mountainous areas. Vistas can be effectively managed through the periodic control of the tall-growing woody component by treating cut stumps with herbicides or by using selective, nonbrownout herbicide treatments. This results in the promotion of low-growing, protective, and/or flowering communities. This will protect the site and prolong the periods between treatments compared to the common frequent recutting of woody resprouters. Vista openings can also present new opportunities for creating and maintaining habitat for songbirds and small mammals.

The beauty of highly visible forest stands and trails can be enhanced by encouraging flowering and fruiting plants through selective removals of competitors by low-impact herbicide treatments. Continued cutting would only result in continued resprouting in most cases.

6. **Multiuse** management of rights-of-way

The 369,000 miles in the Forest Service road system, with 6,000 miles of scenic byways, demands roadside management for safety and aesthetic values. There is growing recognition that rights-of-way (ROW) which were initially created to protect roads, power lines, and pipelines must be managed for more than the inanimate "road-bed, wire, and pipe." ROW management strategies are developing that incorporate enhancement of "woodlands, wildlife, and people" values.

Natural flowering plants and wildflowers can be encouraged with selective herbicides and selective applications to improve the aesthetic appearance and biological diversity of ROW's. Some herbicide-treated ROW's can be used as refuge areas for threatened and endangered species, which are dependent on disturbance.

The vegetation corridors resulting from power transmission, telephone, and pipeline ROW's can be managed as multiple-use habitat (Bramble and Byrnes 1983, Bramble and others 1985, 1992a, 199213). Tall woody plants are undesirable under wire corridors and deep woody roots can penetrate pipes on pipeline corridors. Low-growing perennials for wildlife and/or aesthetic value can be encouraged and maintained through selective control of unwanted woody invaders. Parallel to this low profile, vegetation can be a zone of shrub species, again perpetuated by hardwood control. A parallel zone of midstory tree species (if present in the ecosystem) can then be blended into the adjacent stands. The architecture and shape of these corridor tiers would be customized to blend with the adjacent stand management objectives. Also, ROW's will be increasingly used for recreational access by hikers, bikers, and off-roaders. Their needs can be evaluated, and where possible, incorporated into ROW vegetation management strategies.

These same principles of "edge management" with ROW can be employed across the landscape. The extensive edges that separate stands or within-stand management zones, can be blended and smoothed to increase habitat and aesthetics, by creating size gradients in woody plants through selective control.

Forestry Herbicides are Environmentally Safe

Chemicals used in modern forestry herbicide formulations are "safe" when used properly. They have negligible risks to the environment and human health when used in accordance with label directions and applied by qualified applicators. There are several factors associated with herbicide properties, modern application technology, forest use patterns and risk assessments that support this conclusion (USDA 1988, 1989, 1992).

Chemical herbicides are among the most vigorously tested consumer products on the market today. Herbicides must meet strict standards of environmental safety and human health protection before they are registered for use. Very few products make it through the more than 100 safety related studies required by the Environmental Protection Agency (EPA).

Modern forestry herbicides have relatively low toxicity as compared to older herbicides and other pesticides such as insecticides and fungicides. As measured by the lethal dose criteria, most of the active ingredients in forestry herbicide formulations have toxicity levels below household chemicals, food additives, and nonprescription drugs. Table 1 shows toxicity categories for pesticides and table 2 compares the toxicity of forestry herbicides with some household chemicals.

Unlike insecticides, the newer forestry herbicides act on biochemical processes such as photosynthesis, amino acid pathways, and growth regulators that are unique to plants and do not occur in animals. This is why wildlife species are not directly affected by these chemicals (McComb and Hurst 1987, Miller and Witt 1991). However, wildlife may be influenced by the habitat shifts that can occur with broadcast herbicide treatments or from other vegetation management activities. The use of selective herbicide treatments should help to minimize habitat impacts.

