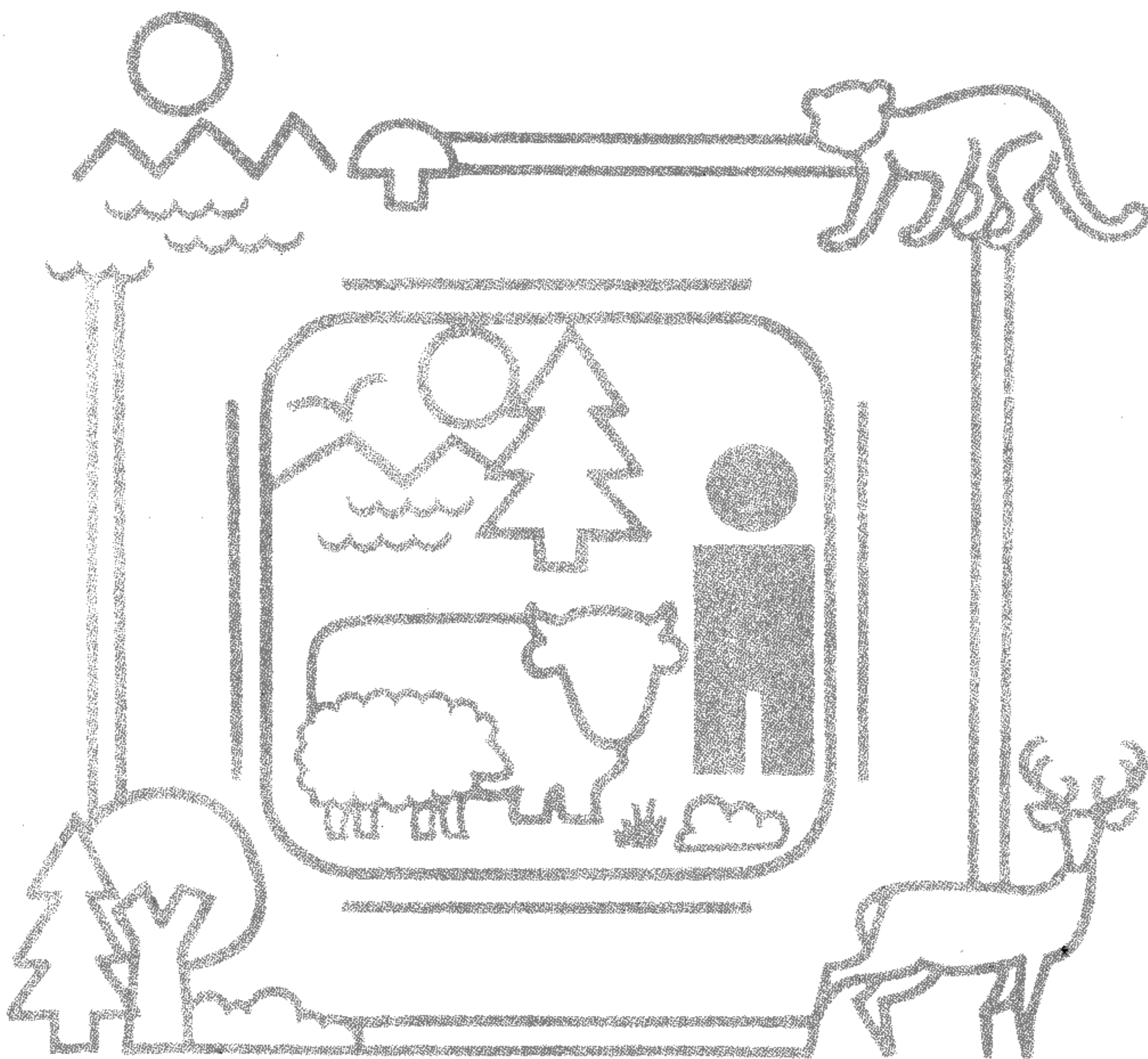


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Vegetation and Environmental Features of Forest and Range Ecosystems



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This is one of four reports that present the concepts, procedures, information, and analyses developed in the Forest-Range Environmental Study (FRES), Forest Service, U.S. Department of Agriculture, 1970-1972.

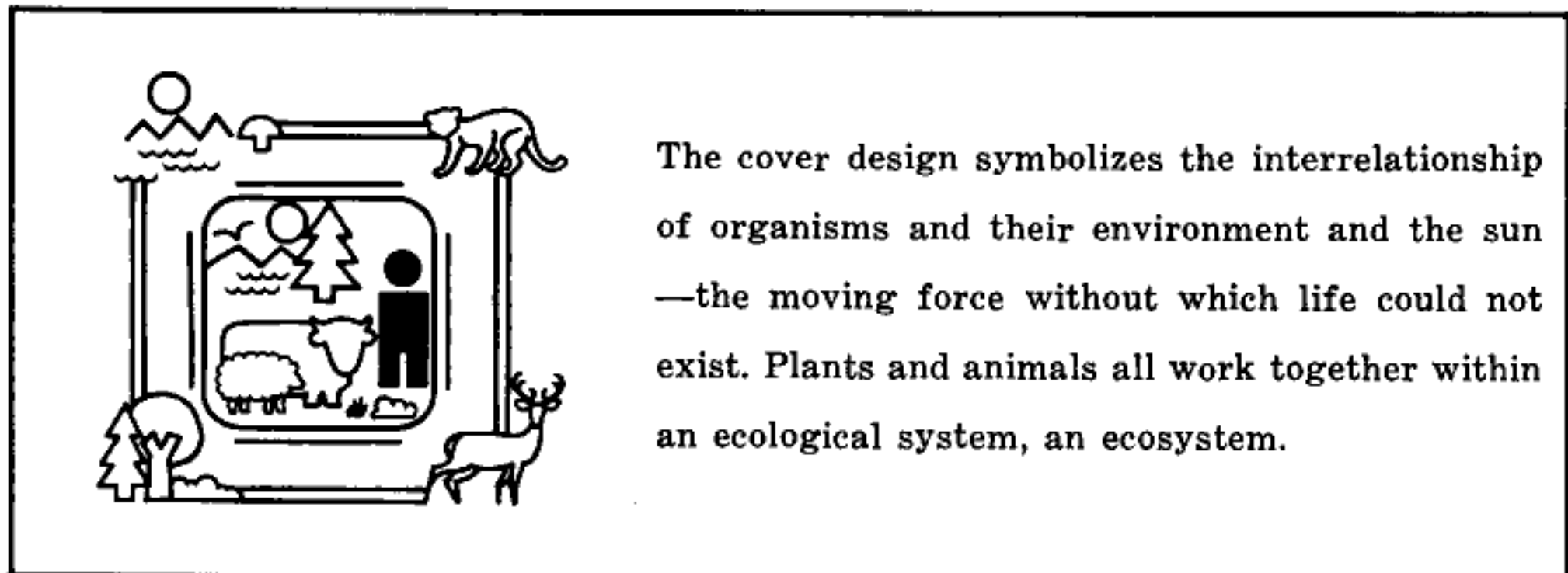
The basic document is:

- *The Nation's Range Resources—A Forest-Range Environmental Study* (Forest Resource Report 19). This report presents basic concepts and methods, information on supply of and demand for resources from all the Nation's forest-range environment, and analyses of alternative mixtures of resource use.

Supporting *The Nation's Range Resources—A Forest-Range Environmental Study* are:

- *Forest-Range Environmental Production Analytical System (FREPAS)* (Agriculture Handbook 430), the analytical and computer capability developed for FRES.
- *Vegetation and Environmental Features of Forest and Range Ecosystems* (Agriculture Handbook 475), a system of classifying all the land area of the 48 contiguous States into 34 units, called ecosystems, and a description of each.
- *Range Management Practices: Investment Costs, 1970* (Agriculture Handbook 435). Definitions of the 18 range management practices used in the Forest-Range Environmental Study (FRES) and lists of investment costs for each practice in each of 956 resource units of forest-range found within 34 major ecosystems.

For copies write to the U.S. Department of Agriculture, Forest Service, Washington, D.C. 20250.



VEGETATION AND ENVIRONMENTAL FEATURES OF FOREST AND RANGE ECOSYSTEMS

by

**George A. Garrison, Ardell J. Bjugstad, Don A. Duncan,
Mont E. Lewis, and Dixie R. Smith**

Forest Service
U.S. Department of Agriculture

July 1977
Agriculture Handbook No. 475

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Garrison, George A., Ardell J. Bjungstad, Don A. Duncan,
Mont E. Lewis, and Dixie R. Smith.

1977. Vegetation and Environmental Features of Forest and Range Ecosystems. U.S. Dep. Agric., Agric. Handb. 475, 68 p., illus.

This publication describes the 34 ecosystems into which all the land of the 48 contiguous States has been classified in the Forest-Range Environmental Study (FRES) of the Forest Service, U.S. Department of Agriculture. The description of each ecosystem discusses physiography, climate, vegetation, fauna, soils, and land use. For a number of the ecosystems, the descriptions include discussions of the productivity classes into which these units have been categorized. For each of these ecosystems, the herbage production in each class is given. An index relates the ecosystems to phytocoenoses.

Keywords: Ecosystems, environment, forests, range, range productivity, phytocoenoses.

Library of Congress Catalog Card Number: 74-600120

Index to FRES Ecosystems and the Kuchler System Equivalents

The number and name of each ecosystem is followed by the phytocoenosis designation or designations (e.g., K-1 Spruce-cedar-hemlock forest) assigned by A. W. Kuchler on his 1966 map, "Potential Natural Vegetation," (USDI Geol. Surv. 1967, 1970).¹

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¹ Years and accompanying references in parentheses refer to literature cited in Appendix A—General References.

² Contains the USDA Forest Service's (1966) Forest Survey local types 95-Bristlecone pine and 96-Whitebark pine that are classified by the Forest Survey as non-commercial but generally occurring in ecosystems related to others included under this general designation.

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³ Not recognized by Küchler but included in FRES because of the significance of their management to rangeland management.

VEGETATION AND ENVIRONMENTAL FEATURES OF FOREST AND RANGE ECOSYSTEMS¹

Introduction

This is one of the reports developed as part of the Forest-Range Environmental Study (FRES) of the Forest Service, U.S. Department of Agriculture. This report presents descriptive sketches of 34 soil-vegetation units, called ecosystems. These cover all the land area of the 48 contiguous States.

The descriptions of the ecosystems are condensations of a considerable body of literature, data, and personal knowledge of the authors and some of their colleagues. Each description contains brief sections on physiography, climate, vegetation, fauna, soils, and land use. In many instances the description also includes an approximation of herbage and browse production, which may be general or detailed, depending upon the amount of information available. Each ecosystem is numbered and titled. The numbering arbitrarily begins with 10. Ecosystem 43 is not described in this publication because, like certain other ecosystems, it does not occur in the 48 contiguous States.

Subunits of the ecosystems described in this report served as the land units for which 1970 yields of 22 products of forest and range lands were estimated. These subunits, called resource classes, also were used as the land bases for predicting outputs from resources when six different management strategies were applied in turn within each resource class.

CLASSIFICATION OF VEGETATION

In establishing the system of classifying vegetation, A. W. Küchler's (1964)² scheme of

mapping vegetation and his revised map of 1966, "Potential Natural Vegetation" (USDI Geol. Surv. 1967, 1970) were used as a basis for aggregating many plant communities (phytocoenoses) into ecosystems. Küchler's system is an approximation of the potential natural vegetation of the United States. To simplify data compilations, the forest and woodland ecosystems were made synonymous with broad geographic forest types described by the USDA Forest Service (1967) in the standards for its nationwide Forest Survey.

Many of the "real vegetation types" of today may continue to be managed so that they may never develop to the Küchler potential. Nevertheless, the concept of potential vegetation provides a realistic common denominator for classification. It is quite widely accepted. Therefore, equivalents were established where possible between the commonly used vegetation units of other land inventory systems and the communities established by Küchler. In this way, data from the Bureau of Land Management, Bureau of Indian Affairs, Soil Conservation Service, National Park Service, Fish and Wildlife Service, and Forest Service were incorporated into an inventory of land by ecosystems.

An ecosystem, as the term is used in the study, may contain one or more major plant communities. In all cases, closely related communities are aggregated into a specific ecosystem. For example, all of the many grassland communities are aggregated into eight grassland ecosystems. On the other hand, the pinyon-juniper community is maintained by itself as an ecosystem in this study. Areas of barren desert and barren rock are included with the ecosystems in which they occur. Lack of complete data in some cases and a practical need for coordination of classification systems resulted in some compromises which meet the practical objectives of the study.

In brief, the vegetation classification scheme used in this report is a composite and compromise of some concepts yet is useful to the objectives of the total study.

¹ By George A. Garrison, principal plant ecologist, Pacific Northwest Forest and Range Experiment Station; Ardell J. Bjugstad, principal plant ecologist, Rocky Mountain Forest and Range Experiment Station; Don A. Duncan, principal plant ecologist, Pacific Southwest Forest and Range Experiment Station; Mont E. Lewis (retired), formerly range conservationist, Intermountain Region; and Dixie R. Smith, chief ecologist, Washington Office—all of the USDA Forest Service.

² Years and accompanying references in parentheses refer to literature cited in Appendix A—General References.

CLASSIFICATION OF PRODUCTIVITY AND CONDITION

Forest Ecosystems

Classification of productivity and condition in FRES differs for forest and for nonforest ecosystems. For nonforest ecosystems, traditional concepts and data are available for use in evaluating productivity and condition in relation to range management. To mechanically extrapolate the concepts derived for Forest Service range to all categories of ownership is comparatively easy. For forest ecosystems, the productivity and condition classifications had to be changed. Because the Forest Survey provides the best data on forest ecosystems, its procedures for evaluating productivity and condition were adapted to meet the needs of FRES. Fortunately, the Forest Survey (USDA Forest Serv. 1973) was able to classify the Nation's forest ecosystems in terms of ownership, site productivity class, and stand condition.

Forest productivity classes.—The range productivity of forest ecosystems should be evaluated by some system that integrates all of the outputs, but we cannot yet achieve such a holistic ideal. We are compelled to accept the Forest Survey system for estimating productivity based on capacity to produce wood. The corresponding categories for estimating the productivity of an acre of forest ecosystem are as follows:

<i>Forest Survey site class</i>	<i>FRES productivity class</i>
120 or more cubic feet	1. High
85 thru 119 cubic feet	2. Moderately high
50 thru 84 cubic feet	3. Moderately low
0 thru 49 cubic feet	4. Low

Commercial forest types that produce less than 20 cubic feet are classified by the Forest Survey as noncommercial unproductive. FRES considers forest lands in this category as being of low productivity.

The productivity of forest ecosystems can be described quite precisely in terms of volume of wood produced, but the physical and biological factors related to productivity can only be described in generalities. It is impossible to describe for forest ecosystems the myriad factors that affect productivity directly or indirectly. Forest ecologists now lean toward describing the potential production of sites in terms of moisture relations. Generally, mesophytic sites have the highest productivity, and productivity falls off when too much or too little moisture is available. Most of the characteristics associated with forest site productivity are related to this concept of moisture availability. Characteristics of sites of high productivity and low productivity are as follows:

<i>Characteristic</i>	<i>High productivity</i>	<i>Low productivity</i>
<i>Soil:</i>		
depth	Deep	Shallow
texture	Friable or light	Sandy or heavy
permeability	Permeable	Impermeable
fertility	Fertile	Infertile
moisture	Optimum	Very dry or wet
drainage	Well drained	Boggy or swampy
<i>Slope:</i>		
position	Bottom lands and lower slopes	Ridgetops and upper slopes
aspect	North and east facing	South and west facing
<i>Growing season</i>	Long	Short
<i>Lesser vegetation</i>	Luxuriant	Sparse

Experts who are knowledgeable about the management and ecology of a specific forest ecosystem can point to the environmental factors most closely related to production of timber, herbs and shrubs, and other outputs of that ecosystem.

Forest condition classes.—Three condition classes unrelated to those used in evaluating range productivity are recognized for each forest ecosystem. Nonstocked stands are considered as being in *condition 1*. Seedling-sapling and pole stands are considered as being in *condition 2*. Sawtimber stands are considered as being in *condition 3*. This system is arbitrary, for it overlooks stocking level, but the Forest Survey cannot as yet provide any better single system for evaluating condition.

Condition 1 is found on areas that are not stocked with trees. Nonstocked areas, according to the Forest Survey, have less than 10 percent of the area occupied by growing stock of forest trees. The nonstocked condition may be temporary, as in the hiatus between crops of forest trees, or it may be relatively permanent, as on lands covered with brush as a result of forest fires. The Forest Survey classified nonstocked land according to its estimated productivity for timber but did not classify such land by timber type. Data on acreages of nonstocked forest land in a State are given only by ownership and productivity class. Therefore, FRES prorated the nonstocked areas to the forest ecosystems occurring in each kind of ownership in a State.

Outputs from nonstocked forest ecosystems are characterized in general by abundant herbage and browse production, rather high storm runoff, and great diversity of species of wildlife. Wood production on sites of low productivity probably would only average 5 percent of the yields of stands in good condition. However, on sites of fairly high to high productivity, wood yields might average 25 to 40 percent of the yields of stands in good condition.

In general it would cost comparatively little to put nonstocked forest ecosystems under a range management strategy that would achieve maximum range outputs. This is in contrast to the relatively great cost of restoring their timber production potentials.

Condition 2 stands with seedlings and saplings or poles have trees up to about 9 inches in diameter generally, or up to 11 inches in the Far West.

Condition 3 stands with sawlogs have at least 50 percent of the trees above 9 or 11 inches in diameter.

Nonforest Ecosystems

Statements of vegetation yields given in the ecosystem descriptions are approximations in some cases, either because there were no production data for some of the vegetation units or because the aggregating of several related units under one ecosystem forced some compromises. Another type of problem exists in conversion of production in pounds per acre to grazing capacity, because herbage production *per se* does not take into account the differences between ecosystems in the quality or nutritive value of their potential output. It is possible, for example, for forage to be very low in nutritive value even though the volume or weight of production is high. Thus, computing animal unit-months of grazing capacity for some of the ecosystems from the herbage weight data presented would require application of appropriate discount factors for proper use level and nutritive status; these factors are not included in this report.

Nonforest classes.—For range ecosystems, productivity classes are expressed in terms of traditional concepts of herbage production. Some ecosystems are potentially high producers of herbage, and others are intermediate or low

producers. Accordingly, the productivity classification is relative to the production capability of each range ecosystem, as follows:

<i>Class</i>	<i>Potential herbage production</i>	<i>Class</i>	<i>Potential herbage production</i>
1.....	First quartile	3.....	Third quartile
2.....	Second quartile	4.....	Fourth quartile

The range condition classes are Good, Fair, and Poor. They are based on vegetative cover, the composition and vigor of the vegetation, and soil factors.

SOURCE MATERIALS

General references consulted in preparing the descriptions of the ecosystems are listed in appendix A. References on mammals and birds are given in appendix B. Other references used in preparing the descriptions of the ecosystems are given in appendix C, by individual ecosystems. The nomenclature of plants largely follows "Standardized Plant Names," by H. P. Kelsey and W. A. Dayton (1942).

THE VEGETATION MAP

The ecosystems map in the back of this report is principally a combination of Küchler's map, which was cited earlier, and the USDA Forest Service map (USDI Geol. Surv. 1969, 1970), developed in the Forest Survey of timber types. Where the two mapping systems differed as to forest type boundaries the Forest Service definition and delineation prevailed. The Forest Service timber type map is based on a compilation of aerial photographs and production inventories in the field. Preparation of the ecosystems map used in this study was done largely under the guidance of Dr. Bjugstad, with assistance in the final stages from Jack E. Schmutz, ecologist, Forest Service.

Descriptions of Ecosystems

NO. 10.—THE WHITE-RED-JACK PINE ECOSYSTEM

Physiography.—The white-red-jack pine ecosystem occurs generally on smooth to irregular plains and tablelands of northern Lake States and parts of New York and New England. More than 50 percent of the area is gently sloping.

Climate.—Precipitation averages 25–45 inches annually and is distributed rather evenly throughout the year. Normal pan evaporation is 30–35 inches. During the frost-free season of 120–140 days, precipitation is roughly equal to evaporation.

Vegetation.—Forests in which 50 percent or more of the stand is eastern white pine, red pine, or jack pine, singly or in combination,

represent the white-red-jack pine ecosystem. Common associates include oak, eastern hemlock, aspen, birch, northern white-cedar, and maple. Much of this ecosystem is included in Küchler's (USDI Geol. Surv. 1967, 1970) Great Lakes pine forest community.

Fauna.—The white-tailed deer and black bear are the most common larger mammals in this ecosystem, and the moose inhabits the extreme northern portion. The woodland caribou formerly was abundant. In times past the eastern timber wolf was very numerous and fed on small animals and the larger mammals just mentioned, but it has become very scarce and is classified as an endangered species. The



Figure 1.—Woodland of eastern white pine in the white-red-jack pine ecosystem.

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coyote, bobcat, great horned owl, and hawks are among current predators. The snowshoe rabbit and other small forest mammals are the main food source of the predators already mentioned. Spruce grouse and ruffed grouse inhabit the ecosystem. Porcupines inhabit parts of the ecosystem and become a problem in forest management when they are overly abundant.

Breeding bird populations average about 153 pairs per 100 acres. The Blackburnian and the black-throated green warbler are the most abundant. Other birds include the whippoorwill, crested flycatcher, wood pewee, white-breasted nuthatch, veery, tanagers, ruffed grouse, great horned owl, pileated woodpecker, hairy woodpecker, downy woodpecker, blue jay, chickadees, red-eyed vireo, black-and-white warbler, ovenbird, redstart, black-throated blue warbler, hermit thrush, magnolia warbler, Canada warbler, yellow-bellied sapsucker, olive-

sided flycatcher, red-breasted nuthatch, brown creeper, winter wren, blue-headed vireo, myrtle warbler, slate-colored junco, and white-throated sparrow. The endangered Kirtland's warbler occurs in limited areas.

Soils.—The cool, moist soils are predominantly Spodosols. They have a low supply of bases and a horizon in which organic matter and compounds of iron and aluminum have accumulated, but they have no dense, brittle, or indurated horizon (Haplorthods). Soils of a significant proportion of the ecosystem are moist throughout the year and coarse textured, and they lack pedogenic horizons (Udipsamments).

Land use.—Nearly all of the land is forested and is used principally for lumbering and recreation. The associated cropland is devoted largely to growing potatoes and forage for dairy cattle. Large urban areas characterize the northeastern portions.

NO. 11.—THE SPRUCE-FIR ECOSYSTEM

Physiography.—The spruce-fir ecosystem occurs on flat plains and tableland in the Lake and New England States and at high elevations in the Appalachian Mountains. At high elevations it occurs as far south as West Virginia. Except for some especially high places, local relief is almost entirely less than 500 feet and often less than 100 feet. Well over half of the area is gently sloping.

Climate.—Normal annual precipitation is 30–40 inches, half of which falls during the frost-free season of 120–140 days. Normal annual evaporation is 30–40 inches. Evaporation is about equal to precipitation during the frost-free season.

Vegetation.—Forests in which 50 percent or more of the stand is spruce or true fir, singly or in combination, characterize this ecosystem. Common associates include northern white-cedar, tamarack, maple, birch, eastern hemlock, and eastern white pine.

Fauna.—The fauna of the spruce-fir ecosystem is similar to that described for other northern conifer regions. A list of mammals at Mount Katahdin, Maine, includes moose, woodland caribou, lynx, marten, black bear, long-tailed weasel, white-footed mouse, and other mice and shrews. The moose, black bear, and white-tailed deer are the most common larger animals in the conifer areas.

The ruffed grouse is common throughout this ecosystem. The wild turkey may be found toward the south; the spruce grouse is found more to the north. The eastern timber wolf is considered an endangered species. Characteristic breeding birds of the ecosystem in the Northeastern States are the olive-backed thrush, magnolia warbler, Cape May warbler, myrtle warbler, bay-breasted warbler, and white-throated sparrow. The density of territorial males may be as high as 430 per 100 acres.

Soils.—The cool, moist soils of this ecosystem are predominantly Spodosols, although a large acreage of Histosols occurs in the Lake States. The Spodosols have a low supply of bases and a horizon in which organic matter and iron and aluminum compounds have accumulated. No dense, brittle, or indurated horizon is present (Haplorthods). The Histosols are wet, organic (peat and muck) soils.

Land use.—In the Northeastern States much of the area is forested. Lumbering and recreation are major uses of the forest. About 10 percent of the area is in crops or pastures. Most of the cropland is in forage crops for dairy cattle. In many cases farming is a part-time enterprise. Many farm occupants in this ecosystem earn their living from nonfarm occupations.

NO. 12.—THE LONGLEAF-SLASH PINE ECOSYSTEM

Physiography.—The longleaf-slash pine ecosystem is restricted to flat and irregular southern Gulf Coastal Plains. Well over 50 percent of the area is gently sloping. Local relief is less

than 300 feet. The southern Gulf Coastal Plains are a grouping of various plains of materials ranging from sandy or gravelly to moderately fine textured; these materials developed from

Soils.—Longleaf-slash pine vegetation grows on a wide variety of upland soils, but most of the soils are acid in reaction, low in content of organic matter, and deficient in the major plant nutrients. The soils are derived mainly from Coastal Plain sediments, ranging from heavy clay to gravel, but with sandy materials predominating. Silty soils occur mainly on expansive level areas. Although sands are most prevalent in hilly sections, they occur on broad flats in central Florida. Sandy soils having a dense, though not impermeable, subsoil are apparently most favorable for longleaf pine.

The soils are mainly of three orders: (1) those low in content of bases and having subsurface horizons of accumulated clay—they are usually moist, but during the warm season some are dry part of the time (Ultisols); (2) those with a low supply of bases and having in subsurface horizons an accumulation of amorphous materials consisting of organic matter and compounds of aluminum and, usually, iron—these soils formed in acid, mainly coarse-textured materials (Spodosols); and (3) those having no pedogenic horizons (Entisols). Hapludults, Haplaquods, and Quartzipsamments

comprise the principal great soil groups.

Land use.—Portions of the ecosystem are largely in farms; other portions are largely owned by pulp and paper mills. In general, half to nearly all of the ecosystem is forested, and the trend is to more forest and improved pasture and less cropland. In southern Florida only about one-fourth of the ecosystem is in forest, which is grazed, and about one-half is in improved pasture.

Productivity

Herbage and browse production varies from 0 to 4,000 pounds per acre, depending upon site potential and the amount of the overstory of pine and hardwoods. Even greater herbage yields may be attained by conversion of land to pasture, accompanied by fertilization and other agricultural practices. Although it is possible to get high yields, the herbage needs to be supplemented by protein, energy, and mineral feeds during the winter. Appreciable forage yields can be sustained by periodically burning the range. In addition to removing the litter, burning improves forage quality and palatability.

NO. 13.—THE LOBLOLLY-SHORTLEAF PINE ECOSYSTEM

Physiography.—The loblolly-shortleaf pine ecosystem generally occurs on irregular Gulf Coastal Plains and the Piedmont where 50–80 percent of the area is gently sloping. Local relief is 100–600 feet on the Gulf Coastal Plains and 300–1,000 feet on the Piedmont. About 20 percent of the ecosystem occurs on the flat Coastal Plains where more than 80 percent of the area is gently sloping and local relief is less than 100 feet. This is the largest ecosystem in the South and Southeast.

Climate.—The climate is rather uniform throughout this ecosystem. Precipitation averages 40–60 inches annually. It is rather evenly distributed through the year but peaks slightly in midsummer or early spring in the western areas. Precipitation exceeds evaporation, but summer droughts occur. The average annual temperature is 60°–68° F. The frost-free period averages 200–280 days—250 days in the Piedmont.

Vegetation.—This ecosystem is characterized by forests in which 50 percent or more of the stand is loblolly pine, shortleaf pine, or other southern yellow pines, singly or in combination. Common associates include oak, hickory, sweetgum, blackgum, red maple, and winged elm. The main grasses are bluestems, panicums, and longleaf uniola. Dogwood, viburnum, haw, blueberry, American beautyberry, yaupon, and numerous woody vines are common.

Fauna.—The fauna varies with the age and stocking of the timber stand, the percentage of deciduous trees, and the proximity to openings, bottom-land forest types, etc. The white-tailed deer is widespread, as is the cottontail. When deciduous trees are present, the fox squirrel is common on uplands. Gray squirrels are found along intersecting drainages. Raccoon and fox are found throughout the ecosystem and are hunted in many areas.

The eastern wild turkey, bobwhite, and mourning dove are widespread. In mature forests the density of breeding birds is about 240 pairs per 100 acres. Of the 20 odd species present, the most common include the pine warbler, cardinal, summer tanager, Carolina wren, ruby-throated hummingbird, blue jay, hooded warbler, eastern towhee, and tufted titmouse. The red-cockaded woodpecker is an endangered species.

Soils.—Typical soils are low in content of bases and have subsurface horizons of accumulated clay. The clay horizons may be relatively thin (Hapludults) or thick (Paleudults). They are usually moist, but during the warmest months some are dry part of the time. Near the coast the soils are seasonally wet and have mottles or concentrations of iron and manganese or are gray (Aquults). The Gulf Coastal Plains are underlain by unconsolidated sands, silts, and clays, while the Piedmont is a dis-



F-502248

Figure 3.—Range of wiregrass, slash pine, and saw-palmetto in the longleaf-slash pine ecosystem, on the southern Gulf Coastal Plains.

the underlying materials of unconsolidated sands, silts, and clays. This ecosystem is often referred to as the "southern pine hills," the "piney-woods," or "pine-wiregrass type."

Climate.—The longleaf-slash pine ecosystem occurs in a moist, warm climate where the average annual precipitation is 40–60 inches. The average annual evaporation is 42–48 inches. The average precipitation in the east is lowest in autumn and highest in midsummer and in the west is lowest in winter and spring. Summer droughts are common in spite of the high amount of precipitation and relatively low evaporation. The mean annual temperature is 64° F, and the average frost-free period is 200–280 days, increasing from north to south.

Vegetation.—Forests in which 50 percent or more of the stand is longleaf pine or slash pine, singly or in combination, characterize this ecosystem. Common associates include other southern pines, oak, and sweet gum.

On most sites, grasses either dominate the understory or share dominance with shrubby

vegetation. East of the Apalachicola River, wiregrasses are the main herbaceous plants; in the western section bluestems provide most of the forage. Other important grasses include panicums, paspalums, and dropseeds. Gallberry, saw-palmetto, waxmyrtle, and shining sumac are prominent among the shrubs.

Fauna.—Longleaf-slash pine forests provide habitats for a wide variety of animal life. Except for a few isolated areas where the black bear or the endangered Florida panther may be encountered rarely, the white-tailed deer is the only large, indigenous mammal. Common small mammals include the raccoon, the opossum, tree squirrels, rabbits, and numerous species of ground-dwelling rodents. The bobwhite and the wild turkey are the principal gallinaceous game birds. Resident and migratory nongame bird species are numerous, as are species of migratory waterfowl. The red-cockaded woodpecker is an endangered species. There are reptiles of many species, the endangered American alligator being the largest of the reptiles.



Figure 2.—A stand of black spruce in the Lake States portion of the spruce-fir ecosystem.

F-290077



F-497024

Figure 4.—A stand of shortleaf pine in the loblolly–shortleaf pine ecosystem on the Gulf Coastal Plains.

sected plateau underlain by schists, gneisses, granites, sandstones, and shales.

Land use.—About 60–70 percent of the ecosystem is in forest, mostly in farm woodland, but a few large areas are in National Forests or are managed by large lumber companies. About 20 percent of the area is in cropland, and cash crops are produced. The trend recently has been toward using more of the area for pasture

and woodland and less for crops.

Productivity

Forage productivity is similar to that of the longleaf–slash pine ecosystem. Forage produced in this ecosystem is also nutritionally deficient and must be supplemented during the winter months to maintain the vigor of livestock.

NO. 14.—THE OAK–PINE ECOSYSTEM

Physiography.—The oak–pine ecosystem occurs on diverse land forms from the southernmost ridges and valleys of the Appalachians westward across the Coastal Plains and north into the Ozark Plateaus and Ouachita provinces. Typically it occupies irregular plateaus where 50–80 percent of the area is gently sloping and local relief is 100–300 feet. Almost as commonly it occupies hills and mountains where gentle slopes may cover as little as 20 percent of the area and local relief may reach 1,000–3,000 feet.

Climate.—The climate is quite uniform throughout the oak–pine ecosystem. Precipitation is relatively high, averaging 40–54 inches annually, and most of it comes in late autumn and spring. Summers are dry. The average annual temperature varies from 55° to 68° F, and the average freeze-free period is 180–220 days.

Vegetation.—This ecosystem is characterized by forests in which 50 percent or more of the stand is hardwoods, usually upland oaks, but in which southern pines, mainly shortleaf pine,



Figure 5.—A stand of oak and pine in the oak-pine ecosystem.

F-477181

make up 25–49 percent of the stand. Common associates include sweetgum, hickory, and yellow-poplar. The productivity of the understory is relatively low, ranging from 50 to 500 pounds of herbage per acre per year.

Fauna.—The fauna is similar to that of the adjacent oak-hickory ecosystem. Animals include the white-tailed deer, fox squirrel, and cottontail, and birds include the mourning dove, bobwhite, and turkey. Many small mammals are present, and the avian fauna is quite varied.

Soils.—Typical soils are low in supply of bases and have a subsurface horizon of accumu-

lated clay that ranges from relatively thin (Hapludents) to thick (Paleudults). They are usually moist but may become dry during part of the dry season. The soils of the Ozarks are developed from cherty limestone, while those of the southern Appalachians are developed from noncherty limestone.

Land use.—Most of this ecosystem is in farms. About 60 percent is in forest, mostly in small holdings. Twenty percent is cropland. This is a cash-crop area. Less than 10 percent is in pasture. Much of the livestock produced is consumed on the home farm.

NO. 15.—THE OAK-HICKORY ECOSYSTEM

Physiography.—The oak-hickory ecosystem occurs in areas of the eastern United States that are more mesophytic than surrounding areas. It reaches from southern Maine to Lake

Huron and to southern Texas. Its most continuous area is that known as the Ozark Plateaus with extensions (Cross Timbers) into the semi-arid grasslands of the southern Great Plains

and the interior low plateaus which fuse with the glacial till plains south of the Great Lakes and extend westward around the Ozark Plateaus (immediately west of the central Appalachian Highlands). This ecosystem also occurs on the uppermost limits of the Appalachian Highlands, known as the Blue Ridge and the Valley and Ridge provinces of these highlands. These areas are geologically the oldest uplifts in the United States.

The Ozark Plateaus and their extensions comprise an area of 72,000 square miles west of the Mississippi River and south of the Missouri River. They consist of plateaus, variously dissected, and of strong rock. Much of the area is steep and lies at altitudes of 1,000 to 2,000 feet. Narrow belts of physiographically similar areas extend as far south as Texas and New Orleans and, along streams, north into Iowa. The interior low plateaus and their extensions lie east and north and extend westward around the Ozark Plateaus. These plateaus are similar to the Appalachian provinces in that the rocks and soils are highly weathered. The extensions are more characteristically glacial till plains.

The Blue Ridge and the Valley and Ridge provinces are Appalachian Mountain belts west of the Piedmont. The mountains are remnants of a former highland. Most of the rocks are old, strong, and of highly complex structure. These provinces are characterized by "folded" mountains in which resistant strata form ridges and weaker rocks are worn down to lowlands.

The oak-hickory ecosystem also includes the Black Belt, which is the richest and best known lowland on the East Gulf Coastal Plain. It is so named because of the deep, black residual soil. The belt varies from 20 to 25 miles wide from near the Georgia border, west through Alabama and north through Mississippi. Its altitude varies from 200 to 400 feet. Rivers cut through the belt; there are few smaller streams.

Climate.—Temperatures vary considerably in this ecosystem. The frost-free season is about 120 days in the northern portion and almost 300 days in southern Texas. In most of the area, the frost-free season ranges from 160 to 200 days. Annual precipitation ranges from less than 30 to more than 50 inches, averaging 35–45 inches. More than half of the precipitation falls in the warmest months. In many areas potential evaporation during the warmest months is about equal to the precipitation.

Vegetation.—The oak-hickory ecosystem varies from open to closed woods with a strong to weak understory of shrubs, vines, and herbaceous plants. By definition, oak and hickory must make up 50 percent of the stand, singly or in combination. The ecosystem includes six vegetation communities: the Black Belt on the Coastal Plain in Alabama and Mississippi, the oak-hickory forest and the mosaic of the oak-

hickory forest and bluestem prairie communities of the Ozark Plateaus and interior low plateaus and their extensions, the oak forest of the Appalachians, the oak savanna, and Cross Timbers.

Sweetgum and redcedar are close associates in the southern (Black Belt) region of the ecosystem. Maple, elm, yellow-poplar, and black walnut often are close associates in eastern and northern parts of the oak forest and the oak-hickory-bluestem mosaic. The major shrubs are blueberry, viburnum, dogwood, rhododendron, and sumac. The major vines are woodbine, grape, poisonivy, greenbrier, and blackberry. Important herbaceous plants are sedge, panicum, bluestem, lespedeza, tickclover, goldenrod, pussytoes, and aster; many more are abundant locally.

Fauna.—The fauna of the oak-hickory ecosystem is similar to that of other eastern hardwood and hardwood-conifer areas and varies somewhat from north to south. Important animals in the ecosystem include the white-tailed deer, black bear, bobcat, gray fox, raccoon, gray squirrel, fox squirrel, eastern chipmunk, white-footed mouse, pine vole, short-tailed shrew, and cotton mouse.

Bird populations are large. The turkey, ruffed grouse, bobwhite, and mourning dove are game birds in various parts of the ecosystem. Breeding bird populations average about 225 pairs per 100 acres and include some 24 or 25 species. The most abundant breeding birds include the cardinal, tufted titmouse, wood thrush, summer tanager, red-eyed vireo, blue-gray gnatcatcher, hooded warbler, and Carolina wren. The box turtle, common garter snake, and timber rattlesnake are characteristic reptiles.

Soils.—The soils of this ecosystem are varied. The northeastern oak-hickory forest and the northeastern portion of the Appalachian oak forest are on Inceptisols and Ultisols. Soils of the smaller Black Belt area are largely Ultisols. The soils of the largest community in the ecosystem, the oak-hickory forest, are mainly Mollisols and Alfisols in the north and Ultisols in the central portion. Two "fingers" of the oak-hickory forest reaching into southern Texas coincide with areas of Alfisols; Vertisols on all sides are in other ecosystems.

Land use.—Small general farms characterize much of the area, but there are also large dairy and livestock farms. Tobacco is an important cash crop in the east and cotton, in the west. The steeper slopes, accounting for almost half the area, are mainly in forest, which is used for both recreation and timber production. A large part of the Nation's coal is mined in this ecosystem.

Productivity Classes

Herbage and browse production varies greatly in this ecosystem, ranging from 200 to

3,000 pounds per acre. The variation is due to differences in the crown cover of hardwoods and in the production capabilities of sites. The data on herbage production in the following paragraphs include only those yields achieved on land in natural cover—they do not include yields achieved when low-grade oak-hickory forests are converted to grasslands. Such grasslands could logically constitute another productivity class with yields ranging from 3,000 to 6,000 pounds per acre.

Class 1.—The vegetation of the oak-hickory-bluestem mosaic occurring on the Cross Timbers and the glacial till area south of the Great Lakes characterizes the highest productivity class of this ecosystem. This vegetation is characteristically a transition between hardwood forest and prairie biomes. Herbage yields vary from 3,000 to 6,000 pounds per acre and average about 4,500 pounds per acre. The major trees are mainly oak and hickory; mixtures of maple, oak, and elm are more common in northern parts than elsewhere. The major grass species are those associated with the tall-grass prairie; namely, big and little bluestem, Indian grass, switchgrass, and side-oats grama. There is a wide variety of forbs in this part of the ecosystem.

The soils are highly variable but are mainly Mollisols (Argiudolls that have a subsurface horizon in which clay has accumulated) in the northern part and Alfisols (Paleustalfs plus Ustorthents which also have a subsurface horizon in which clay has accumulated) in the southern Cross Timbers area. Large areas of Inceptisols (Ustochrepts, shallow soils extending 20 inches to bedrock) also occur in the southern part (Cross Timbers).

About 25 percent of the area of the northern oak-hickory-bluestem mosaic is in tame or native pasture and 10 percent is in woodland. The remainder is in cash crops. About 50 percent of the southern part of this ecosystem (Cross Timbers) is rangeland and open woodland; the remainder is in small grains and other cash crops.