Modern forestry herbicides have low bioconcentration factors and, therefore, do not bioaccumulate when ingested by humans or wildlife. Unlike many older chemical pesticides that build up in fatty tissues, modern herbicides are water soluble and quickly excreted by animals. According to Isensee (1991), "most existing herbicides as well as many of the newer insecticides, have relatively short half-lives and possess properties that are indicative of low bioconcentration factors."

Most forestry herbicides in use today biodegrade relatively quickly. They do their job on the target species and then break down from exposure to sunlight, soil micro-organisms, and plant enzymes. The few herbicides that are persistent in the soil, such as picloram and tebuthiuron, can be used effectively in prescriptions that require residual control of reinvading target species.

Biologically significant amounts of forest herbicides are unlikely to reach ground water by runoff or by leaching through the soil. Herbicide degradation by hydrolysis, microbial decay, photodecomposition, and plant metabolism limits off-site movement. Another major factor which limits the amount of herbicide available for off-site transport is the infrequent use pattern of forestry herbicides. Even in agricultural systems, runoff of pesticides from treated areas to aquatic sites is limited to 3 to 5 percent of the amount applied under "worst case" situations, e.g., high intensity rainfall shortly after application (Isensee 1991). On occasions, trace amounts of forestry herbicides have been found in surface water on or near a site in brief pulses during and following the first three storm events after

Table I-Toxicity categories for pesticides

Toxicity category	Signal word	Acute oral LD_{50} person	Acute dermal LD_{50}	Acute inhalation LD_{50}	Eye effects	Skin effects	Estimated amount needed (orally) to kill the average person
		(mg/kg)	(mg/kg)	(mg/kg)			
I	DANGER	<50	<200	<0.2	Corrosive; corneal opacity not reversible within 7 days	Corrosive	A taste (<7 drops) to a teaspoonful
II	WARNING	50-500	200-2,000	0.2-2.0	Corneal opacity reversible within 7 days; irritation persisting for 7 days	Severe irritation at 72 hours	A teaspoonful to an ounce
III	CAUTION	500-5,000	2,000-20,000	2.0-20	No corneal opacity; irritation reversible within 7 days	Moderate irritation at 72 hours	An ounce to a pint
IV	CAUTION	>5,000	>20,000	>20	No irritation	Mild or slight irritation at 72 hours	Greater than a pint

> = Greater than.
< = Less than.

Table 2-Toxicities of forest herbicides and other products for comparison. Small amounts for acute oral LD_{50}'s indicate a higher toxicity

Trade name	Approximate acute oral LD_{50}[a]	Toxicity category	Signal word
	(mg/kg)		
	Other products for comparison		
Gasoline	150	II	--
Caffeine	200	II	--
Aspirin	1,240	III	
Baking soda	3,500	III	
Table salt	3,000	III	
Herbicides			
AAtrex 4L	1,886	III	CAUTION
AAtrex Nine-O	1,600	III	CAUTION
Accord	5,400	IV	CAUTION
Acme Brush Killer	2,010	III	CAUTION
Arsenal AC	>5,000	IV	CAUTION
Banvel CST	>5,000	IV	CAUTION
Banvel 720	1,707	III	CAUTION
Banvel	2,629	III	CAUTION
Chopper RTU	>5,000	III	CAUTION
Escort	>5,000	III	CAUTION
Garlon 4	2,460	III	CAUTION
Garlon 3A	2,830	III	DANGER[b]
Krenite	24,000	IV	CAUTION
Krenite S	>5,000	IV	WARNING[b]
oust	>5,000	IV	CAUTION
Pathway	8,000	IV	WARNING[b]
Pronone 10G	>5,000	IV	CAUTION
Tordon K	5,000-6,000	IV	CAUTION
Tordon 101 Mixture	3,000	III	CAUTION
Velpar L	7,080	IV	DANGER[b]
Weedone CB	2,140	III	WARNING[b]
Weedone 170	2,000	III	CAUTION
Weedone 2,4-DP	2,200	III	CAUTION

[a] Unless otherwise indicated, values are for the formulated product (as in the container before any additional mixing).
[b] Severe eye irritant, which increases the severity of the signal word.
> = Greater than.

application (Michael and Neary 1993). As might be expected, this will occur more often from broadcast applications as compared to selective single stem, cut surface, or soil-spot applications. Typically, the concentrations of herbicides found are well below known toxicity levels and EPA's drinking water standards and health advisories.