Class 2.—The vegetation that characterizes productivity class 2 of this ecosystem is that of the Black Belt. Yields of browse and herbage in this class range from 1,500 to 3,000 pounds per acre. The vegetation of this area is highly variable, ranging from almost open bluestem prairie to dense forest of tall or medium-height broad-leaved deciduous trees. There are sporadic concentrations of redcedar on calcareous rock outcrops. The major herbage plants are big and little bluestem, switchgrass, Indian grass, and a mixture of forbs and deciduous trees. The most common trees are sweetgum, post oak and other oaks, and hickory. Low-growing trees and shrubs include winged elm, ash, and dogwood.

The soils are variable and include Vertisols (Chromuderts plus Eutrochrepts, gently sloping and clayey), Inceptisols (Eutrochrepts plus Chromuderts, gently sloping and usually moist and high in content of bases), and Ultisols (Paleudults, which are moderately sloping, have a thick horizon of accumulated clay, and are low in content of bases, plus Fragiudults, which are gently sloping and have a fragipan). Most of the Black Belt is in farms, one-fifth being used for cropland, two-fifths for forests, and the remainder for pastures and urban uses.

Class 3.—The open meadows of the oak and oak-hickory forests of the Great Smoky Mountains and the Ozark Plateaus characterize productivity class 3. Herbage production ranges from 1,200 to 1,800 pounds per acre, averaging about 1,500 pounds. The major herbaceous plants are bluestems, poverty oatgrass, panicgrass, and three-awns. Forbs are less common. Blackberry, sassafras, and persimmon are the major browse plants.

The soils are Ultisols (Paleudults plus Fragiudults) and Inceptisols (Dystrochrepts plus Fragiocchrepts) which are soils with fragipans that restrict tree roots but support low-growing plants.

Class 3 areas are usually small and are used mainly for pasture or hay production.

Class 4.—The vegetation within the forest proper (excluding open meadows) of the Appalachian oak forest and the oak-hickory community of the Ozark Plateaus characterizes this productivity class.

In the Appalachian oak forest community, herbage and browse production (mainly browse) varies from 500 to 800 pounds per acre, averaging 650 pounds per acre. The major tree species are white oak, northern red oak, and white ash. Associates are red maple, yellow birch, aspen, black cherry, and butternut in the northern parts and yellow buckeye, yellow birch, sugar maple, and black cherry in the middle and southern parts. White ash is less important or is absent in the southern areas. The major plants of the shrub strata are viburnum, sassafras, mountain laurel, rhododendron, madrone, blueberry, blackberry, sedge, sorrel, cinquefoil, fern, and clubmoss.

The soils of the Appalachian oak forest are mainly Ultisols (Hapludults plus Dystrochrepts and Paleudults) in the southern part and Inceptisols (Dystrochrepts) and Spodosols (Haplorthods plus Haplaquepts and Fragiocchrepts) in the north. All are moderately sloping to steep.

About half the oak forest area is in forest or farm woodlots, and one-fourth to one-third is in cropland and pasture. Cropland and pasture are more common in the northern parts.

In the oak-hickory forest community of the Ozark Plateaus and the interior low plateaus,



Figure 6.—A mixed oak stand in the oak-hickory ecosystem.

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combined herbage and browse yields are 200 to 300 pounds per acre. The major trees are black, red, white, post, and blackjack oak; black, bitternut, and shagbark hickory; and elm. The major shrubs and vines are blueberry, wild grape, blackberry, poisonivy, woodbine, greenbriar, and dogwood. Herbaceous plants include sedge, panicum, tickclover, goldenrod, pussytoes, and aster.

The soils are mainly Ultisols (Hapludults plus Hapludalfs and Paleudults, moderately sloping to steep). Some are Ultisols with a fragipan (Fragiudults).

About three-fifths of the oak-hickory forest area is in forest or woodland, and the other two-fifths is used for cropland and pasture. Conversion of forest land to grassland has become increasingly common in this area.

NO. 16.—THE OAK-GUM-CYPRESS ECOSYSTEM

Physiography.—The oak-gum-cypress ecosystem is characterized by the vegetation of the Mississippi Valley and other bottom lands in every Southern State, the cypress savanna west of the Everglades in Florida, the mangrove swamps south of the Everglades, and the east coast of Florida, Georgia, and the Carolinas. Many of the rivers that cross the Coastal Plain province have little drop in elevation—the Mississippi River drops only 7.5 inches per mile from Memphis to Vicksburg—and are meandering. The rivers have created large alluvial

plains. The largest plains are along the Mississippi River and extend from the Gulf of Mexico to the Ozark-Ouachita Highlands and north-eastward to Indiana. Other river flood plains are much smaller but in aggregate constitute several million acres.

The alternating drylands and wetlands west of the Everglades are known as the cypress savanna, which is a monotonous flatland, very few feet above sea level. Outcrops of dense, fine-grained limestone are scattered through the area, but these do not affect the flatness of



Figure 7.—A forest of live oaks, draped with Spanish moss, in the oak-gum-cypress ecosystem.

F-501614

the plain. The mangrove swamps of southern Florida are an extension of the Everglades into the ocean. Salt water invades that part of the coastline, making it different from the Everglades and the cypress savanna.

Climate.—Most of this ecosystem has a moist, mild climate, the frost-free season ranging from 200 days to practically all year at the tip of Florida. Precipitation ranges from 60 inches in Florida to about 35 inches at the northern extremity of the ecosystem in Indiana. More than half the precipitation comes in the warmest months, and in most of the area rainfall exceeds evaporation during the frost-free season.

Vegetation.—The vegetation of this ecosystem varies considerably, but the dominants are of tree life-form. It is made up of bottom-land forests in which 50 percent or more of the stand is tupelo, blackgum, sweetgum, oak, and bald-cypress, singly or in combination—except where pines comprise 25–49 percent of the stand (in which case the ecosystem is oak-pine). Common associates include willow, maple, sycamore, cottonwood, and beech. Most species are broad-leaved deciduous trees. Trees of the mangrove swamp are mainly black mangrove and red mangrove. The vegetation of the cypress savanna is dominated by needle-leaved deciduous trees and some broad-leaved evergreen or deciduous trees and shrubs. The trees and shrubs occur in groves surrounded by open grassland dominated mainly by three-awn species. Mangrove swamps are often flooded by tidewater; the cypress savanna is flooded less frequently and only by fresh water.

Fauna.—This ecosystem is the most fertile and productive of southern habitats for wildlife. In times past, large animals, such as the

deer, elk, black bear, mountain lion, bobcat, and wolf, inhabited the forest. Presently, the white-tailed deer is common in most areas. Other mammals include the gray fox, gray squirrel, fox squirrel, raccoon, opossum, striped skunk, eastern cottontail, swamp rabbit, and many small rodents and shrews.

Birds include wild turkeys and, in the flooded areas, ibises, cormorants, herons, egrets, and kingfishers. Among the numerous species of birds in the area, the ivory-billed woodpecker, Bachman's warbler, and the southern bald eagle are classed as endangered species. The Carolina parakeet is extinct. Many species in the mangrove swamps and the cypress savanna are the same as those in the Everglades, in the wet grasslands ecosystem. Common mammals in the mangrove area are the fox squirrel and raccoon. Nesting birds include the mangrove cuckoo and various herons and egrets. The key deer is very scarce and is classed as an endangered species.

Soils.—Soils of this ecosystem are varied. In the largest area, the Mississippi bottom land, they are Mollisols, Alfisols, and, primarily, Inceptisols. The soils of the small area in southern Florida are primarily Inceptisols. In the many bottom lands extending inland from the Atlantic coast, the soils are mainly Ultisols, smaller areas of Inceptisols being near the coast.

Land use.—Nearly all of the area is in farms. The wettest parts that are not artificially drained, about 10 percent of the area, remain in forests. The remainder is evenly divided between cropland and pasture. Cotton, soybeans, and corn are major crops in most of the region; rice and sugarcane are important locally.

NO. 17.—THE ELM-ASH-COTTONWOOD ECOSYSTEM

Physiography.—The elm-ash-cottonwood ecosystem occurs in narrow belts along major streams or scattered areas of dry swamps. The major portion is on the lower terraces and flood plains of the Mississippi, Missouri, Platte, Kansas, and Ohio Rivers from the Dakotas, Minnesota, and Ohio south through Kansas and Missouri. The ecosystem also is scattered throughout the area including States adjacent to the Great Lakes and extending to the east coast, where it occurs on dissected glacial-till plains.

Climate.—The ecosystem crosses several climatic zones. It is characteristic of sites that are moist as a result of either flooding or precipitation. Average annual precipitation varies from 10 inches near the foothills of the Rocky Mountains to 50 inches in the southern and

northeastern areas. Temperatures vary considerably, the January mean daily low ranging from zero in the north to 30° F in the south. The average frost-free period varies from 100 days in the north to 200 days in the south.

Vegetation.—The vegetation of this ecosystem is a tree life-form of low to tall broad-leaved deciduous trees, varying from open to dense and often accompanied by vines. Cottonwood species usually dominate the ecosystem and often occur in pure stands. Cottonwood is most common along the streams. Swamp cottonwood is more common in other places. Common associates in the north are willow species and green and white ash. Sycamore and sugarberry are common associates in the south. Other common associates are willow, sycamore, beech, and maple. The cottonwood-willow stage is



Figure 8.—A stand of ash in the elm-ash-cottonwood ecosystem.

F-437117

short lived. This stage is followed by the river birch and silver maple-American elm types in the north and by the sycamore-pecan-American elm or sugarberry-American elm-green ash types in the south.

Fauna.—Since this ecosystem is far flung and is in the main flood plains of rivers dissecting a number of other, quite different ecosystems, the fauna is varied and, in many cases, influent from the surrounding ecosystems. Forest-edge animals and birds are common, and numerous ones include the cottontail, bobwhite, white-tailed deer, raccoon, red fox, coyote, striped skunk, spotted skunk, meadow jumping mouse, fox squirrel, and ground squirrels. The sharp-tailed grouse inhabits grassy areas and open areas in the forest. The ruffed grouse is also present. Other birds include the

catbird, goldfinch, yellow-billed cuckoo, indigo bunting, cardinal, lark sparrow, mockingbird, common crow, blue jay, robin, ruby-throated hummingbird, and Cooper's hawk.

Soils.—The soils are mainly Mollisols (Haplaquolls plus Udifluvents, Hapludolls, and Hapludalfs) which are seasonally wet and have a thick, nearly black surface horizon and gray subsurface horizons. The materials in the horizons have been altered or removed, but no clay or calcium carbonate has accumulated.

Land use.—At least 30 percent of this ecosystem is in forest, mainly as small woodlots on wet bottom land and steep slopes bordering stream valleys. The rest is cropland devoted primarily to corn, soybeans, oats, and other feed grains. Much of the grain is fed to beef cattle and hogs on the farms where it is grown.

NO. 18.—THE MAPLE-BEECH-BIRCH ECOSYSTEM

Physiography.—The maple-beech-birch ecosystem is best developed in the New England States. Typically, it occurs on open high hills and low mountains. Only about 20–30 percent of the area is gently sloping. Ridges rise 500 to

3,000 feet above the broad valleys. Farther west, in the Lake States, the ecosystem occurs on irregular plains and tablelands. There, 50–80 percent of the area is gently sloping and local relief is normally 100–300 feet.

Climate.—Mean annual precipitation ranges from 40 to 48 inches and is about 41 inches at central locations. The average annual snowfall of 72 inches covers the ground for about 87 days each year. The number of freeze-free days ranges from 120 to 150 per year. The mean daily maximum temperature is 24°–36° F in January and 74°–80° F in July. The corresponding minimum temperatures are 4°–18° F and 52°–60° F. Potential evapotranspiration is 17–28 inches. The mean annual water surplus is 10–34 inches.

Vegetation.—A forest is classified as being in this ecosystem when 50 percent or more of the stand is maple, beech, or yellow birch, singly or in combination. Common associates include hemlock, elm, basswood, and white pine.

Fauna.—The white-tailed deer occurs throughout much of the maple-beech-birch ecosystem. The hardwood forest and the openings and farms within it provide food and cover for

a varied fauna. The black bear is present in many areas. The wolf is no longer common, but the red fox and gray fox are rather widespread, as is the bobcat. Several species of squirrels are in the forest, and a number of smaller rodents inhabit the forest floor.

The ruffed grouse is widespread, and the bobwhite inhabits the interspersed farmlands and forest openings. Songbirds include the ovenbird, red-eyed vireo, hermit thrush, scarlet tanager, blue jay, black-capped chickadee, wood pewee, and magnolia warbler.

Soils.—Typical soils have a low supply of bases and a subsurface horizon that is dense and brittle but not indurated or that contains an accumulation of organic matter and iron and aluminum compounds (Fragiorthods and Haploorthods). Other major soils have light-colored surface horizons and a subsurface horizon that is dense and brittle but not indurated (Fragiochrepts).



F-522874

Figure 9.—A mixed stand in the maple-beech-birch ecosystem. The largest trees are sugar maples. Other trees are yellow birch. The saplings are beech. The ground vegetation is largely a mixture of young trees and hobblebush.

Land use.—Much of the area is in farms. Feed grains and forage for dairy cattle are the principal crops. Potatoes are important locally.

The steeper land is mainly forested, produces significant amounts of timber, and is an important recreation resource.

NO. 19.—THE ASPEN-BIRCH ECOSYSTEM

Physiography.—The aspen-birch ecosystem lies mainly within the Great Lakes section of the Central Lowland east of the Mississippi River and extends from western Minnesota to Lake Erie. This area is characterized by a great variety of features of recent glacial origin. In addition to moraines and outwash plains, thousands of lakes and large areas of swamps are in the area. The underlying rock strata of the area are buried by thousands of feet of glacial till. These strata span the ages from Cambrian to Carboniferous. Three strong formations of dolomite, limestone, and sandstone form outcrops on the edges of two cuestas. The intervening weak beds do not form any particular features. Elevations vary from 600 to 1,500 feet.

Climate.—The areas occupied by this ecosystem have a moist and cool climate. The frost-free period varies from 100 to 140 days. Average annual temperatures are 35°–47° F. Annual precipitation is 30–35 inches, of which 40–66 percent falls during the warmest months. Precipitation during the frost-free season ranges from about 80 percent of the evaporation potential to about equal that potential.

Vegetation.—This ecosystem is characterized by forest in which 50 percent or more of the stand is aspen, balsam poplar, paper birch, or

gray birch, singly or in combination. Common associates include maple and balsam fir. Major aspen species in the Great Lakes area are big-tooth and quaking aspen. Paper birch is a common associate. Balsam poplar is important only along streams and the margins of swamps.

Fauna.—The fauna of the aspen-birch ecosystem is similar to those of the spruce-fir and white-red-jack pine ecosystems, with which this ecosystem is intermingled. The white-tailed deer and black bear are common. The coyote, bobcat, great horned owl, and other predators feed on a variety of small mammals. The ruffed grouse is present. Among the songbirds are the tufted titmouse, blue jay, hairy woodpecker, downy woodpecker, wood thrush, eastern wood pewee, goldfinch, catbird, and red-eyed vireo.

Soils.—The aspen-birch ecosystem occurs on a wide variety of soils, but they are mainly within three orders. The better drained soils are mostly Alfisols, and the wetter, poorly drained soils are Entisols and Mollisols.

Land use.—More than 80 percent of the area is in forest. Lumbering, recreation, and mining are major industries. Feed grains and forage for dairy cattle and other livestock are the main products of cropland. Potato growing is important locally.

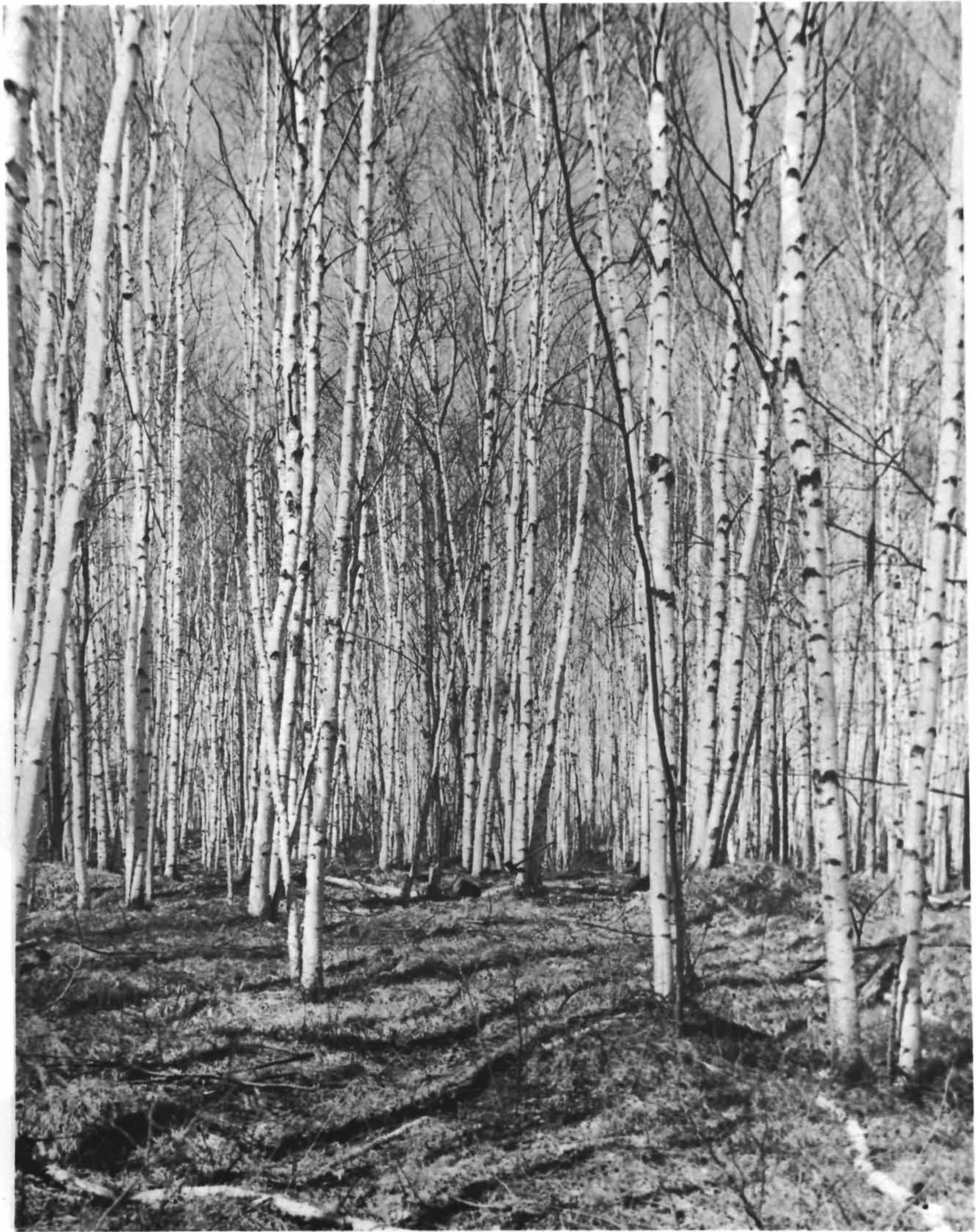
NO. 20.—THE DOUGLAS-FIR ECOSYSTEM

Physiography.—The Douglas-fir ecosystem encompasses one of the larger blocks of western timber in that it includes much of the mountains in western Oregon and western Washington and extends well south into the northern California Coast Ranges. It is an extensive ecosystem, for there are large acreages of it in the Northern Rocky Mountains and lesser scattered areas in the Blue Mountains of Oregon and the Middle and Southern Rocky Mountains. The elevational range is great, from 500 feet up into the high mountains.

Climate.—The length of the frost-free season is 200 days in western coastal areas and 160 days in the rest of western Oregon and Washington. In the rest of the ecosystem, the frost-free season is about 80 to 120 days. Average annual precipitation is 40 to 80 inches in the extreme west and 20 to 30 inches in most of the interior portion of the ecosystem. In the extreme west 50 to 60 percent of the total precipitation occurs during the period December to March. In the rest of the ecosystem, only

25 to 40 percent of the precipitation occurs in the coldest months. The amount of precipitation during the frost-free season is equal to, or not less than, 40 percent of the evaporation, in western Oregon and western Washington. In the rest of this ecosystem, precipitation during the frost-free season is only 30 to 40 percent of the evaporation potential.

Vegetation.—This ecosystem is characterized by forest consisting of 50 percent or more Douglas-fir, except where redwood, sugar pine, or western white pine comprise 20 percent or more of the stand. Most common ecological descriptions of one of the largest blocks of timber in western Oregon and Washington define it as subclimax stands in areas where the climax is western hemlock-western redcedar. Common shrubs in the ecosystem are of the genera of maple, rockspirea, filbert, blueberry, snowberry, barberry, currant, blackberry, ninebark, rose, and spirea. Herbage includes grass and other vegetation having a grasslike growth form, especially in the stands in interior States.



F-502403

Figure 10.—A young stand of paper birch in winter, in the aspen–birch ecosystem, in the Great Lakes area.



95-G-48608

Figure 11.—A stand of old Douglas-firs with western hemlock in the understory, in the Douglas-fir ecosystem in the Pacific Northwest

Here, pinegrass and *Carex concinnoides* are present.

Fauna.—Common large mammals in this ecosystem include elk, deer, and black bear. Grizzly bear and moose are in the northern Rockies. Blue and ruffed grouse are present. Most of the northwestern part of the ecosystem has hawks and owls. Mammalian predators include mountain lions and bobcats. Small mammals include mice, squirrels, marten, chipmunks, and bushy-tailed wood rats. Some of the more common birds are the chestnut-backed chickadee, red-breasted nuthatch, gray jay, and Steller's jay.

Soils.—In western Washington and Oregon the soils of this ecosystem are Inceptisols and Ultisols. In the northern coastal area of California they are Ultisols. In the Blue Mountains of Oregon, the soils are Mollisols with an overburden of very absorptive Vitrandepts. In the northern Rockies the soils are Inceptisols (including considerable areas of Vitrandepts), Alfisols, and Mollisols. In the Middle and Southern Rocky Mountains, the soils are Mollisols, Entisols, and Alfisols.

Land use.—About 75 percent of the land area is forested, and lumbering is a major industry. Less than 20 percent is in crops or improved pasture. Fruit, vegetables, and grain are the major crops. Forage and feed grains occupy large acreages.

The best sites in this ecosystem have historically been used for timber production in western Washington, Oregon, and California. Use of the land for livestock production is not so well known. However, there are now more sheep in western Oregon and Washington than in the range flocks of the eastern parts of these States. The big increase in sheep raising has been in farm flocks in the lowlands on land enclosed with woven-wire fences. However, some privately owned cutover lands in the hills and mountains have been converted to seeded ranges for livestock, and the favorable precipitation has permitted high stocking rates to be successfully achieved—1 to 2 animal units

months (AUM's) per acre.

Without management of the average tract of old cutover land, it usually becomes uneconomical to use it for grazing, because of the invasion of bracken and brush. Under serious and responsible management, there are some possibilities for more and better use of forest lands for livestock. Chiefly, there is the possibility of grazing recently logged lands in combination with seeded land at lower elevations. A relatively small number of cattle- or sheep-raising operations presently make use of recently logged-over lands, yet it is possible to start grazing patch clearcuts within 2 or 3 years after logging (as soon as new tree seedlings are established) and continue grazing for about 15 years, or until the tree canopy closes.

Land use in this ecosystem in the Blue Mountains of Oregon and in the northern Rockies is similar to the grazing-timber growing relationship in the ponderosa pine ecosystem. "Jungling" or "brushing-up" is, however, more prevalent in interior Douglas-fir stands than in the ponderosa pine stands. The pine stands are estimated to be 60 percent jungled, whereas interior Douglas-fir stands are about 90 percent jungled. Suppression of timber growth by too great a density of trees has been slower to occur in the stands of Douglas-fir than in the stands of pine because of the former's tolerance to shading. Nevertheless, wherever the stand density is excessive in this ecosystem, forage production has been reduced to 150 pounds per acre.

Productivity

Grazing in major portions of this ecosystem, in western Washington, western Oregon, and western California, is usually confined to patch clearcuts and lands converted to pasture by logging and grass seeding. Under good management, grass production of 1,000 to 3,000 pounds per acre can be achieved. With no opening of the tree canopy, herbage production is 50 to 150 pounds per acre.

NO. 21.—THE PONDEROSA PINE ECOSYSTEM

Physiography.—Since ponderosa pine has a rather wide range of adaptability and can dominate some of the less mesic true forest sites, it occupies low mountains and foothills in many places; yet in mixtures with other species, it is found at moderate elevations. The extensive distribution of ponderosa pine and associates includes parts of 14 western States from Nebraska to the Pacific coast and from Arizona to Canada. It is the largest western forest type in the United States. Local topography can be gentle, as on plateau tops and low mountains, or it can be steep, as on canyon

walls and faces. Semiarid, low mountain sites are common, but it is difficult to characterize the physiography of the ecosystem because it varies greatly.

Climate.—The length of the frost-free season at any location in the ecosystem depends largely upon the latitude and elevation. In general, in much of the northern area the frost-free period is 120 days, whereas in many foothill areas and in parts of the Sierra and the Gila Mountains of the Southwest, it can be 240 days.

Annual precipitation is about 15 to 20 inches in the more pure pine areas, but where there

are combinations of pine and other conifers at moderate elevations, the precipitation can total 30 inches. In the far western sector, only 25 percent of this moisture falls in the warmest months. In the Northern Rocky Mountains, 40–50 percent of the precipitation occurs in the warmest months. In the middle to southern Rockies, 66 to 75 percent occurs in the warmest months. In the southern areas and those at low elevations, precipitation during the frost-free season is only 20 percent of the evaporation potential. In northern areas precipitation during the growing season may be as high as 40 percent of the evaporation potential.

Vegetation.—By definition, ponderosa pine forest is 50 percent or more of one of these pines: ponderosa pine, Jeffrey pine, sugar pine, limber pine, Arizona ponderosa pine, Apache pine, or Chihuahua pine. The exceptions are those situations where western white pine or sugar pine comprises 20 percent or more of the stand; then these species control the name of the forest.

The impact of logging and ecological dynamics can cause some problems in maintaining good delineation of the ponderosa pine ecosystem. This ecosystem is idealized as open and parklike with an excellent ground cover of grasses, sedges, and forbs or with an understory of shrubs of low to medium height. The shrubs, however, may vary from antelope bitterbrush in Oregon to beararmat in the Sierra Nevada in California. In perhaps 60 percent of the area, the idealized open character of the ponderosa pine ecosystem has changed to that of a dense and growth-retarded stand,³ particularly in the Pacific Northwest.

Fauna.—In the ponderosa pine ecosystem, the major mammalian influents are the Rocky Mountain elk, mule deer, mountain lion, and coyote. Animals of less importance include the bushy-tailed wood rat, white-footed mouse, bobcat, rock squirrel, cottontail, porcupine, mantled ground squirrel, Kaibab squirrel, and chipmunks. The Kaibab squirrel is rare. It is endemic to this ecosystem on Arizona's Kaibab Plateau.

The most abundant and important resident birds in the ponderosa pine ecosystem include the pygmy nuthatch, long-crested jay, sharp-shinned hawk, Rocky Mountain nuthatch, mountain chickadee, Cassin's purple finch, red-shafted flicker, red-backed junco, western goshawk, and western red-tailed hawk. Birds that are common during the summer include the chestnut-backed bluebird, Audubon's warbler, Natalie's sapsucker, western chipping sparrow, horned owl, and band-tailed pigeon.

³ "Dense and growth-retarded" means 2,000 to 10,000 pine stems per acre instead of 125 per acre. In most such cases, growth rings are 20 to 40 per inch instead of 15 or fewer rings per inch.

Soils.—The soils occupied by the ponderosa pine ecosystem vary tremendously. Along the western edge of the Columbia Plateau and the east slope of the Cascade Mountains, they are Mollisols, Inceptisols, Entisols, and Aridisols. In northern and eastern California, ponderosa pine stands are associated with Ultisols. At the northern edge of the Columbia Plateau (Okanogan Highlands) and in much of the Northern Rocky Mountains, pine and the related forest types occur on Inceptisols; the soils of the rest of these areas are largely Alfisols and Entisols. In the Blue and Wallowa Mountains of eastern Oregon, pine stands occupy Mollisols. In the Middle and Southern Rocky Mountains, pines and associates are on Mollisols, Aridisols, Entisols, and Alfisols. Pine stands in the Gila Mountains are largely on Mollisols. The small stands of pine in the Great Basin are on Aridisols.

Land use.—Ponderosa pine lands continue to be producers of softwood that is highly desired for either millwork or framing. The forage supply within the ecosystem has been highly prized for summer range, since the land is usually high enough to get good precipitation and the forest soils are deep enough to store sufficient water for growing timber and good ground cover. These precipitation and soil characteristics make the ecosystem productive of forage during the hot months when range forage at lower elevations has dried.

Currently forage production in the ponderosa pine ecosystem is lagging behind its potential, and the total productivity is suppressed enough to create a seasonal shortage of summer range for livestock. In some areas this shortage is such that if ranchers stock to fully use the winter, spring, and fall range, there is a 40 to 50 percent shortage of summer range. Many ranchers are forced to meet this situation by using spring and fall range also as summer range. Ranchers operating this way have to accept substantial weight losses in brood cows by fall of each year, and they have to accept calf crops only about 75 to 83 percent of the calf crops of ranchers with true summer range who maintain 1,000- to 1,400-pound cows with a 90 percent calf crop.

The mountain range of the ponderosa pine and Douglas-fir ecosystems is a prime summer range for a high proportion of the mule deer and is a spring and fall range for elk. Approximately 20 to 30 percent of the herbage is reserved by land managers for use by big game. However, this is not to say that this range is critical for big game; for these animals the winter forage supply of low-elevation shrub and bunchgrass ranges is critical.

Productivity

Excessive density of tree stands and consequent arrested tree growth in some parts of



F-459737

Figure 12.—A parklike stand of timber and ground cover of grass in the ponderosa pine ecosystem in the Pacific Northwest.

the ponderosa pine ecosystem make it impossible to estimate the potential timber and forage productivity of many sites. At such locations an inverse relationship can be found between the density of the tree stand and forage production.

About 500 to 600 pounds of herbage per acre is commonly produced in open stands of mature pine with about 200 saplings per acre. In stands that have an understory of tree reproduction numbering 2,000 stems per acre, the herbage production is only about 250 pounds per acre. At about 5,000 stems or more per acre, herbage production can be 0 to 50 pounds per acre. When pure stands of ponderosa pine are thinned to approximately 75 to 100 stems per acre, herbage production of 850 pounds per acre is obtainable. On reseeded skid trails it is possible

to produce 1,000 to 2,000 pounds of herbage per acre.

The quality of herbage for livestock and game is improved by the timber stand improvement practice of thinning; that is, the nondigestible fraction of forage decreases and the proportion of carbohydrates increases. The floristic composition of the herb and shrub understory in pine forests seems to vary with several factors, including the overstory. In the Northwest, grasses and sedges of such genera as *Calamagrostis*, *Carex*, *Agropyron*, *Festuca*, *Muhlenbergia*, *Poa*, *Stipa*, and *Danthonia* constitute 10 to 40 percent of the composition. Shrubs are very conspicuous in certain areas and include such genera as *Purshia*, *Ceanothus*, *Rosa*, *Symphoricarpos*, *Holodiscus*, *Spirea*, *Salix*, and *Arctostaphylos*. Various forbs are common.

NO. 22.—THE WESTERN WHITE PINE ECOSYSTEM

Physiography.—The western white pine ecosystem mainly occurs in the high mountains of the Northern Rocky Mountains of western Montana and northern Idaho. It is also in scattered small areas in the Cascade Mountains of Oregon and Washington. Less than 20 percent of the total area is gently sloping, and local relief is over 3,000 feet. Elevations are mostly 4,000 to 8,000 feet.

Climate.—Annual precipitation in this ecosystem is 20 to 30 inches; of this, 60 to 65 percent occurs during the warmest months. During the frost-free season, precipitation is 20 to 40 percent of the evaporation potential. The length of the frost-free period is 80 to 120 days.

Vegetation.—Forests in which 20 percent or more of the stand is western white pine or sugar pine characterize this ecosystem. Küchler's classification of cedar-hemlock-pine forest corresponds with this ecosystem. Daubenmire and Daubenmire (1968) would classify western white pine as being in various western redcedar habitats, but also as being seral to some western hemlock and true fir habitats. In summary, western white pine is sometimes found in pure stands yet commonly occurs in mixtures with other conifers. Shrubs and forbs are prominent in the understory, whereas grasses and sedges are minor.

Fauna.—The fauna of the western white

pine ecosystem is similar to that of the fir-spruce ecosystem. The ecosystem is noted for its population of big game, particularly the Rocky Mountain elk and mule deer. Smaller mammals include the snowshoe hare, long-tailed weasel, marten, coyote, bobcat, and various mice and shrews. The black bear is present. The many birds include the ruffed grouse, chestnut-backed chickadee, red-breasted nuthatch, and Swainson's thrush.

Soils.—Most of the soils have formed from ashy materials or have low bulk density and large amounts of amorphous materials, or both. Horizons are weakly developed (Andepts). The most productive sites in this ecosystem have moist but well-drained soils and occur in valleys and on moderate to gentle slopes with northern exposures.

Land use.—Heavy forests cover much of the land; croplands occupy less than 2 percent of the ecosystem. The forests are important for timber production as well as summer cover for wildlife—the area is famous for its elk hunting. Wood of western white pine is soft and highly "workable," like that of eastern white pine; thus, it is valued for a variety of millwork items. The most productive forage sites are usually limited to logged-over areas or natural meadows and openings that are adjacent to, or interspersed within, the general forest type.

NO. 23.—THE FIR-SPRUCE ECOSYSTEM

Physiography.—The fir-spruce ecosystem lies within the Sierra-Cascade and the Northern, Middle, and Southern Rocky Mountains provinces. It is normally the highest forest zone in the mountain ranges but varies from as low as 1,500 feet in the Northwest to as high as 12,000 feet in the Southern Rocky Mountains. Much of the topography is rough and broken.

Climate.—Annual precipitation ranges from somewhat less than 22 inches in the Rocky Mountains to 50–75 inches in the Sierras. In the Rockies 50–65 percent of the precipitation falls in the warmest months, while in the Sierra-Cascade Mountains province only 25–40 percent falls in the warmest months. Precipitation in the period December-March is 50–60 percent of the annual total in the Sierra-Cascade Mountains and 15–25 percent in the Rocky Mountains. During the frost-free season, precipitation is 20 to 40 percent of the evaporation potential.

Vegetation.—The fir-spruce ecosystem is characterized by open to dense forests of low to tall needle-leaved evergreen trees and patches of shrubby undergrowth and scattered herbs.

Fifty percent or more of the stand is silver fir, subalpine fir, red fir, white fir, mountain hemlock, Engelmann spruce, or blue spruce, singly or in combination—except where western white pine comprises 20 percent or more of the stand (in which case the ecosystem would be classified as western white pine). Because of the dense overstory and limited understory, heavily stocked stands are usually not considered a forage resource for domestic livestock unless timber is harvested by patch clearcuts.

The usual dense stand produces about 0 to 50 pounds of herbaceous and shrub material. Patch clearcuts or burns which are rehabilitated by tree planting and grass seeding can produce 2,000 to 3,000 pounds of herbage per acre for 10 to 12 years.

Fauna.—Seasonally, the fir-spruce ecosystem and, in particular, the interspersed openings and stream bottoms with broad-leaved woody species such as aspen and willows are used by moose, elk, mule deer, and white-tailed deer. Mountain caribou originally wintered in Idaho, Washington, and Montana; a few still do. The wolverine, lynx, black bear, mountain lion,



F-379195

Figure 13.—The shrub understory in this forest in the western white pine ecosystem provides good cover for wildlife.

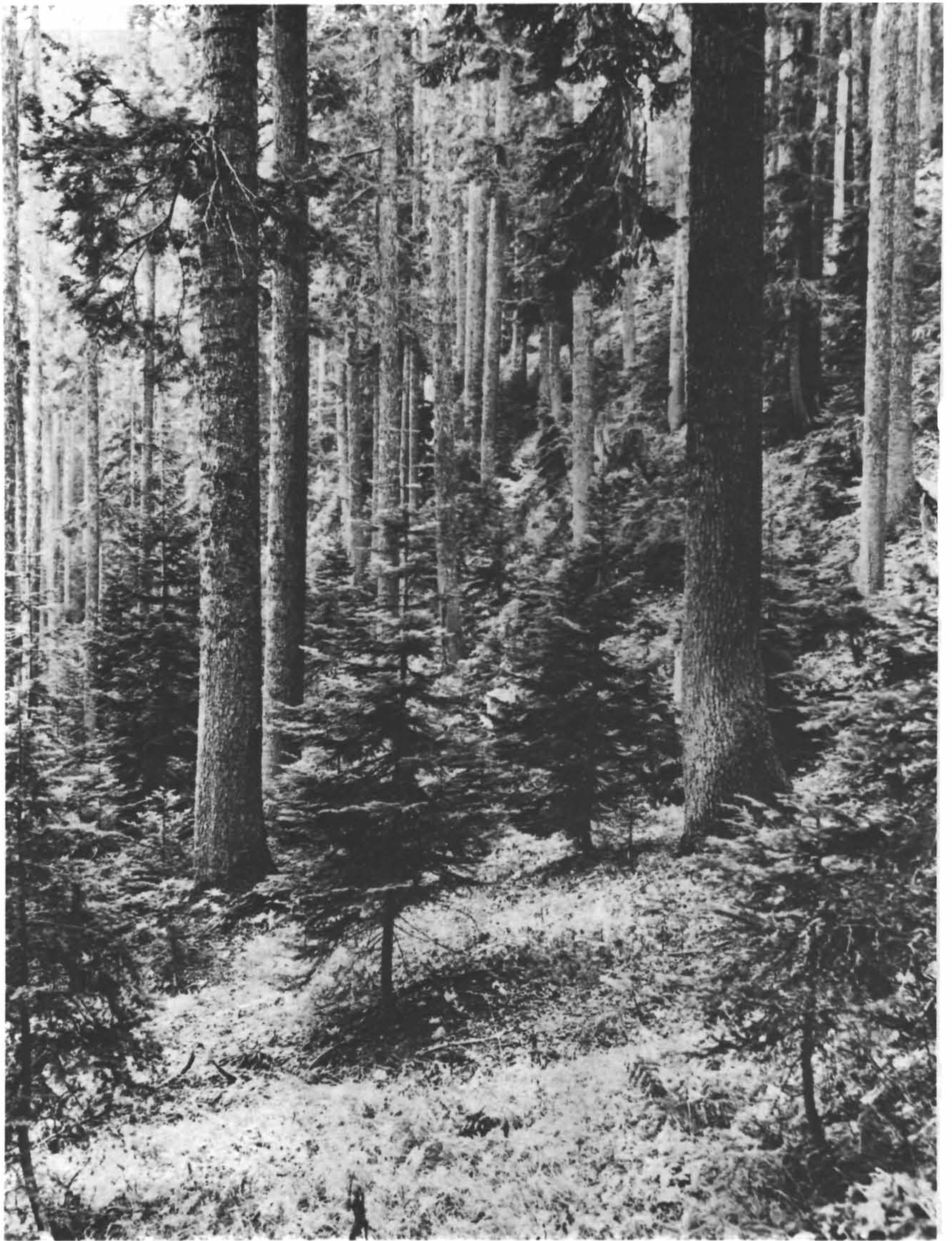


Figure 14.—A stand of Pacific silver fir and noble fir in the fir-spruce ecosystem.

F-522875

coyote, and wolf occur in the ecosystem. The grizzly bear is present, though in a fraction of its original numbers and is classified as a rare species. Grizzlies are about the only predator of elk and possibly are a useful natural control over excessively large elk herds.

Several of the species that have been mentioned use the fir-spruce ecosystem only seasonally, primarily as cover or in following migratory routes. This is the case with the mountain sheep and the mountain goat, which occur more commonly in steep rocky areas. Among the birds in the ecosystem are several of the blue grouse and spruce grouse groups, ruffed grouse, and various chickadees, nuthatches, bluebirds, robins, and jays. Among the more common rodents and lagomorphs are the porcupine, beaver, snowshoe rabbit, squirrels, flying squirrels, pocket gophers, chipmunks, and various

species of mice.

Soils.—The soils of this ecosystem are extremely varied. In the Northwest, Inceptisols (Cryandepts and Cryumbrepts) predominate. Ultisols occur in the Sierra Nevada Range. Alfisols (Boralfs) are common in the Rocky Mountains, and there are also significant areas of Entisols. Areas of deep overburdens of absorptive Vitrandepts are very productive sites in eastern Oregon and the northern Rockies.