The trend toward efficacy at low application rates continues to lower the overall environmental risk of modern forestry herbicides. Today, many prescriptions call for ounces rather than pounds of active ingredient per acre to achieve the desired effects. When low rate prescriptions and selective application methods are coupled with the patterns of herbicide use in forestry, the result is an overall negligible risk to the environment.

The forestry herbicide formulations available today provide many options for selectivity that can be factored into site specific prescriptions that will insure effectiveness and also safeguard the environment. Options for selectivity may be associated with: the use of a foliar versus a soil acting chemical; a granular versus a liquid formulation; the timing of the application; and the application methodology (broadcast, directed spray, soil-spot, injection, etc.). The use of two or more herbicides in a tank mix, the rate of application, and/or the use of additives such as surfactants are other ways to enhance activity on certain species and components while promoting others.

The frequency and patterns of use of forestry herbicides is probably the most compelling but one of the least known factors that helps to safeguard forest ecosystems from negative impacts. In a typical year, less than 0.1 percent of national forest lands are treated with a herbicide (USDA 1993a). In most silvicultural applications, a site will be treated only once or twice in a 30- to 90-year rotation. This contrasts sharply with household (lawns and gardens) and agricultural use of herbicides where a given site may receive six or more applications each and every year. According to Pimentel and Levitan (1986), 75 percent of household lands and 58 percent of agricultural (crop) lands are treated with herbicides each year while only 0.7 percent of all forest lands are treated with herbicides in a typical year. Infrequent use, low levels of active ingredient applied, and fragmented treatment patterns allows the natural resiliency of forest ecosystems to overcome temporary disturbances to nontarget species and their habitat.

Forestry herbicide-use statistics are easy to understand when one looks at the growth patterns of trees and competing vegetation in a forest ecosystem compared to agricultural crops and lawns. Still, many in our forestry community and most of the general public assume herbicides are constantly being applied to our forests at high levels each and every year. For example, more than half of the nonindustrial private forest owners in Alabama mistakenly believe that forest industries spray their pine plantations annually with herbicides (Alabama Cooperative Extension Service 1993).

There have been numerous herbicide and vegetation management environmental impact statements and risk assessments conducted in recent years (USDA 1988, 1989, 1992). However, it is obvious we need to do a better job of communicating the use patterns and risk findings to the forestry sector and the general public. We also need to inform and educate Forest Service line officers of the relative risks associated with all tools available for implementing ecosystem management strategies. This open communication will be needed if we expect to build partnerships and reach informed consent (and/or support) for the continued role of herbicides in ecosystem management. Central to this task will be the following: a clearer explanation of the overall role of vegetation management strategies in ecosystem management; why we sometimes use herbicides in lieu of alternatives; the multiresource benefits to be derived over the long run; the frequency and patterns of use on an ecosystem or landscape basis; and a clear explanation of potential risks to human health and environmental safety.

Concluding Remarks

Since the current administration took office in January 1993, and with the release of the National Academy of Science study "Pesticides in the Diets of Infants and Children" (Landrigan and others 1993), the emphasis on pesticide safety has increased dramatically. The administration has proposed significant reform for pesticide safety by endorsing reduced pesticide use and the use of "safer" pesticides. This reform is strongly endorsed by EPA, USDA, and the Food and Drug Administration. Legislation will be introduced in 1994 to modify the Federal Insecticide, Fungicide and Rodenticide Act which supports "safer" pesticides, and for the introduction of integrated pest management strategies on all agricultural lands.

Consistent with this national trend of "safer" pesticide use, selective herbicide applications can be tailored to direct vegetation succession and manage habitat to support the principles of ecosystem management. Soil productivity can be safeguarded and fertility improved through low-impact removals of selected components and the encouragement of soil-forming leguminous species. Creation of coarse woody debris and snags can enrich species diversity on upland and riparian habitats. Recreational values on Forest Service lands can be greatly improved and efficiently maintained with judicious herbicide use. The selective removal of individual plants through quick and simple applications of modern forestry herbicides represents a sophisticated and safe management tool for ecosystem scale management.

Forestry herbicides offer selectivity through both directed applications and the inherent selective nature of all modern herbicides where some undesirable plants are controlled, others are suppressed, and the desirable plants are released. Herbicide applications can and should be used as part of an integrated vegetation management approach employing other treatments such as manual cutting and prescribed fire to reach multiresource ecosystem management objectives. This wise-use, low-impact approach will require a well-trained cadre of knowledgeable applicators under competent supervision and contract monitoring.

The six roles briefly outlined in this paper are not necessarily a complete list of all possible roles for herbicides in ecosystem management. However, they serve to illustrate how this readily available silvicultural tool can be used for more than just economically driven objectives. Moreover, describing the use of selective herbicide treatments for the protection of noncommodity values may help overcome some of the myths and misperceptions that have long surrounded the use of herbicides in forestry.

The traditional role of forestry herbicides to enhance commodity outputs will continue on many landscapes in the United States, especially in areas of mixed public and private ownerships and in the East where most of the forest lands are in the private sector. In many areas of the United States, herbicide use in the private sector has not been as regulated or constrained as in the public sector. Balancing natural resource values associated with ecosystem management with traditional national values (i.e., private property rights), will require building new partnerships and new lines of communication between the public and private sectors. In order to maintain a viable working partnership with the private forestry sector, it would appear essential that natural resource agencies retain chemical herbicides in their vegetation management programs. In that way, the forestry community and the general public will not receive "mixed signals" about what are safe and acceptable ecosystem management practices.

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Closing Remarks
National Silviculture Workshop

Philip S. Aune

We have had a great time and a wonderful national workshop. Join me in a round of sincere appreciation to all those who helped put on this workshop, especially our hosts, the Southern Region and the Southeastern Station. Dave Hessel stole a lot of my thunder with his kind and thoughtful words last night.

Well, ever since then, I have really been in a quandary about how to close this conference. How long will this take? I really don't know-might take till hell freezes over, but that happened yesterday. What does one say after 37 great discussion papers and a truly cutting and exhilarating day in the field with your peers? What does one say about a workshop of silviculturists, ecologists, entomologists, pathologists, geneticists, wildlife biologists, sociologists, planners, economists, landscape architects, logging engineers, and just plain foresters that was held in of all places, a church camp? A church camp in the cradle of forestry in the heart of America???

First of all let me talk about some commendations:

The most important is what we did not talk about. You looked outside the traditional scope of silvicultural workshops to develop and expand your knowledge.

You had a pretty good breadth of professions present. Just check out the background of the list of attendees.

You had excellent presentations. You were excellent listeners.

Some areas of improvement:

Not enough time for dialogue. Work hard next time to allow and demand dialogue. As a generalized goal to allow more time for discussion based on the presentations at Asheville, every third speaker must go.

Require every speaker to not use red letters in their slides.

Require every speaker not to define ecosystem management.

Require every speaker to describe a brief historical perspective of the context of their remarks. Remember, the world was not created on June 4, 1992, with the Chief's policy on ecosystem management.

We must all work on separating dogma, fads, theory, hypothesis, and factually proven information. It really does not matter if it is wildlife dogma, silviculture dogma, landscape dogma, or even (heaven forbid) ecosystem dogma, there is a difference. We must strive to know the difference.

We need to improve on the consistency of terminology and acronyms. For example, what is the difference between opportunity areas, analysis areas, integrated resource allocation areas, allocation analysis areas, landscapes, implementation areas, ecological assessment areas, etc., etc., etc. And, these were some of the terms used in this workshop to define an area larger than a stand but smaller than the world. No wonder the public does not trust us, we are not even talking among ourselves in common terms for the relatively new discipline of landscape ecology.