Land use.—Heavy forests cover much of the ecosystem, and they are used as wildlife habitats and watersheds and for recreation and lumbering. There is virtually no cropland. Much of the area is owned by the Federal Government. Grazing by domestic livestock is generally limited to natural parks and meadows that occur within the forest matrix.

NO. 24.—THE HEMLOCK-SITKA SPRUCE ECOSYSTEM

Physiography.—The hemlock-Sitka spruce ecosystem extends south from British Columbia along the Oregon and Washington Coast Ranges and occupies part of the Cascade Range in Washington. The elevation ranges from 200 to 4,000 feet.

Climate.—The length of the frost-free season for that portion of the ecosystem along coastal Oregon and Washington is about 200 days. The portion in the northern Cascades has a frost-free season of about 120 days. Precipitation is about 60 to 115 inches annually in western Oregon and Washington. In western Oregon and Washington, about 60 to 70 percent of the precipitation occurs in the months of December to March. In western Washington the amount of precipitation is mostly equal to double the evaporation potential. In western Oregon it is 80 percent of potential evaporation.

Vegetation.—This ecosystem is defined as having 50 percent or more of the forest in western hemlock or Sitka spruce or both. Other tree species which may be present to a lesser degree are Douglas-fir, grand fir, and western redcedar. Common shrubs include the vine maple, red whortleberry, Cascades mahonia, California dewberry, and coast rhododendron.

Usual herbs are American twinflower, hollyfern, cutleaf goldthread, and redwoods violet.

Fauna.—The most common large mammals in this ecosystem include the elk, deer, black bear, and moose. In the hemlock areas of the northwestern portion, the red-tailed hawk, screech owl, pygmy owl, and great horned owl are avian predators. Mammalian predators include mountain lions, bobcats, wolves, the Pacific marten, and the western spotted skunk. Smaller animals include the deer mouse, Douglas squirrel, bushy-tailed wood rat, Townsend's chipmunk, and coast mole. Among the more common birds are the red crossbill, chestnut-backed chickadee, red-breasted nuthatch, raven, gray jay, Steller's jay, hermit warbler, western wood pewee, and pine siskin. Blue and ruffed grouse are also present.

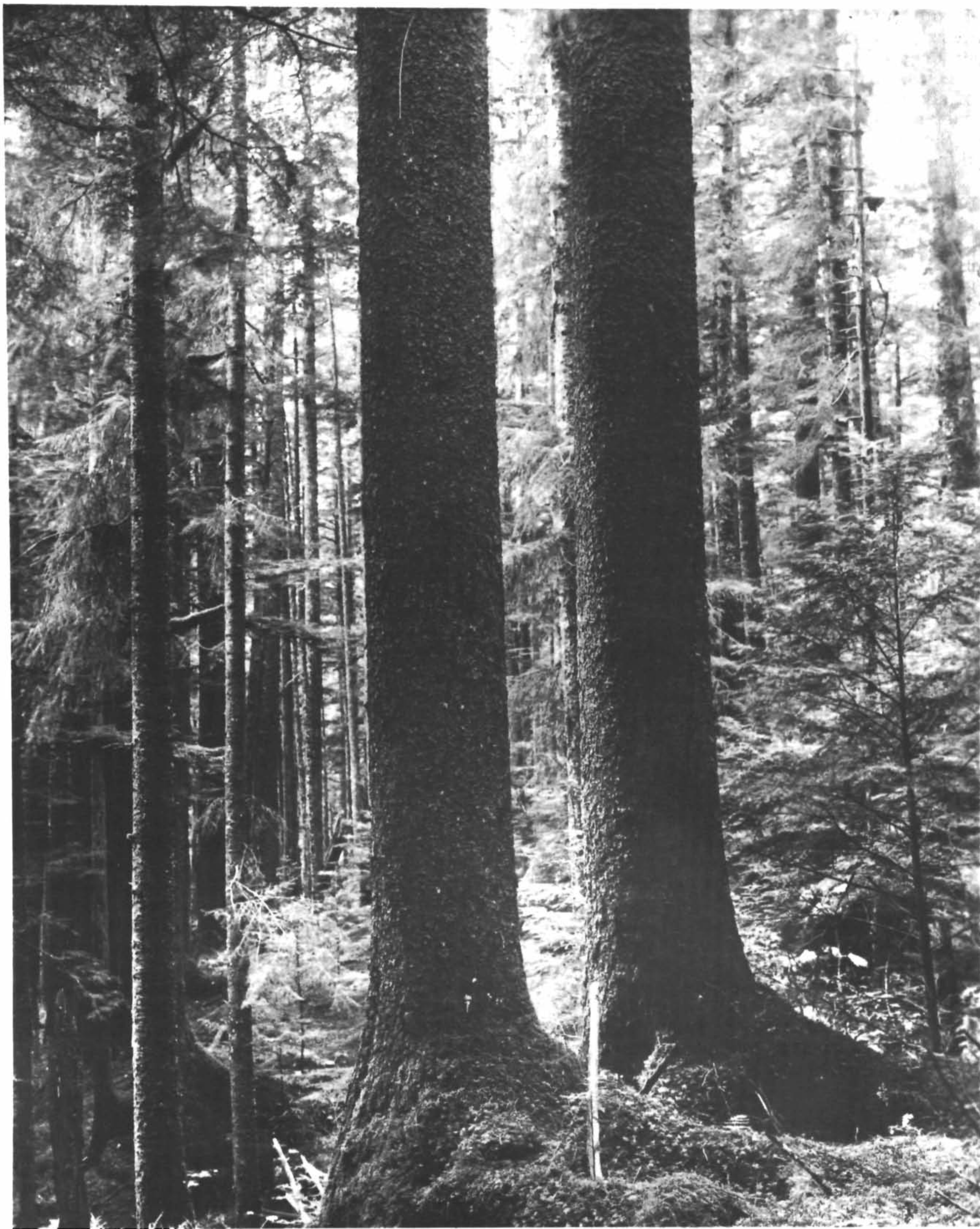
Soils.—Along coastal Oregon and Washington and in the northern Cascade Mountains, the soils of this ecosystem are Inceptisols.

Land use.—Nearly all the area is in forest. In the Pacific Northwest, most of the ecosystem is privately owned. Lumbering is the major industry. The narrow valleys and coastal plains, about 5 percent of the total area, are cleared. Hay for dairy cattle is the chief crop.

NO. 25.—THE LARCH ECOSYSTEM

Physiography.—The larch ecosystem occupies the high mountains of eastern Oregon, northern Idaho, and western Montana. Less than 20 percent of the area is gently sloping. Local relief is over 3,000 feet. Larch commonly occupies the upper slopes or northern exposures at lower elevations—about 3,500 feet.

Climate.—The length of the frost-free season in the ecosystem is 120 days in the Blue Mountains of eastern Oregon and 80 to 120 days in the northern Rockies. Annual precipitation is 20 to 30 inches in eastern Oregon and 20 to 50 inches in the northern Rockies. Of this precipitation, 40 to 50 percent occurs in the period



F-70500

Figure 15.—A stand of western hemlock and Sitka spruce in the hemlock–Sitka spruce ecosystem. The large trees are Sitka spruce.



F-500637

Figure 16.—Stand of young larch trees in foreground, in the larch ecosystem. In this ecosystem, local relief exceeds 3,000 feet.

December to March in the eastern Oregon area and only 35 to 40 percent occurs in the coldest months in the northern Rockies. During the frost-free season, precipitation is 20 percent of the evaporation potential in eastern Oregon and 20 to 40 percent in the northern Rockies.

Vegetation.—This ecosystem is characterized by forests in which 50 percent or more of the stand is western larch, except where western white pine comprises 20 percent or more of the timber volume. Ecologically, larch is considered seral to stands of grand fir and stands of Douglas-fir. This ecosystem produces 75 to 150 pounds of understory herbage per acre. However, where it is patch clearcut, planted to trees, and seeded to grass, it will produce 2,000 to 3,000 pounds of herbage per acre for 10 to 15 years. Understory species are commonly of the genera found in spruce-fir stands and some Douglas-fir stands.

Fauna.—The fauna in the larch ecosystem is

similar to the faunas of the Douglas-fir and fir-spruce ecosystems. Larch, however, being a deciduous conifer, lets more light into the stand during part of the year. The difference in the amount of light leads wildlife to prefer the larch stands at times.

Soils.—In eastern Oregon, the soils of this ecosystem are Mollisols, particularly on north and northeast slopes where there is an overburden of deep, absorptive Vitrandepts. In the northern Rockies they are Inceptisols, Alfisols, and Mollisols.

Land use.—Much of the land is heavily forested, affording wildlife habitats, providing livestock forage, and offering opportunities for recreation, as well as producing timber. Mining is important in northern Idaho and western Montana. A very small percentage of the land is cropped. Forage and grain grown in some of the valleys provide feed for dairy cattle and other livestock.

NO. 26.—THE LODGEPOLE PINE ECOSYSTEM

Physiography.—The lodgepole pine ecosystem occupies sites on high mountains of Western States. It occurs even in some places where less than 20 percent of the area is gently sloping and at elevations ranging from 4,000 to 11,500 feet, with local relief over 3,000 feet. However, the ecosystem is best developed on gentle mountain slopes.

Climate.—Commonly, lodgepole pine is on sites where the length of the frost-free season is 80 to 120 days, but it seems to be tolerant of

frost at almost any time of year. This species grows where the average annual rainfall is as low as 20 inches, but it can grow well with 50 inches of precipitation. During the frost-free season in lodgepole pine areas, precipitation is commonly 20 percent of potential evaporation and is often 40 percent. Lodgepole pine stands are adapted to varied distribution of rainfall. In the southern Cascade Mountains and the mid-Sierras, lodgepole pine stands receive 50 to 60 percent of their annual precipitation in the



Figure 17.—A stand of old lodgepole pines in the lodgepole pine ecosystem.

F-489697

period December to March. Yet, in the middle Rockies they receive only 15 to 35 percent of their precipitation in this period.

Vegetation.—This ecosystem is characterized by forests in which 50 percent or more of the stand is lodgepole pine. Ecologically, lodgepole pine stands are seral to some of the western interior coniferous forests. "Doghair" stands often develop after fires. Understory species, if present, are of about the same genera as found in stands of western larch, spruce-fir, and interior Douglas-fir. Herbage production can be 0 to 50 pounds per acre in dense stands or 2,000 to 3,000 pounds per acre where clear-cuts, burns, or conversions to a different coniferous stand are carried out. Of course, herbage productivity in treated areas declines with closure of the tree canopy and in 10 to 20 years will return to a very low level.

Fauna.—The lodgepole pine ecosystem has about the same fauna as Douglas-fir, larch, and

spruce-fir forests of the same elevational zone. Low productivity of understory flora in many cases limits the number of animals that can be supported. Islands of uncut lodgepole pine provide excellent escape routes and protective refuges or cover for big game animals.

Soils.—In the Sierras, the lodgepole pine ecosystem occupies Ultisols. In the eastern Cascades of Oregon, it occupies Entisols. In the Blue Mountains of eastern Oregon, lodgepole pine grows best on Vitrandepts, which deeply overburden bedrock or Mollisols. In the Rocky Mountains, this ecosystem occupies Inceptisols, Mollisols, and Alfisols.

Land use.—Much of the land of this ecosystem is forested. About 80 percent is owned by the Federal Government. In addition to producing timber, the forest yields water, affords wildlife habitats, and provides opportunities for recreation. Several national parks are in the area of this ecosystem.

NO. 27.—THE REDWOOD ECOSYSTEM

Physiography.—The redwood ecosystem occupies only the low coastal mountains of northern California and the southwestern portion of Oregon. Less than 20 percent of the area is gently sloping. Local relief ranges from 1,000 to 3,000 feet.

Climate.—The climate is moist and temperate. Annual precipitation averages nearly 60 inches, of which 10–25 percent falls in the warmest months and 60–70 percent in the period December to March. Normal annual pan evaporation is 40–50 inches. The amount of precipitation is two and one-half to five times the potential evaporation during the frost-free season.

Vegetation.—The vegetation of this ecosystem is a dense forest of very tall, evergreen, needle-leaved trees, sometimes with much undergrowth—20 percent or more of the stand is redwood. The dominant plants are redwood and Douglas-fir. Other major components of the vegetation include grand fir, salal, Pacific waxmyrtle, coast rhododendron, western hemlock, box blueberry, and swordfern.

Fauna.—The Columbian black-tailed or coast

deer is present in the redwood ecosystem. Elk use the ecosystem in some areas but are much less numerous than in the past. Mountain lions, bobcats, and black bears may be seasonally active within the forest. The red-tailed hawk, screech owl, and great horned owl feed on mice and other small animals on the forest floor. The sharp-shinned hawk and Cooper's hawk prey chiefly on birds. The band-tailed pigeon may occur as a summer resident. The blue grouse is the most common ground-nesting bird. Other characteristic birds include the pileated woodpecker, gray jay, brown creeper, hermit warbler, and red crossbill.

Soils.—The soils are Ultisols. Base saturation is low; organic matter content is high. A relatively thin subsurface horizon of accumulated clay is present (Haplohumults).

Land use.—Most of the land is in privately owned farms, ranches, or forest. Lumbering is the major industry. Only about 10 percent of the ecosystem is in grassland used for grazing. The cultivated land in valleys, less than 5 percent of the total area, is used mainly for growing forage and grain for dairy cattle.

NO. 28.—THE WESTERN HARDWOODS ECOSYSTEM

Physiography.—The western hardwoods ecosystem occurs in northern California and southern Oregon on tablelands where 50–80 percent of the area is gently sloping and the relief is only 300–500 feet and on low mountains where slopes are mostly steep and the local relief is 1,000 to 3,000 feet. It also occurs in the Rocky

Mountains, and this portion of the ecosystem (mostly aspen areas) varies considerably.

Climate.—The west coast portion of this ecosystem has rainy winters and dry summers. Annual precipitation ranges, on the average, from 15 inches in California to 48 inches in Oregon and occurs mostly as rain between the

months of November and May. Normal annual pan evaporation ranges from about 40 inches in Oregon to nearly 100 inches in southern California. Evaporation during the frost-free season ranges from about two to five times the potential evaporation. The climate of the widely scattered Rocky Mountain portions corresponds to that described for adjacent or surrounding ecosystems.

Vegetation.—This ecosystem is characterized by forests in which 50 percent or more of the stand is hardwood species—except where western white pine, sugar pine, or redwood comprises 20 percent or more of the stand (in such cases the ecosystem is classified as western white pine or redwood). The vegetation is a forest of low to medium-tall, broad-leaved deciduous or evergreen trees, sometimes with an admixture of low to medium-tall needle-leaved evergreens, often with an understory of grass and shrubs.

In the California and Oregon portions of this ecosystem, dominant species include Oregon

white oak, Coulter pine, Digger pine, coast live oak, canyon live oak, blue oak, valley oak, and interior live oak. In California this ecosystem lies mainly between the annual grasslands and the chaparral and mixed conifer zones. The widely scattered Rocky Mountain and Plains States “hardwood” portion of the ecosystem consists primarily of quaking aspen stands with an understory of grasses, forbs, and shrubs. In many places where the aspen stands are inclusions within areas of sagebrush or conifers, they are important sources of food and cover for wildlife. Cottonwood becomes dominant on plains, more or less replacing aspen.

Fauna.—In California several subspecies of the mule deer are numerous in various parts of this ecosystem. The now-extinct California grizzly was once numerous. An occasional black bear comes down from forests at higher elevations. Mountain lions are no longer numerous; the largest numerous predatory animals are the coyote and the bobcat. Avian predators include golden eagles and red-tailed and other hawks.



F-522876

Figure 18.—Some of the trees in this forest in the redwood ecosystem are more than a thousand years old.



Figure 19.—A representative scene in the western hardwoods ecosystem.

F-325590

Two endangered species, the California condor and the San Joaquin kit fox, occur. California quail are often abundant at lower elevations, and mountain quail winter at the higher elevations. The striped skunk is widespread. Among the more common small mammals are the Beechy ground squirrel, kangaroo rat, pocket gopher, and a number of types of mice. Also occurring in this part of this ecosystem are additional species found in the annual grasslands ecosystem.

The fauna of the Oregon oakwoods portion of the ecosystem is somewhat similar to that in the California portion, but species representative of the southern part of the California oakwoods may not be present and more northern species, such as the ruffed grouse, are present. Deer are common; elk were numerous in the past. The western gray squirrel frequents stands of Garry oak. The fauna of the aspen portion of the ecosystem throughout the

Rocky Mountain area is essentially that of the adjacent or surrounding ecosystems, but the aspen stands serve as important areas of food and shelter for many species of wildlife. Where hardwood stands occur on river bottoms in the plains, they are a home for many arboreal and forest-edge species that are not present in the surrounding open country.

Soils.—In Oregon the soils of this ecosystem are deep and have well-developed illuvial horizons (Argixerolls). Drainage is generally good. Farther south, in California, the surface horizons are somewhat lighter and lower in content of organic matter, but the illuvial horizon of accumulated clay is again present (Xeralfs).

Land use.—Livestock grazing in the ecosystem is limited to the more open portions of stands adjacent to grasslands. Wildlife find cover in the several variations of the ecosystem, and the aspen portions provide browse for big game.

NO. 29.—THE SAGEBRUSH ECOSYSTEM

Physiography.—The sagebrush ecosystem is prominent principally on the Columbia Plateaus, in the Northwestern States; in the central portion of the Great Basin, in Utah, Nevada, and southern Idaho; in the Wyoming Basin; and on the Colorado Plateaus and some

of the lower reaches of adjacent mountains. This broad ecosystem occupies vast plains and plateaus derived from lava flows, ancient lake beds, and broad basins of alluvium. The more individual plateau sections are usually delineated in terrace and tablelike fashion and range



F-419065

Figure 20.—Sagebrush shrubs in the sagebrush ecosystem. In the area shown, herbaceous plants are lacking, having been killed by overgrazing.

from rolling lava plains to maturely fringed and dissected mesas. Elevations range roughly from 600 feet to 10,000 feet.

Climate.—The length of the frost-free season normally is 120 days but is reduced to only 80 days at certain mountain sites. Annual precipitation is 5 to 12 inches—in some places almost 20 inches—40 to 50 percent of it coming in the period December to March and only 25 to 40 percent occurring in the warmer half of the year. Precipitation is only 20 percent of the evaporation potential during the frost-free season.

Vegetation.—The sagebrush ecosystem is characterized by shrubs, principally of the genus *Artemisia*, which are usually 1 to 7 feet high. In some situations, other shrubs are part of the vegetation. In other places, grasses such as those of the genera *Agropyron*, *Festuca*, *Poa*, and *Bromus*, as well as broad-leaved herbs, are found in the understory.

Fauna.—Pronghorn, or antelope, use parts of this ecosystem as rangeland throughout the year, whereas mule deer prefer to use sagebrush rangeland only during the winter. The Utah prairie dog is an endangered species of

this ecosystem. Other wild mammals that are principal inhabitants of this ecosystem are the Great Basin coyote, black-tailed jackrabbit, pygmy cottontail, Ord's kangaroo rat, and Great Basin kangaroo rat.

Bird populations are low during the breeding season, averaging only about 25 pairs per 100 acres. The major influent birds include the marsh hawk, red-tailed hawk, Swainson's hawk, golden eagle, bald eagle, Cooper's hawk, prairie falcon, burrowing owl, and long-eared owl. The sage grouse and chukar are important game birds. More than 50 additional species of birds nest within the ecosystem.

Soils.—In the Columbia Plateaus province, the sagebrush ecosystem occupies Mollisols having black, friable, organic surface horizons and a high content of bases. Inceptisols (Andepts) of ashy nature are conspicuous in parts of the Columbia Plateaus. In the Great Basin and part of the Wyoming Basin, the soils of the sagebrush ecosystem are Aridisols which have pedogenic horizons, are low in content of organic matter, have a clay horizon in some places, and have accumulations of various salts in some places. In part of the Colorado Plateaus

province, as well as part of the Wyoming Basin, they are Entisols, which have no pedogenic horizons. The remaining soils of the sagebrush ecosystem in the Colorado Plateaus province are Aridisols and Mollisols.

Land use.—Most of the land within the sagebrush ecosystem is used for sheep and cattle grazing, principally in the spring and fall. Where sufficient water is available, irrigation ranching and farming are practiced. The principal crops are hay, grain, potatoes, and beets.

Productivity Classes

Class 1.—Productivity class 1 represents the best growing conditions in the sagebrush ecosystem. It includes the most productive sites of Küchler's sagebrush steppe and wheatgrass-needlegrass shrubsteppe communities. Dense to scattered shrubs and dense to open grasslands are characteristic of the class. Dominant species of the sagebrush steppe are big sagebrush, bluebunch wheatgrass, and Idaho fescue. Other important plants are balsamroot, Sandberg bluegrass, and lupine. Dominant species of the wheatgrass-needlegrass shrubsteppe are western wheatgrass, needle-and-thread, and plains bluegrass. Herbage production varies from 1,500 to 2,000 pounds per acre. Forage production ranges from 500 to 700 pounds per acre.

Class 2.—Productivity class 2 of the sagebrush ecosystem includes the less productive portions of the sagebrush steppe and wheatgrass-needlegrass shrubsteppe communities. The physiognomy and dominant species are the

same as those of productivity class 1. Herbage production ranges from 1,000 to 1,500 pounds per acre. Forage production ranges from 300 to 500 pounds per acre.

Class 3.—Productivity class 3 includes the more productive portion of Küchler's Great Basin sagebrush community. Rainfall averages nearly 10 inches per year. The class is characterized by dense to open brush, 1 to 3 feet in height, with various mixtures of grass and forbs. The dominant shrub is big sagebrush. Some important associated plants are shadscale, hopsage, ephedra, and milkvetch. Herbage production ranges from 500 to 1,000 pounds per acre. Forage production varies from 100 to 200 pounds per acre.

Class 4.—Productivity class 4 encompasses the area of least moisture in the sagebrush ecosystem. Rainfall is less than 10 inches a year, and evaporation is high. The physiognomy is similar to that of class 1, except that the brush is more scattered and of lower stature in many places. Dominant species, in addition to big sagebrush, are black sagebrush and low sagebrush. Herbage production ranges from 0 to 500 pounds per acre. Forage production ranges from 0 to 150 pounds per acre.

HERBAGE PRODUCTION

A summary of herbage production in the ecosystem follows:

<i>Productivity class</i>	<i>Pounds per acre</i>	<i>Productivity class</i>	<i>Pounds per acre</i>
1.....	1,500-2,000	3.....	500-1,000
2.....	1,000-1,500	4.....	0- 500

NO. 30.—THE DESERT SHRUB ECOSYSTEM

Physiography.—The desert shrub ecosystem is a composite of various desert shrublands and includes the salt flats of Great Salt Lake, the southwestern desert plains and plateaus, the western third of the Great Basin's mixture of mountains and basins, the eastern edge of the Great Basin, parts of Wyoming and Big Horn Basins, and parts of the dissected Colorado Plateaus.

Climate.—The normal length of the frost-free season is 120 days in the more northerly parts of the ecosystem and 200 days in the southwest. Annual precipitation is only 5 to 10 inches. In the western portion of the ecosystem where the Pacific climate has an influence, 50 percent or more of the meager precipitation occurs in the winter, whereas in the more easterly portions which are under the influence of continental or Rocky Mountain weather, only 15 to 25 percent of the precipitation occurs during the winter. The amount of precipitation is only 20

percent of the evaporation potential during the frost-free season.

Vegetation.—The vegetation of the ecosystem is characterized by xeric shrubs varying in height from 4 inches to many feet. Stands are generally open, with a large amount of bare soil and desert pavement exposed. However, some stands may be relatively dense. Understory vegetation is generally sparse. During years of above-average rainfall, annuals may be conspicuous for a short time.

Fauna.—There is a great diversity of habitats in the desert shrub ecosystem. Consequently, the species of the fauna are quite varied. However, dominant animals are characteristically species of rats and pocket mice. In the saltbush-greasewood community the pale kangaroo mouse and little pocket mouse are common. Animals associated with black sagebrush are the desert wood rat and Nuttall's cottontail. The black-tailed jackrabbit is most numer-

ous in the greasewood sites. The cactus mouse and desert kangaroo rat are abundant in the saltbush desert. Merriam's kangaroo rat is strongly associated with creosotebush. Other important species in the ecosystem are the long-tailed pocket mouse and antelope ground squirrel.

Common larger mammals in the desert shrub ecosystem are the desert kit fox, coyote, and western spotted skunk. Desert mule deer and peccary are associated with the paloverde-cactus shrub community. Many desert birds are very selective in their type of habitat. Greasewood may furnish a permanent residence for the loggerhead shrike. Areas where tall cactus is plentiful furnish homes for many birds, including the Gila woodpecker, several species of owl, and the purple martin. Gambel's quail, the cactus wren, and the roadrunner are common in the southern part of the ecosystem. Reptiles include numerous species of snakes and lizards, including the Gila monster of the

tall cactus areas. The Sonoran pronghorn is classed as an endangered species; few if any of this species are left in southern Arizona. The masked bobwhite quail is also an endangered species in this ecosystem.

Soils.—The soils of the desert shrub ecosystem include Aridisols (with pedogenic horizons) in the Great Basin and on southwestern desert plains and plateaus, Entisols (with no horizons), and Aridisols in the Wyoming Basin and on the Colorado Plateaus. The soil of the Great Salt Flats is unclassified.

Land use.—In the northern extension of this ecosystem, livestock grazing is the principal industry. Much of this grazing is done in the winter. Where irrigation water is available, ranching and farming are practiced. The principal crops are hay and small grains. In some areas potatoes and sugar beets are grown.

In the Sonoran Basin and southern Arizona and New Mexico, limited grazing is done at favorable times. Irrigation farming is prac-



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Figure 21.—Shadscale and winterfat dominate this vegetation community of the desert shrub ecosystem.

coyote, and wolf occur in the ecosystem. The grizzly bear is present, though in a fraction of its original numbers and is classified as a rare species. Grizzlies are about the only predator of elk and possibly are a useful natural control over excessively large elk herds.

Several of the species that have been mentioned use the fir-spruce ecosystem only seasonally, primarily as cover or in following migratory routes. This is the case with the mountain sheep and the mountain goat, which occur more commonly in steep rocky areas. Among the birds in the ecosystem are several of the blue grouse and spruce grouse groups, ruffed grouse, and various chickadees, nuthatches, bluebirds, robins, and jays. Among the more common rodents and lagomorphs are the porcupine, beaver, snowshoe rabbit, squirrels, flying squirrels, pocket gophers, chipmunks, and various

species of mice.

Soils.—The soils of this ecosystem are extremely varied. In the Northwest, Inceptisols (Cryandepts and Cryumbrepts) predominate. Ultisols occur in the Sierra Nevada Range. Alfisols (Boralfs) are common in the Rocky Mountains, and there are also significant areas of Entisols. Areas of deep overburdens of absorptive Vitrandepts are very productive sites in eastern Oregon and the northern Rockies.

Land use.—Heavy forests cover much of the ecosystem, and they are used as wildlife habitats and watersheds and for recreation and lumbering. There is virtually no cropland. Much of the area is owned by the Federal Government. Grazing by domestic livestock is generally limited to natural parks and meadows that occur within the forest matrix.

NO. 24.—THE HEMLOCK-SITKA SPRUCE ECOSYSTEM

Physiography.—The hemlock-Sitka spruce ecosystem extends south from British Columbia along the Oregon and Washington Coast Ranges and occupies part of the Cascade Range in Washington. The elevation ranges from 200 to 4,000 feet.

Climate.—The length of the frost-free season for that portion of the ecosystem along coastal Oregon and Washington is about 200 days. The portion in the northern Cascades has a frost-free season of about 120 days. Precipitation is about 60 to 115 inches annually in western Oregon and Washington. In western Oregon and Washington, about 60 to 70 percent of the precipitation occurs in the months of December to March. In western Washington the amount of precipitation is mostly equal to double the evaporation potential. In western Oregon it is 80 percent of potential evaporation.

Vegetation.—This ecosystem is defined as having 50 percent or more of the forest in western hemlock or Sitka spruce or both. Other tree species which may be present to a lesser degree are Douglas-fir, grand fir, and western redcedar. Common shrubs include the vine maple, red whortleberry, Cascades mahonia, California dewberry, and coast rhododendron.

Usual herbs are American twinflower, hollyfern, cutleaf goldthread, and redwoods violet.

Fauna.—The most common large mammals in this ecosystem include the elk, deer, black bear, and moose. In the hemlock areas of the northwestern portion, the red-tailed hawk, screech owl, pygmy owl, and great horned owl are avian predators. Mammalian predators include mountain lions, bobcats, wolves, the Pacific marten, and the western spotted skunk. Smaller animals include the deer mouse, Douglas squirrel, bushy-tailed wood rat, Townsend's chipmunk, and coast mole. Among the more common birds are the red crossbill, chestnut-backed chickadee, red-breasted nuthatch, raven, gray jay, Steller's jay, hermit warbler, western wood pewee, and pine siskin. Blue and ruffed grouse are also present.

Soils.—Along coastal Oregon and Washington and in the northern Cascade Mountains, the soils of this ecosystem are Inceptisols.

Land use.—Nearly all the area is in forest. In the Pacific Northwest, most of the ecosystem is privately owned. Lumbering is the major industry. The narrow valleys and coastal plains, about 5 percent of the total area, are cleared. Hay for dairy cattle is the chief crop.

NO. 25.—THE LARCH ECOSYSTEM

Physiography.—The larch ecosystem occupies the high mountains of eastern Oregon, northern Idaho, and western Montana. Less than 20 percent of the area is gently sloping. Local relief is over 3,000 feet. Larch commonly occupies the upper slopes or northern exposures at lower elevations—about 3,500 feet.

Climate.—The length of the frost-free season in the ecosystem is 120 days in the Blue Mountains of eastern Oregon and 80 to 120 days in the northern Rockies. Annual precipitation is 20 to 30 inches in eastern Oregon and 20 to 50 inches in the northern Rockies. Of this precipitation, 40 to 50 percent occurs in the period



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Figure 22.—Grassland in the shinnery ecosystem; scattered stands of oak in rear.

of the rest of the ecosystem is on Alfisols. In some places the soils are Entisols.

Land use.—Where shrubs are not too dense, livestock grazing is common.

Productivity Classes

Class 1.—The most productive areas of this ecosystem yield an average of 2,000 pounds of herbage per acre. These areas have a high proportion of tall-grass species, such as big bluestem and sand bluestem, together with midgrasses, such as side-oats grama and little bluestem. The soils are mainly Mollisols (Calciustolls plus Haplustolls) which are medium to high in content of bases and are moist during part of the growing season but dry for extended periods. Most of the level areas are dry-farmed or irrigated. Wind erosion makes continuous use of cover crops necessary. The trend is toward hay production.

Class 2.—Herbage yields average 1,500 pounds per acre in this productivity class. The major species are little bluestem and side-oats grama. There are scattered stands of big bluestem and sand bluestem. The shrub species characteristic of this ecosystem occur in small, dense patches. The soils are mainly Alfisols (Haplustalfs). Areas in productivity class 2

are used as native rangeland or are farmed if conditions permit.

Class 3.—The vegetation characterizing this productivity class is a mixture of midgrasses and short grasses occurring on or near the outer edge of valleys and on the valley walls. Class 3 areas receive runoff when it occurs, but are dry for long periods. Herbage yields average 1,000 pounds per acre. The major grasses are three-awns, grammas, and, in scattered areas, western wheatgrass. Shrubs, such as Havard oak and sumacs, occur more commonly here than elsewhere in the ecosystem. Mesquite occurs as scattered low trees. The soils are mainly Aridisols (Haplargids, gently to moderately sloping). Class 3 areas are used as native rangeland.

Class 4.—This productivity class is represented by vegetation occurring on the more sandy areas (stabilized sand dunes). Herbage yields average 500 pounds per acre. Sand bluestem and little bluestem are the major grass species. Other species are big sandreed, giant and sand dropseed, and hairy and side-oats grama. Yucca and sand sagebrush are the two most important low shrubs. The soils are mainly Entisols (Ustipsamments, moderately sloping) characterized by fine sand. Class 4 areas are still in native grasses and forbs.

NO. 32.—THE TEXAS SAVANNA ECOSYSTEM

Physiography.—The Texas savanna ecosystem occupies the western end of the West Gulf Coastal Plain and the southern part of the Great Plains. It is commonly referred to as the Rio Grande Plains of south Texas and the Edwards Plateau of south-central Texas. The Rio Grande Plains is alluvial and is possibly a deltaic plain of the Rio Grande. It is a relatively flat plain, about 400-600 feet above sea level, that rises 1,000 feet rather abruptly to the Edwards Plateau. The Edwards Plateau itself reaches an elevation of 3,600 feet at its western end. Its edges are maturely dissected by streams. The surface in its interior is a flatland traversed by dry valleys or "draws".

Climate.—In this ecosystem the frost-free season ranges from about 250 to well over 300

days. Precipitation ranges from 20 to 30 inches annually, more than half of which falls in the warmest months and less than a quarter in the period December to March. Annual evaporation is 70-80 inches; during the period May to October, the potential evaporation is about twice the precipitation.

Vegetation.—This is a high-shrub savanna ecosystem with a dense to very open synusia of broad-leaved, deciduous and evergreen, low trees and shrubs and needle-leaved, evergreen, low trees and shrubs. The grass varies from short to medium tall, and the herbaceous vegetation varies from dense to open. Mesquite is the most widespread woody plant. Others are *Acacia* spp., oaks, juniper, and ceniza along the Rio Grande valley and bluffs. *Opuntia* spp. are



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Figure 23.—Herefords in an open stand of low trees and shrubs and short and medium-tall grasses in the Texas savanna ecosystem.

widespread. The herbaceous plants are mainly bluestems, three-awns, buffalo grass, grammas, and curly mesquite and tobosa on the Edwards Plateau.

Fauna.—The Texas savanna ecosystem is noted for the abundance of white-tailed deer and wild turkeys. The collared peccary is common in some areas along the Rio Grande, where several species of Mexican or tropical distribution make their only entry into the United States. Examples are the chachalaca and the coatimundi. The armadillo is present. The fox squirrel is hunted in wooded areas along streams. Among the fur bearers are the ring-tail and the raccoon.

Great numbers of white-winged doves once nested in brushy areas along the southern Rio Grande, but clearing of land for agricultural purposes has contributed to reducing their population. The golden-cheeked warbler is a rare species. The mourning dove, scaled quail, and bobwhite are game birds in the ecosystem. A number of hawks and owls are present.

Soils.—Soils in the Texas savanna ecosystem are varied, but the different soil orders are unusually well correlated with the different plant communities within the ecosystem. The mesquite-live oak savanna, for example, is on the only Entisols within the ecosystem. The soils of the juniper-oak savanna are almost entirely Mollisols, while an "island" of Alfisols within the area of Mollisols corresponds with the boundaries of the mesquite-oak savanna. In the mesquite-acacia savanna, Mollisols, Alfisols, and Vertisols occur.

Land Use.—Land which is not cropped and on which the brush is not too dense is grazed by livestock.

Productivity Classes

Class 1.—The mesquite-live oak savanna community on the West Gulf Coastal Plain characterizes this productivity class. Herbage yields average 2,600 pounds per acre. Annual precipitation averages 29 inches but fluctuates greatly, and droughts are common. Consequently, the yield of herbage also fluctuates greatly. Major components of the overstory are live oak, shin oak, and mesquite. Major grasses are seacoast bluestem, Texas wintergrass, curly mesquite, and three-awns. Forbs are important and often make up about 25 percent of the herbage production. The soils are Entisols (Ustipsamments) that are moderately sloping. These are loamy sands and are intermittently dry for long periods. About four-fifths of the vegetation community remains as rangeland of native shrubs and grasses. The remainder is irrigated or dry-farmed.

Class 2.—Although this class contains a number of vegetation communities, the mesquite-

acacia savanna on the West Gulf Coastal Plain represents the class. This savanna is a dense-to-open grassland with broad-leaved, deciduous, low trees and shrubs. *Acacia* spp. are the most common shrubs, and mesquite is scattered throughout the community. The major grasses are seacoast bluestem, plains bristlegrass, and buffalo grass. Herbage production averages 2,100 pounds per acre, of which about 35 percent is forbs. The most abundant forbs are one-seed croton, horse mint, and prairieconeflower.

The soils of productivity class 2 are Mollisols (Haplustolls plus Argiustolls, gently sloping, and Calciustolls, shallow and gently sloping), Alfisols (Haplustalfs plus Haplustolls and Calciustolls, shallow and gently sloping), and Vertisols (Pellusterts plus Chromusterts, gently sloping). All these soils have similar characteristic subsurface horizons high in content of bases, are mostly shallow, and are intermittently dry for long periods during the warmest months. Most of this area remains in ranges of native shrubs and grasses, which are grazed by beef cattle. About 10 percent of the area, mainly along the Rio Grande and the Nueces River, is irrigated.

Class 3.—The mesquite-oak savanna and the juniper-oak savanna on the Edwards Plateau are vegetation communities in this productivity class. In the areas of these savannas, herbage production averages up to 1,500 pounds per acre. Mesquite and oak dominate the open synusia of broad-leaved deciduous trees of the mesquite-oak savanna. Ashe juniper and live oak dominate the open synusia of trees of the juniper-oak savanna. The herbaceous dominants of both savannas are little bluestem, curly mesquite, tobosa, and buffalo grass. Pricklypear occurs here and there throughout the plateau area. Forbs are of lesser importance.

The soils are Mollisols (Haplustolls, shallow, extending 20 inches to bedrock, plus Pellusterts, gently to moderately sloping) in the mesquite-oak savanna and Alfisols (Haplustalfs plus Argiustolls, gently to moderately sloping) in the juniper-oak savanna. The juniper-oak savanna occurs on the deeper soils that have a thin subsurface horizon of accumulated clay, while the mesquite-oak savanna occurs on shallow soils that have subsurface horizons in which salts or carbonates have accumulated. More than four-fifths of the area of these two savannas is in rangeland or shrubs and grasses used by cattle, sheep, and goats. The remainder is used for dry farming. Deer habitats in the area are managed for economic returns.

Class 4.—The ceniza shrub vegetation community of productivity class 4 is characterized by open to dense stands of broad-leaved, deciduous and evergreen shrubs and a patchy synusia of grass. It is located along the lower Rio

Grande valley and bluffs. The dominant vegetation consists of creosotebush, ceniza, and mesquite, underlain with patches of gramas, curly mesquite, sacaton, Arizona cottontop, and three-awns. Pricklypear is common. Herbage production sometimes averages as much as 1,600 pounds per acre but is usually much less.

The soils of this vegetation community are Vertisols (Pellusterts plus Camborthids and Torrerts, gently sloping) which are clayey soils that, when dry, have wide, deep cracks that remain open intermittently for periods totaling more than 3 months. This area can be very productive when there is adequate precipitation. Most of the floor of the Rio Grande valley, in which approximately 50 percent of the ceniza

shrub community is located, is irrigated. The remainder of the unit is on valley slopes and bluffs which are still in native shrub and grass species. Conversion of brush areas to agricultural use has resulted in a drastic reduction in the nesting habitat of the white-winged dove in the United States.

HERBAGE PRODUCTION

A summary of herbage production in the ecosystem follows:

<i>Productivity class</i>	<i>Pounds per acre</i>	<i>Productivity class</i>	<i>Pounds per acre</i>
1.....	2,250-3,000	3.....	750-1,500
2.....	1,500-2,250	4.....	0- 750

NO. 33.—THE SOUTHWESTERN SHRUBSTEPPE ECOSYSTEM

Physiography.—The southwestern shrubsteppe ecosystem occurs south of the Rocky Mountains. It occurs as relatively large blocks of almost-level desert plains isolated between roughly parallel low mountain ranges of the Sonoran Desert, Mexican Highland, and Sacra-

mento section, through southern Arizona, New Mexico, and Texas. This ecosystem occurs at a lower altitude than the pinyon-juniper ecosystem and is often referred to as the semidesert grass-shrub type.

Climate.—Temperatures in this ecosystem



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Figure 24.—Areas of short grass and scattered shrubs and of shrubs with scattered patches of short grass are characteristic of the southwestern shrubsteppe ecosystem.

are not as variable as in ecosystems covering larger geographic areas. The frost-free season ranges from slightly less than 180 days in Arizona to more than 240 days at the southeastern boundary, in Texas. Precipitation, half of which normally falls in the warmest months, varies from 10 inches in the west to about 18 inches at the eastern boundary of the ecosystem. Potential evaporation is high, being 80-90 inches annually. During the warmest months it is 4 to 10 times the precipitation.