Reduce the practice of describing and criticizing the assumed sins of our past. Is it appropriate for solid dialogues? I doubt it, since you were not walking in the moccasins of the times, you only described the part of the story that suited your needs, and the complete picture of context and supporting rationale is often omitted.

We must remember that not all ancient forest stands were open parklike stands developed from frequent low intensity fires. Some were closed, dense stands fully following Langsaeter growth curves. The reason that this was not described in journals is that not too many early settlers documented their attempts to travel through dense forests and then documented it in a journal for their friends to read later. Imagine,

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"We rode for miles through thick forest so dense that we couldn't see where we were going. There were huge limbs and lots of trees so thick that I was knocked off my horse three times in one morning and broke my leg on the last fall. Took me 6 months to get from Asheville to Hendersonville."

Why this was never written down or photographed is clearly described by a wonderful southern phrase from this early traveler, "mamma didn't raise no fool."

Also, somehow I missed the fact that some stands are actually capable of growing as even-aged single story and that they are well within the range of natural variability and anything less would be outside of the actual biological range.

Enough of the things to work on. Back to my original question. How can I summarize this workshop? Well, I finally decided that what would be best was to read a letter from one of our campers home to mom and dad. Don't you all recall those carefree days at summer camp and all the excitement of writing a letter to mom and dad about your adventures. That was about as exciting as getting a kiss from your 11-year-old cousin!! Here is the letter I intercepted, and I would like to read it to you as I think it really captures the spirit of this freezing boot camp!

Camp Kanuga

November 4, 1993

Dear Mom and Dad:

Wow-what a place! Do you remember when you told me I was going to church camp in North Carolina and I cried for 3 days? Boy was I ever wrong. This place is really great! First, they greeted me and all my friends by having us line up and register by our last name in three different areas alphabetically. Everyone did great except little Bobby Kitchens. You remember Bobby, he is the one who is always trying to teach us to speak southern with words like ET LAN TA, you know ET like in ET tu Brutus, and HEPPA which is the southern variant of NEPA. I found this out when Bobby said, "HEPPA means Helping Everyone Practice Practical Appeals." Anyway, as I said-Bobby had trouble at registration, evidently, he got in the wrong line, he thought Kitchens was spelled with a C. It really helped Bobby when they gave us our name tags on strings like the idiot mittens you gave me last year to play in the snow.

This church camp is a pretty good place for a Lutheran. Remember how you told me your favorite Bible verse when you said to me, "The Lord says, make a joyful noise and sing unto the Lord-except you Phil." Well, I am just so moved about this place, I decided I would like to sing a little song I wrote all about camp. Here goes:

Hello Mudda, Hello Fadda
Here I am at Camp Kanuga
Camp has many-of my heroes,
And they say we'll have fun if it gets above zero!

This church camp is real southern with weird meals and traditions. Dinner is called supper and lunch is called dinner. And, for breakfast they serve this thing called GRITS, which clearly describes and embellishes the taste! This morning I found out it also helps to clear great noses. They also have a "Kanuga Toast" which is so tough that the scientists from the Intermountain Station used it for baseball bases.

Every evening we have a ritualistic celebration similar to communion only with more booze than the time we honored Uncle Toivio and Aunt Lena for their successful ice fishing trip in the Duluth hockey arena. Evidently, that is a very famous event because one of the speakers mentioned it during his presentation. Everyone laughed, and I don't know why. After all, Uncle Tovio brought home a limit of hockey pucks, which was more than we could have possibly eaten with our lutefisk!

Speaking of lutefisk. Do you remember that nasty camp counselor I mentioned to you who was at our camp in Petersburg, AK, and told all those stories about our dog Murph who changed the color of the Christmas lutefisk from white to yellow when it was thawing on the porch. You know, the one you threw in the pot and it had that terrible smell but was the most delicious lutefisk ever. UFFDA, what a taste! Well, he was here again this year, but more on that later.