Vegetation.—The southwestern shrubsteppe ecosystem is characterized by vegetation types ranging from short grass with scattered shrubs to shrubs with scattered areas of short grasses. Yucca is one of the most characteristic woody plants in the ecosystem. Mesquite is abundant in many areas. Creosotebush and tarbush are dominant among the shrubs. Black grama, three-awns, and tobosa dominate the herbs. Side-oats grama and curly mesquite are also important. The shrub-grass stands occupy shallow soils with no development or little development. The grass-shrub stands occupy the soils with more development.

Fauna.—Because of the geographic proximity of the two ecosystems, the fauna of the southwestern shrubsteppe ecosystem is similar to that of the desert grasslands ecosystem. Pronghorn, or antelope, and mule deer are the most widely distributed large game animals. The common white-tailed deer occurs in the eastern portion of the ecosystem, in Texas. The collared peccary or javelina is common in the southern part of the ecosystem. The white-winged dove is locally important in Arizona, as is the more widespread mourning dove. The scaled quail and Gambel's quail are present in most of the area, and the bobwhite reaches the eastern portion of the ecosystem. The black-tailed jackrabbit, desert cottontail, kangaroo rat, wood rats, and numerous smaller rodents compete with domestic and wild herbivores for available forage and are preyed upon by the coyote, bobcat, golden eagle, great horned owl, red-tailed hawk, and ferruginous hawk.

Soils.—In the western portion of this ecosystem, the soils are primarily Aridisols. Some are Mollisols. The eastern portions, the Trans-Pecos shrub savanna, are mainly on Aridisols in the north and Entisols in the south. Junipers occur entirely in the areas of Entisols, according to Küchler.

Land use.—The areas in this ecosystem are used as rangeland except where they have been converted to irrigation farming or other uses.

Productivity Classes

Class 1.—The grama-tobosa shrubsteppe community that has a low shrub population of

creosotebush and yucca characterizes this productivity class. Herbage production averages 500 pounds per acre, ranging from 450 to 600 pounds. Black grama and tobosa occur most commonly. The soils are mainly gently sloping Aridisols that have a loamy horizon of accumulated clay and, usually, a horizon containing large amounts of calcium carbonate or gypsum.

The Trans-Pecos shrub savanna, where junipers commonly occur, also characterizes this productivity class. This community occupies the Stockton Plateau, which is the southwestern portion of the Edwards Plateau. It is in a belt of higher rainfall and at a higher altitude than the grama-tobosa shrubsteppe. The major grass species of this community are tobosa, curly mesquite, and buffalo grass. Forbs are of lesser importance. Soils are mainly gently to moderately sloping Entisols, which are clayey, have a regular decrease in organic-matter content with depth, have a gravelly or stony surface in this area, and are usually less than 2 feet deep above caliche. Four-fifths of this vegetation community remains as rangeland. The remainder is under irrigation or in nonfarm uses.

Class 2.—The Trans-Pecos shrub savanna characterizes this productivity class. Herbage yields average 300 pounds per acre. Shrubs such as tarbush and creosotebush are common. Short grasses such as tobosa, chinograss, and bush muhley are present. Forbs are few. The shrubs and dwarf shrubs occur as stands that are dense or scattered; consequently, herbage production varies. The soils are mainly gently sloping Aridisols (Calciorthiss) that are shallow and have a horizon in which large amounts of calcium carbonate or gypsum have accumulated. The area of productivity class 2 is used mainly as rangeland.

Class 3.—This class is represented by the grama-tobosa shrubsteppe community. There is a relatively common occurrence of Joshua-tree yucca and other species of yucca, as well as a grass synusia varying from open to dense. Black grama and tobosa are the major species in the grass synusia. Herbage production varies from 150 to 300 pounds per acre and averages approximately 200 pounds. This vegetative community occupies a small area in western Arizona. The soils are Aridisols (Durargids) that have a hardpan cemented with silica and Entisols (Torriorthents) that extend less than 20 inches to bedrock. This area is used as rangeland.

Class 4.—No one type of vegetation characterizes this productivity class. The class is characterized by areas tending toward the desert shrub ecosystem; in these areas shrub vegetation is more prevalent, and herbage production averages 100 pounds per acre. Major shrubs are

creosotebush, tarbush, Joshua-tree yucca, and juniper. Major grasses are tobosa and gramas. The soils are mainly gently to moderately sloping and have a stony surface. They are Aridisols (Durargids) that have a hardpan and Entisols (Torriorthents) that extend less than 20 inches to bedrock. Class 4 areas are used as rangeland.

HERBAGE PRODUCTION

A summary of herbage production in the ecosystem follows:

<i>Productivity class</i>	<i>Pounds per acre</i>	<i>Productivity class</i>	<i>Pounds per acre</i>
1	450-600	3	150-300
2	300-450	4	0-150

NO. 34.—THE CHAPARRAL-MOUNTAIN SHRUB ECOSYSTEM

Physiography.—The chaparral-mountain shrub ecosystem occupies mountain areas over 3,000 feet high in northern California and southern Oregon, areas ranging from sea level to low mountains (up to 3,000 feet high) in the southern part of the California Coast Ranges, mountains over 3,000 feet high in the Middle Rocky Mountains, low mountains in the Gila Mountains, and low and high tablelands in the southern part of the Great Basin.

Climate.—The length of the frost-free season in much of the California portion is 160 to 200 days, depending on latitude and elevation. However, one area along the southern coast has a frost-free season of 300 days. In the Middle Rocky Mountains, the frost-free period is 80 to 120 days, depending on elevation. The Gila Mountains have a frost-free period of 160 to 180 days. In the southern part of the Basin and Range province the frost-free season lasts 200 days. Annual precipitation varies from 10 to 28 inches, sometimes more. The California area receives only 10 to 25 percent of its precipitation in the warmest months. The northern part of the Great Basin and the part of the ecosystem in the Middle Rocky Mountains get 40 to 50 percent of their precipitation in the warmest months. The Gila Mountains and the southern part of the Basin and Range province receive 50 to 66 percent of their annual precipitation in the warmest months.

Year-round mild temperatures in much of the California portion of the ecosystem tend to offset some of the disadvantages of lack of rain in summer. Furthermore, coastal areas receive some moisture from fog in summer. The precipitation is normally only 20 percent of the evaporation potential in the Middle Rocky Mountains, the Gila Mountains, and the southern Basin and Range province. In California the precipitation is 20 to 40 percent of the evaporation potential.

Vegetation.—The vegetation of the ecosystem consists of dense to open brush or low trees. Deciduous, semideciduous, and evergreen species are represented. Some of the brush types are so dense that understory vegetation is practically eliminated, while other types support a

highly productive understory. Recent activities of man have altered the types of vegetation to such a degree that reconstruction of their original state would be difficult.

Fauna.—The fauna is quite diverse from north to south in the chaparral-mountain shrub ecosystem; however, some species are quite widespread. Mule deer throughout the ecosystem and white-tailed deer in the south are the most important large mammals. Other large mammals, such as the coyote, mountain lion, bobcat, black-tailed jackrabbit, ringtail, striped skunk, and spotted skunk, are widespread in the ecosystem. Some important species, such as the javelina and the band-tailed pigeon, are found only in the southern part of the ecosystem. The wood rat is one of the most characteristic animals of the ecosystem. Other small mammals include ground squirrels and mice.

Birds are very numerous in the brush types of the ecosystem throughout the year. More than a hundred species were identified in the scrub oak type in Utah. Over 40 resident birds were noted in the oak-juniper community. Among the birds in the oak-juniper areas are the golden-fronted woodpecker, turkey, and bobwhite. Reptile species are quite numerous in the southern portion of the ecosystem. Two rare and endangered species are found in the ecosystem, both in the chaparral community. One of them, the California condor, has its range partially within the community. The other is the San Joaquin kit fox. A third endangered species, the masked bobwhite, has been extirpated from the United States portion of the ecosystem.

Soils.—In the northern part of California, the chaparral-mountain shrub ecosystem occupies Ultisols which are low in content of bases and have subsurface horizons of clay and weatherable minerals. The remainder of the California portion of the ecosystem in the Coast Ranges occupies Mollisols which are on steep slopes, are high in content of bases, and lack accumulations of clay; Alfisols which have accumulations of clay and sometimes have a carbonate-cemented horizon; and Entisols which have no horizons, are low in content of



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Figure 25.—Areas of brush and low trees are characteristic of the chaparral-mountain shrub ecosystem.

organic matter, and are less than 20 inches deep in some places. In the Rocky Mountains, this ecosystem occupies Mollisols that have a sub-surface horizon of clay. In the southern edge of the Basin and Range province and the upper Gila Mountains, the ecosystem mainly occupies Aridisols that have a low content of organic matter and a loamy horizon of accumulated clay.

Land use.—Large portions of the California areas of the ecosystem have been converted to grass range for livestock and for firebreaks. Production of range livestock is the principal enterprise in these places. The vegetation serves as cover to retard erosion and protect watersheds, thus benefitting croplands, high-value developments, and urban areas below. Grassed fuel breaks to retard spread of fires and the required grazing treatment of them are striking and may become more common. The conver-

sion of the shrubland has also increased deer habitats.

The interior and southwestern portions of the ecosystem are largely used for livestock grazing. Lands in these places that are suitable for cropping and irrigation are most often used for production of forage crops.

Productivity Classes

Class 1.—Productivity class 1 includes the northern two-thirds of the chaparral community in California and southern Oregon and the more productive part of the mountain-mahogany-oak scrub community. Precipitation in class 1 areas is as high as anywhere in the ecosystem. Where a site is not fully occupied by thick brush, high yields of herbaceous vegetation are common.

Dominant plants of the chaparral community

are chamise, species of manzanita, and species of California-lilac. Chamise may form a dense, impenetrable cover in places. Gambel oak is dominant in this productivity class of the ecosystem but may be associated with substantial amounts of other species. Herbage production in the productivity class is 1,500-2,000 pounds per acre. Forage production may be as high as 900 pounds per acre, or it may be less than 100 pounds, depending on the thickness and species of the brush.

Class 2.—This productivity class includes moderately productive sites of the mountain-mahogany-oak scrub and the oak-juniper woodland communities and the transition between the two. Gambel oak and other deciduous shrubs are dominant in the northern areas but give way to evergreen species in the southern areas. The dominant species of the oak-juniper woodland are alligator juniper, one-seed juniper, Emory oak, and Mexican blue oak. Blue and side-oats grama, as well as numerous brush species, are associated with this community. Herbage production in the productivity class is 1,000 to 1,500 pounds per acre. Forage production, depending on the thickness of the brush and species composition, varies from 100 to 700 pounds per acre.

Class 3.—Productivity class 3 encompasses the less productive areas of the chaparral community, including the part in southern California. The mountain-mahogany phase of the mountain-mahogany-oak scrub community is also included. Dominant plants in the chaparral areas are chamise, manzanita, and California-lilac. The dominant species of the mountain-mahogany phase is mountain-mahogany. Herbage production ranges from 500 to 1,000 pounds per acre. Forage production varies from 50 to 300 pounds per acre.

Class 4.—The coastal sagebrush community is included in this productivity class. It is characterized by low-growing brush (generally 1 to 2 feet high). Dominant species are California buckwheat, white sage, and black sage. Herbage production in this class is from 0 to 500 pounds per acre. Forage production is from 0 to 100 pounds per acre.

HERBAGE PRODUCTION

A summary of herbage production in the ecosystem follows:

<i>Productivity class</i>	<i>Pounds per acre</i>	<i>Productivity class</i>	<i>Pounds per acre</i>
1.....	1,500-2,000	3.....	500-1,000
2.....	1,000-1,500	4.....	0- 500

NO. 35.—THE PINYON-JUNIPER ECOSYSTEM

Physiography.—The pinyon-juniper ecosystem occupies portions of the Basin and Range province (Utah, Nevada, southern Idaho, and southeast Oregon) with its intermingled basins and mountains and also occupies many of the Colorado Plateaus, where it is often adjacent to sagebrush sites. Juniper usually occupies rockier and rougher terrain than sagebrush. Where sagebrush is common on the plains, terraces, and gentle portions of plateaus, the pinyon-juniper ecosystem tends to occupy the adjacent contiguous sites of eroded and rough dissections.

Climate.—The normal length of the frost-free season is 120 days. Annual precipitation is 10 inches, 40-50 percent of which occurs during the warmest months in the Great Basin, whereas 50-66 percent occurs during the warmest months in the Colorado Plateaus. Precipitation is normally only 20 percent of the evaporation potential during the frost-free season.

Vegetation.—The name "pygmy forest" characterizes the pinyon pine and juniper woodlands of this ecosystem. The trees occur as dense to open woodland and savanna woodland. They may grow to a height of 30 feet but are generally less than 15 feet tall. They are bushy,

being almost as wide as they are tall.

Herbage production is determined to a large extent by the amount of tree canopy. However, soil factors that affect the moisture supply also affect the production of herbage. These factors are texture, development of the B horizon, depth of solum, stoniness, and nature of the substrata. Slope or aspect is also a factor.

Fauna.—The major mammalian influents in the pinyon-juniper ecosystem are the mule deer, mountain lion, coyote, and bobcat. Elk are locally important. The less important influents include the wood rat, white-footed mouse, cliff chipmunk, jackrabbit, cottontail, rock squirrel, porcupine, and gray fox. The ring-tailed cat and spotted skunk occur rarely.

The most abundant resident birds in the pinyon-juniper ecosystem are the gray titmouse, Woodhouse's jay, western red-tailed hawk, golden eagle, red-shafted flicker, pinyon jay, lead-colored bushtit, and rock wren. Summer residents include the western chipping sparrow, night hawk, black-throated gray warbler, northern cliff swallow, western lark sparrow, Rocky Mountain grosbeak, desert sparrow, and western mourning dove. The common winter residents are the pink-sided junco, Shufeldt's junco, gray-headed junco, red-backed junco,



Figure 26.—“Pygmy forests” are characteristic of the pinyon-juniper ecosystem.

F-522878

Rocky Mountain nuthatch, mountain bluebird, western robin, and long-crested jay. Turkeys are locally abundant during the winter.

Among the reptiles are the horned lizard, sagebrush swift, collared lizard, and Great Basin rattlesnake.

Soils.—In the Basin and Range province, the pinyon-juniper ecosystem occupies Aridisols which have pedogenic horizons, are moderate to low in content of organic matter, and may have accumulations of carbonates. In the Colorado Plateaus the woodland occupies Aridisols, Entisols which have no pedogenic horizons, and Mollisols which have an organic surface horizon and a high content of bases.

Land use.—The pinyon-juniper ecosystem is used principally for grazing and yields a limited amount of timber products, mainly pinyon Christmas trees, pine nuts, and juniper fence posts.

Productivity Classes

Class 1.—Productivity class 1 is associated with open or savanna woodlands, the deeper (depths of 12 inches or more), better developed soils, and northerly aspects, where moisture conditions are most favorable to plant growth. Dominant species are one-seed juniper, Utah juniper, pinyon pine, singleleaf pinyon, and western juniper. Important understory species are big sagebrush, western wheatgrass, bluebunch wheatgrass, blue grama, cliffrose, bitterbrush, and Indian ricegrass. Herbage production varies from 600 to 800 pounds per acre. Forage production is from 200 to 300 pounds per acre.

Class 2.—Productivity class 2 occurs on sites of fairly open woodlands and on soils comparable to those of productivity class 1. The dominants and understory species are the same as

those of productivity class 1. Herbage production varies from 400 to 600 pounds per acre. Forage production is from 150 to 200 pounds.

Class 3.—Productivity class 3 occurs on sites with a moderate cover of woodland or on soils with lower water-holding capacity than those of the two higher productivity classes. The dominant species remain the same, but the shrubs may be sparse or suppressed. Associated grasses are thinned out to some extent. Herbage production is from 200 to 400 pounds per acre. Forage production is from 75 to 150 pounds per acre.

Class 4.—Productivity class 4 occurs on sites where the woodland cover is heavy; the crown canopy may cover 50 percent or more of the

land. The class also occurs on the drier soils. Dominants are the same as those in the other three classes, but the understory is sparse and may consist almost entirely of scattered cryptantha and pricklypear. Herbage production is from 0 to 200 pounds per acre. Forage production is from 0 to 75 pounds per acre.

HERBAGE PRODUCTION

A summary of herbage production in the ecosystem follows:

<i>Productivity class</i>	<i>Pounds per acre</i>	<i>Productivity class</i>	<i>Pounds per acre</i>
1.....	600-800	3.....	200-400
2.....	400-600	4.....	0-200

NO. 36.—THE MOUNTAIN GRASSLANDS ECOSYSTEM

Physiography.—The mountain grasslands ecosystem of the western Mountain States consists mainly of open, untimbered areas, yet it is often adjacent to or surrounded by ponderosa pine, Douglas-fir, or lodgepole pine at moderate elevations. At high elevations the ecosystem is subalpine and is on mountain slopes or faces adjacent to spruce-fir forests and patches of alpine fir or whitebark pine. It also occupies some of the best drained soils of valleylike areas intermingled with mountains, and it occupies various foothills, tablelands, and low mountains. The higher mountain settings can be rich with streams and lakes. These beautiful pastoral openings and exposures commonly provide unobstructed mountain vistas which are not observable from mountain terrain completely cloaked in forest.

Climate.—The normal length of the frost-free season in most of the mountain grasslands ecosystem is 120 days. However, in the mountain valleys of the Northern Rocky Mountains, it is less than 120 days, being only 80 days or less at high elevations. Annual precipitation in much of the ecosystem is 20 inches, and in the high mountains it is 30 inches or more. Sixty-six to 75 percent of the precipitation falls during the warmest months in central Colorado and east of the Continental Divide in Montana. In the Northern Rocky Mountain grasslands west of the Divide, 50 to 66 percent comes during the warmest months, and in the Palouse hills of the Northwest, only 25 to 40 percent comes during this period. Annual precipitation is 30 to 35 percent of the evaporation potential.

Vegetation.—Although the mountain grasslands ecosystem ranges from foothills at northerly latitudes to high mountain sites, it is characterized throughout by bunchgrasses of the fescue and wheatgrass groups. An abundance of desirable forbs appears to increase the

productivity of some of the higher sites.

Fauna.—In the foothills portion of the mountain grasslands ecosystem, pronghorn, or antelope, are resident and mule deer are winter visitors. Where there is an interface with the sagebrush ecosystem, common animals are the black-tailed jackrabbit, pygmy cottontail, and various mice. At low to medium elevations, various subspecies of ground squirrels are present, as well as the badger. At medium to high elevations, the grasslands seasonally support Rocky Mountain elk and mule deer. The pocket gopher is well distributed throughout the ecosystem. Predators which are well distributed at high elevations are the bobcat, black bear, and coyote. Two of the more common birds present are the robin and horned lark. Marsh hawks, sparrow hawks, and golden eagles are common raptors.

Soils.—In central Colorado the ecosystem occupies Aridisols and Mollisols with developed horizons. In the Yellowstone River area of south-central Montana, the grassland soils are Entisols with no horizon development. In the grasslands of the Northern Rocky Mountains, the soils are Alfisols and Mollisols. Mollisols are also the major soils of the Columbia Plateau's foothills or Palouse hills. Much of the central and eastern portion of rolling hill land is locally termed part of the Palouse Prairie and has wind-laid soil of great depth.

Land use.—Much of the ecosystem at lower elevations or on foothills was plowed soon after settlement for production of small grains, most notably the Palouse Prairie hills of north central Oregon and the extreme eastern portion of Washington and adjacent parts of Idaho. Unbroken portions of the foothill grasslands on steep slopes and in canyons are used as spring-fall range for livestock and as winter range for big game. These areas are a partic-



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Figure 27.—This open rangeland of fescue and wheatgrass, next to timbered areas, is representative of the mountain grasslands ecosystem.

ularly critical resource in big-game management. At moderate elevations the mountain grasslands are sites of livestock ranches in some places. At higher elevation, as in Colorado, Wyoming, and Montana, the grasslands are important summer ranges for big game and cattle, prime watersheds and recreation areas, and the traditional mountain settings of sheep and shepherds.

Productivity Classes

The productivity classes for this ecosystem are related to total precipitation, the abundance of precipitation during the growing season, and soil factors.

Class 1.—This productivity class is commonly associated with high-elevation lands of subalpine character, or nearly so, where 66 to 75 percent of the precipitation falls in the growing season. There are many grasses, including Idaho fescue and five species of wheatgrass. Forbs may make up 35 percent or more of the cover. Herbage production varies from about 2,250 pounds to 3,000 pounds per acre.