This year there seemed to be a great deal of actors here. Especially, people called line officers. Some were frozen, some on extended details, some filling in, some getting paid, some not, some confused, and most really needed lots of acting lessons before their next performance! One thing for sure, none of the silviculturists present were acting, they were simply surviving.

Speaking of acting, remember that old meanie who told those stories of Scandinavian pluck, intelligence, and courage in Petersburg, AK. Like I said, he was here and boy did he get his at the banquet. It all centers around his, vhat is it .... UFFDA, how can I describe it? Ah, it is easy, you know my favorite TV movie show is the MUPPETS. Remember that character, Gonzo, well our friend from Alaska got the award for the biggest GONZA! UFFDA Durante would be proud!

Oh yes, we had a wonderful field trip. It was so cold I had to wear a tee shirt simply to help keep the ice flecks off of my chest hairs. Normally, you know how I like to try to keep a California tan when I am in the field so I can look like those relatives of ours who are growing oranges in California. Anyway, you know how easy it is to get a tan on a cold day in Finland. Well, the field trip was held on a day Finns would call an excellent winter day in January. It was a cold, windy, foggy, and cloudy day with ozone and acid rain penetrating the outer epidermal tissues and changing the cortex chlorophyll beta-carotenes into anemophily, enzymes, and foehn DNA resulting in the subsequent pigmentation improvement. Isn't it wonderful how many ecosystem terms I learned at this conference!

Anyway, it was so cold and windy for most of the people, that one guy refused to clap his hands after he heard the good news that the trip was over at the end of the day in the field. He was definitely warming his hands and longing to get back to Camp Kanuga. Before we left the field, we had a great picture taken of the entire group. We all looked like ghosts and the picture might come out looking like a cloud or fog. I hope not.

Well it is time to get down to the SERIOUS BUSINESS of the workshop!

The theme of the workshop was, "Silviculture-From the Cradle of Forestry to Ecosystem Management." That sounds noble and simple to discuss. But, boy was it complicated. Most of the speakers immediately tried to define ecosystem management. Without too much success, I might add. Maybe you are right, the complicators are going to inherit the Earth.

They also spent a great deal of time on other terminology, especially silvicultural terms. UFFDA, you should have been here! Some definitions lasted for paragraphs. One definition even copped out for coppice!

I was really confused and then after one presentation, I walked back to the main lobby and found a poster display prepared by the Southeastern Station. This poster seemed to take the words of Jim McMinn to heart when he said, "Definitions must clarify rather than confuse!" Anyway, this wonderful Southeastern Station poster said, "Silviculture (Derived from Latin Silvi for forest and English culture)." This was followed by an elegant simple definition, "The Art of Producing and Caring for a Forest."

"The art of producing and caring for a forest." It is so profound and clear, it must be repeated again. "The art of producing and caring for a forest." It contains elements of nobility, a sense of purpose, a cause, and perhaps even the foundation for an ethic.

If a silviculturist is one who practices silviculture, then a silviculturist is, "one who practices the art of producing and caring for a forest." I wonder, is the wildlife biologist who knows and understands the wildlife of forests and the habitats they live in a silviculturist? My answer is yes, if they turn this knowledge into the art of producing and caring for a forest.

Is the entomologist who knows and understands the role of insects in controlling, tending, regulating the dynamic growth, and development of forests a silviculturist? My answer is yes, if they turn this knowledge into the art of producing and caring for the forest.

Is the economist who knows and understands the role of supply, demand, and market forces surrounding the use of forest products a silviculturist? My answer is yes, if they turn this knowledge into the art of producing and caring for the forest.

Is the geneticist who knows the functions of heritability, genetic diversity, and population dynamics a siiviculturist? My answer is yes, if they turn this knowledge into the art of producing and caring for the forest.

Is the planner who knows laws, regulations, policies, linear programming, geographic information systems, and other planning techniques a silviculturist? My answer is yes, if they turn this knowledge into the art of producing and caring for the forest.

These examples could go on and on, but finally, is the silviculturist who knows HOW to integrate the silvics, growth, and dynamics development of vegetation in the forest into developing desirable forests a silviculturist? My answer is yes, if they turn this knowledge into the art of producing and caring for the forest.

If the answer to the question was no, then clearly the person is not a silviculturist, rather a fine human being who may be concerned about his field and will be another example of what the noted German forester Heinrich Cotta said in the early 1800's, something like, "Among the problem with understanding the forest is the long life it takes to grow our forests and those who practice little write much, and those who practice much write little."

So if the answer is no, I sincerely expect to see reams of publications, assessments, and other documents but very little added to the art of producing and caring for the forests.

Now going back to ecosystem management. A common concern expressed was, what is the role of the silviculturist in ecosystem management. I would like to offer that if ecosystem management is the art of producing and caring for forested ecosystems, then it is truly the same as silviculture. Separation and distinctions are impossible. The role question is moot, and we are back to the definitions of silviculture and what is a silviculturist.

Finally, if forest ecosystem management is discussed as something other that the art of producing and caring for forested ecosystems, then we all have the responsibility to simply state to the speaker that they are talking drivel loaded with "ecobabble" and ask if they have ever heard of a fable about a certain emperor lacking clothes.

This has been a long letter and it is time to close. At our workshop we started with the cradle of forestry and ended with ecosystem management. Throughout that transition has passed thousands, if not millions, of bits of data and research and years, decades, and centuries of experience all leading to usable information which collectively has led to a greater and greater understanding of the dynamics of our wonderful forest ecosystems. These ecosystems have been here since the beginning of time, ever changing, everlasting. We now have an even greater need to expand our base of information and knowledge. Our audience is growing and we have a major responsibility to change some of the misconceptions provided in the popular media, and even some professional journals. A popular example is the myth of the so called "fragile forest ecosystems." They are anything but fragile. If any phrase or word captures the true scope of forest ecosystems, it would be resilient. Our usable information is from a relatively short time period in terms of the natural world. We have inherited most of it, helped to expand some of it, and we are now challenged to reexamine and enlarge the basic traditional foundation of our information. We must do this by keeping the fundamental results from our foundations and traditions and by seeking new and exciting means to leave an even greater legacy of real knowledge to our successors.

AND THIS is our greatest legacy we can give to the management of ecosystems. It is not short-term, popular biological legacies, but real understanding about the art of producing and caring for a forest. We were told that our predecessors have been doing it for centuries; we have been doing it throughout our careers and our successors will carry on this fine and noble cause. We truly are silviculturists practicing silviculture! Congratulations to all of us and keep up the good work. This seems like a nice way to end my letter and this excellent workshop!

Your loving son,

Phil

Attendees of the
1993 National Silviculture Workshop

WO

Barbara Anderson, PAO
* Bob Bailey, LMP
* Ann Bartuska, ECO MGMT
Karl Bergsvik, TM
Calvin Bey, FMR
Frank Burch, TM
Mark Delfs, TM
Dick Fitzgerald, TM
Dave Hessel, TM
Henry Lachowski, E-NFAP
Nelson Loftus, FMR
Doug MacCleery, TM
Dick Miller, TM
Rob Mrowka, TM
Dennis Murphy, TM
Rick Prausa, TM
Dan Schroeder, TM-FC
Jim Stewart, FIDR

Region 1

* Barry Bollenbacher, RO
Rick Floch, Bitterroot NF
* Sam Gilbert, Helena NF
* Bob Naumann, RO
Chris Reichert, Kootenai NF
* Jim VanDenburg, Flathead NF

Region 2

** Susan Gray, RO

Region 3

Marlin Johnson, RO
Mike Manthei, Coconino NF

Region 4

Jack Amundson, RO
Doug Austin, RO
Brian Ferguson, Dixie NF
Doug Myers, RO
* Roland Shaw, Toiyabe NF

Region 5

Kathy Clement, RO
John Fiske, RO
* Tom Jimerson, Six Rivers NF
Bill Jones, Six Rivers NF
Mike Landram, RO
Mike Srago, RO
Ed Whitmore, RO

Region 6

* Joanna Booser, Deschutes NF
* David Caraher, RO
Stu Johnston, Siuslaw NF
* Dan Karnes, Siuslaw NF
Ernie Meisenheimer, RO
John Nunan, RO
** Dick Shaffer, RO
* Tom Turpin, Siuslaw NF
* Jim White, Gifford Pinchot NF

Region 8

Patty Beyer, NFs in Florida
Larry Bishop, RO
Charley Bolen, NFs in NC
Chad Boniface, NFs in NC
Joe Bonnette, NFs in NC
** Ed Brown, NFs in NC
Jim Brown, RO
Bill Culpepper, NFs in NC
John German, NFs in NC
Finis Harris, Kisatchie NF
Doug Jones, NFs in NC
** Bobby Kitchens, RO
Ariel Lugo, Institute Trop. For.
Dave McGrew, NFs in NC
* George Martin, Cherokee NF
* Marv Meier, RO
David Meriwether, RO
Randy Moore, NFs in NC
Ralph Mumme, RO
Sten Olsen, NFs in Texas
Ted Oprean, NFs in NC
Tom Reule, George Washington NF
Colleen Scarrow, NFs in NC
Paul Schuller, NFs in NC
Karl Stoneking, RO
Tom Tibbs, RO
Jimmy Walker, RO

Region 9

Gary Bustamente, Monongahela NF
* Lois Demarco, Allegheny NF
John Eschle, RO
Phil Freeman, Chequamegon NF
Heather Harvey, Allegheny NF
Mike Lanasa, Hiawatha NF
Monty Maldonado, RO
Don Mikel, Hiawatha NF
* Dave Morton, Ottawa NF
Bob Panek, Hiawatha NF
Al Saberniak, Hiawatha NF
Ken Shalla, RO

Region 10

* Ron Dippold, RO
Dave Ellen, RO
Ken Rollns, Tongass-Ketchikan NF
Bill Wilson, RO
Dick Zaborske, RO

RESEARCH

Intermountain

Dennis Ferguson
* Russ Graham
* Ray Shearer
** Dwane Van Hooser

North Central

* Jeff Niese
* Terry Strong
Ron Teclaw

Northeastern

John Brissette
* Kurt Gottschalk
* Jim Redding
* Susan Stout
Dan Yaussy

Pacific Northwest

* Joe McNeel
Charley Peterson
* Andy Youngblood

Pacific Southwest

* Phil Aune
* Gary Fiddler
* Jerry Verner

Rocky Mountain

* Wayne Shepperd

Southeastern

* Fred Cubbage
Phil Dougherty
Jane Gattis
Bill Harms
Paul Kormanik
** David Loftis
* Jim McMinn
* Henry McNab
Earl Sluder
Nancy Tilghman
*** Charles Van Sickle
Tom Waldrop
* Joan Walker
David White
Michelle Wrenn

Southern

* Bill Boyer
* Charle McMahon
Ralph Meldahl

Guests

George Briggs, NC Arboretum
Maryfrances Brown, VPI
* Walt Knapp, Retiree
Tom McLintock, Retiree
Bob Ruiz, Volunteer
* Bill Shands, Pinchot Institute
* Dave Smith, VPI
Congressman Charles Taylor
Bob Thatcher, Retiree
* Don Wood. Retiree

*= Presented paper or poster
**= Moderator
***= Presenter and Moderator

The Forest Service, 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.

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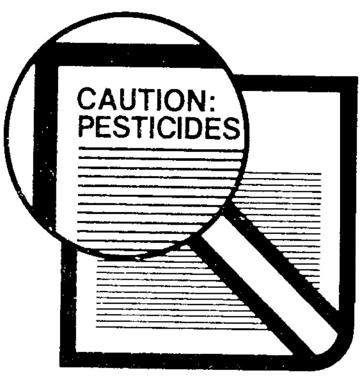

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KEYWORDS: Biological diversity, ecological classification, forest health, Geographic Information Systems, resource management, watershed

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