Class 2.—This class occupies areas that are at moderate to high elevations and reach subalpine conditions. Desirable forbs constitute 10 to 35 percent of the vegetation in some places. Several fescues are prominent. Associated

grasses are of the genera *Muhlenbergia*, *Stipa*, *Danthonia*, and *Agropyron*. Herbage production varies from 1,500 to 2,250 pounds per acre.

Class 3.—This class occupies low mountains and higher foothills in areas where not more than 40 percent of the precipitation comes in the growing season. Its dominant grasses are Idaho fescue and bluebunch wheatgrass. The large forbs of the genera *Balsamorhiza* and *Helianthella* are conspicuous. Herbage production varies from 750 to 1,500 pounds per acre.

Class 4.—Productivity class 4 occupies foothills at northerly latitudes and, at its lower edge, is bordered and invaded by big sagebrush. Bluebunch wheatgrass is the dominant plant. There are about 300 to 500 bunches of it per 100 square meters. The spaces in between are sparsely to fairly well covered with Sandberg bluegrass and small forbs, mostly annuals. Herbage production varies from 0 to 750 pounds per acre.

HERBAGE PRODUCTION

A summary of herbage production in the ecosystem follows:

Productivity class	Pounds per acre	Productivity class	Pounds per acre
1.....	2,250-3,000	3.....	750-1,500
2.....	1,500-2,250	4.....	0- 750

NO. 37.—THE MOUNTAIN MEADOWS ECOSYSTEM

Physiography.—The mountain meadows ecosystem consists of wet to intermittently wet sites in the forest zone of mountains in the Western States. Typically it occurs on almost flat to gently sloping topography, as in valleys and basinlike areas along lakes and streams, where surface or subsurface water accumulates in the root zone for at least part of the year.

Climate.—Saturation of the soil in this ecosystem during at least part of the growing season is strongly related to local topography or geology, rather than to the climate of the ecosystem. However, there must be adequate annual precipitation on the site or runoff from higher areas to create the soil moisture conditions necessary to the development of the meadows. The temperature regime of meadows is generally that of the surrounding areas, yet in some cases, meadows are the sites of frost

pockets in which temperatures deter establishment of some forest stands as effectively as intermittent high moisture in the rooting zone.

Vegetation.—Grasses, sedges, rushes, and in some cases, phreatophytic shrubs dominate the mountain meadows ecosystem. Under the best conditions 70 percent of the ground is covered by vegetation, more than three-fourths of which may be perennial grasses. Sedges may constitute as much as 15 percent of the cover. Perennial forbs with showy flowers make up only about 10 percent of the cover. The proportions of the various growth forms are easily manipulated by the degree and timing of grazing.

Fauna.—In many places this ecosystem contains lakes and streams that provide water for wildlife, and it is usually more productive of herbage than surrounding areas. Thus, it attracts fauna daily from the larger ecosystems



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Figure 28.—Rangeland in the mountain meadows ecosystem in the Southwest, surrounded by stand of Engelmann spruce and subalpine fir in the fir-spruce ecosystem.

in which it occurs. The wetter meadows, especially those with streams or permanent lakes, are a home for such wildlife as beaver, waterfowl, and fish. The fauna of intermittently wet meadows may shift as moisture conditions change. For example, the burrowing rodents and the predators which feed upon them use the meadows only during the drier periods. Deer, elk, and moose are among the large mammals which, though using heavy timber sites for cover, depend heavily upon meadows for food. In large expanses of forest and rangeland, the meadows are about the only suitable habitat for the nesting of migratory waterfowl.

Soils.—Soils of mountain meadows commonly have been, and are currently, recipients of alluviation, illuviation, or glaciation products from above. Consequently, no classification by soil orders is attempted for this ecosystem.

Land use.—Small, high-elevation mountain meadows commonly have not been cultivated. Only at lower elevations or in more accessible areas have meadows been converted to hayland or drained and farmed. On the other hand, many small mountain meadows have been obliterated by roadbuilding and trails made by horses used for recreation. Disturbances to plant cover have, in some cases, resulted in the cutting of streambeds to such depths that the water table has been lowered. Where this has happened, the meadows have lost their productive herbaceous cover and have been invaded by brush or lodgepole pine stands.

Because of the potentially high productivity

of mountain meadows, those of considerable size warrant sophisticated range management and investment in physical improvements. Where water flows or permanent pools occur in the drainage lines through meadows, consideration should be given to an intensive form of meadow management, including provision for wildlife and certain types of recreation.

Productivity Classes

The length of the wet period and the depth of soil largely regulate productivity in the mountain meadows ecosystem. Sedge and hair-grass meadows are the most productive, yielding 3,000 pounds or more of herbage per acre. Another type of meadow is one dominated by such shrubs as willow. Such meadows are moderate to poor producers of grass forage but a good source of browse for deer, moose, and other animals. The least productive meadows are those on soils whose wet season is short or on shallow soils or soils that are shallow in effect because of a tight soil horizon near the surface which restricts drainage. Such shallow and temporarily wet sites commonly produce only unpalatable species of rush.

HERBAGE PRODUCTION

A summary of herbage production in the ecosystem follows:

<i>Productivity class</i>	<i>Pounds per acre</i>	<i>Productivity class</i>	<i>Pounds per acre</i>
1.....	3,000-4,000	3.....	1,000-2,000
2.....	2,000-3,000	4.....	0-1,000

NO. 38.—THE PLAINS GRASSLANDS ECOSYSTEM

Physiography.—The plains grasslands ecosystem, also known as the Great Plains, occurs on a broad belt of high land which slopes gradually eastward and down from an altitude of 5,500 feet near the eastern foothills of the Rocky Mountains to an altitude of 1,500 feet in the Central States, where it gives way to the prairie ecosystem. The most striking feature of the ecosystem is the phenomenal flatness of the interstream areas, which make up a great expansive fluvial plain or alluvial slope. The eastern margin has been most exposed to erosion, being near the trunk line of drainage and in a climate of greater rainfall than the western edge. The plains grasslands ecosystem of 280 million acres is larger than any other vegetation region in the United States.

Climate.—Temperatures vary considerably, the frost-free season ranging from less than 100 days in the north to more than 200 days in Texas. The ecosystem is characterized by periodic droughts. Average annual precipitation

ranges from 10 inches in the north to more than 25 inches in the south, 68-80 percent of the precipitation falling in the warmest months. Normal annual pan evaporation is roughly four times the precipitation. Precipitation ranges from about one-third to one-half of potential evaporation.

Vegetation.—Short, warm-season grasses predominate in this ecosystem, and there is a minor interspersed of forbs and shrubs. Vast stretches are dominated almost exclusively by blue grama, buffalo grass being a companion in many areas. However, the eastern part of the ecosystem is dominated by grasses of medium stature, such as western wheatgrass and needlegrass. The occasional shrubs include juniper, silver sagebrush, silver buffaloberry, and skunkbush sumac in the northern reaches and rabbitbrush and mesquite in the southern part. Forbs are generally quite common, but many are ephemerals.

Fauna.—Huge herds of American bison once



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Figure 29.—Cattle on productive rangeland in the phenomenally flat plains grasslands ecosystem.

migrated with the seasons across the central plains. Currently, the pronghorn, or antelope, is probably the most abundant large mammal, but mule deer and white-tailed deer are often abundant where brush cover is available, as along stream courses. The white-tailed jackrabbit occupies the northern part of the ecosystem and the black-tailed jackrabbit, the area south of Nebraska. The desert cottontail is widespread. The lagomorphs, the prairie dogs, and a variety of small rodents are preyed upon by the coyote and a number of other mammalian and avian predators, one of which, the black-footed ferret, is classed as an endangered species. The wolf once existed on the plains in great numbers, feeding to a considerable extent upon bison.

The lesser prairie chicken, formerly abundant, is now classed as a rare species. Sage grouse, greater prairie chickens, and sharp-tailed grouse are present in the area. Among the many smaller birds are the horned lark, lark bunting, and western meadowlark. The endangered golden-cheeked warbler is in the southeastern portion of the ecosystem in places where the Ashe juniper is present. Stock pond construction has created an important "duck factory" in the northern Great Plains.

Soils.—The soils of this ecosystem are varied. Mollisols occur from the Canadian border to the southern boundary of the ecosystem in Texas, as do Entisols. Alfisols and Aridisols are less extensive and are mostly in the southern portion.

Land use.—Large areas of the most productive sites have been converted to crop farming; the remainder is rangeland.

Productivity Classes

Class 1.—Productivity class 1 is characterized by the wheatgrass–bluestem–needlegrass community, which is adjacent to the northcentral part of the prairie ecosystem and receives more rainfall (about 18 inches) than other areas of the plains grasslands ecosystem. Western wheatgrass, big bluestem, and needlegrass are characteristic, medium-tall to tall grasses being dominant. Woody plants are absent or grow sparingly along streams. Herbage production ranges up to 2,000 pounds per acre, 70 percent being forage. Fifty percent utilization is considered appropriate for maximum sustained yield.

The soils of class 1 areas are Mollisols which have the characteristic carbonate horizon but have a weak, thin horizon of accumulated clay characteristic of Argiustolls; they are gently sloping. Approximately one-fourth of the land is in native grasses. The other three-fourths is used for growing grain as a cash crop.

Class 2.—The wheatgrass–needlegrass community of the western Dakotas is characteristic of productivity class 2. It occurs as a moderately dense, short or tall, wide expanse of gently to moderately rolling grassland dissected by small, deeply eroded, intermittently flowing streams. The dominants are western wheat-

grass, blue grama, needle-and-thread, and green needlegrass. Forbs and woody plants occur sparingly. Herbage production ranges up to 1,500 pounds per acre, 70 percent being forage. Fifty percent utilization is considered appropriate for maximum sustained yield.

The soils of class 2 areas are Mollisols, including Argiborolls plus Haplustolls that are gently sloping. Most of the soils have a subsurface horizon that is high in content of bases and a subsurface horizon in which clay has accumulated. Precipitation averages 15 inches per year. Three-fifths to three-fourths of the land is in native grasses grazed by cattle and sheep. Irrigation is common along streams.

Class 3.—The grama-needlegrass-wheatgrass and wheatgrass-grama-buffalo grass communities in the 12-inch precipitation belt represent this productivity class. Class 3 areas are rather short, fairly dense grasslands dominated almost exclusively in many places by blue grama. Associated dominants are western wheatgrass, needle-and-thread, and buffalo grass. Juniper occurs in some places. Herbage production ranges up to 1,000 pounds per acre, 60 percent being forage—50 percent of the herbage is short-grass plants. Fifty percent utilization is considered appropriate for maximum sustained yield.

The soils of class 3 areas are mainly gently to moderately sloping Mollisols and Entisols which are intermittently dry for long periods during the warm season and usually have a horizon of accumulated clay and calcium carbonate. The areas also include Aridisols. About three-fourths of the land is in grass, and about 5 percent is dry-farmed. The remainder is either irrigated or classified as open woodland of

western redcedar.

Class 4.—This production class is characterized by the grama-buffalo grass and the mesquite-buffalo grass communities of the south-central Great Plains. Annual precipitation averages 20 inches, exceeding that of northern areas of this ecosystem. However, high average annual temperatures cause much of the moisture to evaporate. Blue grama and buffalo grass are, exclusively, the dominant herbaceous plants. They form a fairly dense grassland. Mesquite commonly occurs in the southeastern portion of this ecosystem. Herbage production ranges up to 500 pounds per acre, 60 percent being forage. Sixty percent utilization is possible because of the outstanding resistance of the native short grasses to damage by grazing; this is partly due to their low stature.

The soils are mainly Mollisols and Alfisols, and there is a scattering of Entisols. The topography ranges from gently sloping to moderately sloping. The most common characteristic of these soils is that they are intermittently dry for long periods. The Mollisols and Alfisols have a subsurface horizon in which salts or carbonates and clays have accumulated. About three-fifths of the land is in grass, and one-fourth is dry-farmed. The remainder is under irrigation.

HERBAGE PRODUCTION

A summary of herbage production in the ecosystem follows:

<i>Productivity class</i>	<i>Pounds per acre</i>	<i>Productivity class</i>	<i>Pounds per acre</i>
1	1,500-2,000	3	500-1,000
2	1,000-1,500	4	0- 500

NO. 39.—THE PRAIRIE ECOSYSTEM

Physiography.—The prairie ecosystem is a relatively large contiguous grassland which lies between the deciduous forests of the East and the short-grass plains of the West, on the flat to rolling hill land of the Central Lowland. Topographic relief delineates the boundaries of this ecosystem, the 1,500-foot contour being the western boundary and the 500-foot contour, the eastern boundary. The northern limits extend into Canada, and the southern limits extend into southern Texas. Most of the lands of this ecosystem, excluding those south of the Missouri River, are those of young glacial drifts and dissected till plains. The area south of the Missouri River is older, has well-developed drainage systems, and is flat to rolling hill land.

Climate.—The climate varies widely in this ecosystem. The length of the frost-free season varies from less than 120 days in the north to almost 300 days in the south. On the east, from

Texas to Indiana, the prairie boundary lies close to the 40-inch isohyet. On the west, the southern boundary is near the 30-inch isohyet; while further north, the prairie reaches the 20-inch isohyet. In general, more precipitation occurs in the warmer part of the year. During the growing season the amount of precipitation, on the average, varies from 60 percent of potential evaporation in the west to 100 percent in the east.

Vegetation.—The prairie ecosystem is known to many as the tall-grass or true prairie. Blue-stems constitute about 70 percent of the vegetation and reach heights of 5 to 6 feet in lowland areas. Large numbers of flowering forbs are present but are usually overshadowed by the grasses. Most of the plants are classified as warm-season plants. Woody vegetation is rare. Willow occurs in some places in exceptionally moist areas of the northern part of the ecosys-

tem, and needle-leaved evergreens and broad-leaved deciduous trees are scattered in the southern part. Deciduous trees are common along permanent streams in the eastern portion.

Fauna.—Bison once grazed at the western margin of the tall-grass prairie, and the pronghorn, or antelope, is still present there. Jackrabbits are common residents of the prairie, and cottontails are present where there are streams and cover. Burrowing rodents include ground squirrels, prairie dogs, pocket gophers, and many smaller rodents. Burrowing predators include the badger and the black-footed ferret, now considered an endangered species. The Texas red wolf is classed as an endangered species on the southern border of the ecosystem. The coyote is still common.

The northern portion of the prairie ecosys-

tem is an important breeding area for a number of species of migrating waterfowl. Many of these migrators winter on the coastal plains of Texas and Louisiana. Mourning doves have become abundant as shelterbelt plantings have developed. Among the gallinaceous birds, the sharp-tailed grouse, greater prairie chicken, and bobwhite are present in fair numbers. However, the northern greater prairie chicken is considered a rare species, and Attwater's prairie chicken, on the Gulf coast of Texas, is listed as an endangered species.

Soils.—The soils of the prairie ecosystem are primarily Mollisols. There are smaller areas of Entisols and one small area of Vertisols. Most of the soils have dark upper horizons.

Land use.—Most of the ecosystem has been converted to cropland.



F-522879

Figure 30.—The dominant grasses in the lowland areas of the prairie ecosystem—sometimes referred to as the true prairie or tall-grass prairie—can be taller than a man.

Productivity Classes

Class 1.—This productivity class is characterized by lands that are level, have deep, fertile soils, and receive adequate moisture for maximum production of vegetation. Big bluestem, little bluestem, switchgrass, Indian grass, and side-oats grama are the dominant plants. Herbage production ranges from 4,500 to 6,000 pounds per acre on the bluestem prairie. Seventy percent of the herbage is forage. Fifty percent utilization is most satisfactory for maximum sustained yield. The soils are Mollicsols and have dark surface horizons that are rich in organic matter. About 10 to 15 percent of this area is in permanent pasture of tame and native grasses. The remainder of the area is used for growing corn and other feed grains.

Class 2.—This productivity class is characterized by lands that have gently sloping, clayey soils and receive adequate moisture for the growth of herbaceous plants. However, summer droughts are common. Little bluestem and Texas needlegrass are dominants in the blackland prairie community, in Texas. Seacoast bluestem and coastal sacahuista are dominant in the bluestem-sacahuista prairie community of the coastal plains of Texas and Louisiana. Herbage production averages 3,000 pounds per acre, of which 70 percent is forage. Fifty percent utilization is considered satisfactory. The soils are Vertisols that have a black or dark-gray surface horizon. About two-thirds of the area is in cropland, and one-sixth is in pasture. The remainder is in abandoned fields or narrow strips of woodland along streams.

Class 3.—The cedar glades and Nebraska Sand Hills prairie communities represent this productivity class of the prairie ecosystem. They are medium-tall grasslands with an ele-

ment of dwarf to medium-high shrubs (broad-leaved and cedar shrubs). These grasslands occur on gently to moderately sloping areas. Dominant species in the cedar glades community include little bluestem, big bluestem, and Indian grass. Big bluestem, sand bluestem, and prairie sandreed are dominants on the Nebraska Sand Hills prairie. Herbage production averages 2,500 pounds per acre, 70 percent of which is forage. Fifty percent is usable to maintain maximum sustained yield.

The cedar glades lie in a 42-inch precipitation belt, but the soils are shallow and droughty. The soils in the Nebraska Sand Hills show weak pedogenic development and, consequently, become dry quickly during periods of drought. The cedar glades soils are Ultisols that have a thick horizon of accumulated clay, and the soils of the Nebraska Sand Hills are Entisols that contain easily weatherable materials. Both areas are droughty for extended periods each year. Most of the class 2 areas are in native grass ranges grazed by livestock.

Class 4.—This productivity class is characterized by grasslands that differ from the typical prairie ecosystem by having dwarf shrubs and scattered open groves of deciduous trees. The sandsage-bluestem prairie and Fayette prairie communities represent this class. Herbage yields in these units average 1,500 pounds per acre. Forage yields are 60 percent of herbage yields. Forty percent utilization is satisfactory. The dominant species in the sandsage-bluestem prairie community are little bluestem, sand bluestem, sand sagebrush, and hairy grama. On the Fayette prairie dominant grasses are little bluestem and buffalo grass, and dominant trees are oak and hickory. About one-fifth of the class 4 area remains in native range grazed by beef cattle. The remainder is used for growing grains as cash crops.

NO. 40.—THE DESERT GRASSLANDS ECOSYSTEM

Physiography.—The desert grasslands ecosystem occurs in scattered areas on tablelands of moderate to considerable relief in the Colorado Plateaus province in Arizona, New Mexico, and Utah and on the plains with low mountains of the Mexican Highland section in southwestern Texas. Elevations range from 5,000 to 7,000 feet. These tablelands or plateaus are moderately to severely dissected by rugged canyons.

Climate.—The amount of precipitation in this ecosystem is low, ranging from 8 to 12 inches annually. Usually more than half falls in the warmer part of the year. During the frost-free season, the evaporation potential is five or more times the normal rainfall. The frost-free season ranges from over 200 days in

Texas to about 120 in Utah.

Vegetation.—The grass life-form predominates on these plateaus at intermediate elevations, and shrub life-forms are dominant at higher and lower elevations. In transition zones, shrubs give way to galleta to black grama to blue grama. Consociations of these species occur, but almost pure stands are the rule. Tobosa replaces galleta in the southern extensions in Texas of this ecosystem, and three-awn becomes the dominant in the northern extensions in Utah. In its northern extensions this ecosystem is a more open grassland with low shrubs.

Fauna.—Pronghorn, or antelope, are the primary larger mammals in the desert grasslands ecosystem. Mule deer also occur. The coyote and bobcat are among the chief animal predators.



F-489029

Figure 31.—The grass life-form predominates in the desert grasslands ecosystem, but mismanagement can result in an increase in the occurrence of cactus and desert shrubs.

They prey upon black-tailed jackrabbits, cottontails, wood rats, and a large number of small rodent species, such as the kangaroo rat and the deer mouse. Scaled quail range into the grasslands, especially where brush has made an invasion. Among the smaller birds of the ecosystem are the horned lark, several sparrows, the loggerhead shrike, and nighthawks. Avian predators include the golden eagle, great horned owl, and various hawks.

Soils.—The soils are almost entirely Entisols that have no pedogenic horizons and Aridisols that lack pedogenic horizons and are never moist for as long as three consecutive months.

Land use.—Most of this ecosystem is used as rangeland.

Productivity Classes

Class 1.—The grama-tobosa prairie community characterizes this productivity class. It is an open grassland of rather low growth and scattered succulents. Herbage production is 750 to 1,000 pounds per acre. Woody plants are absent or occur sparingly. Blue grama and tobosa are the characteristic dominants. The

soils are mainly Entisols (Torriorthents) that are shallow (20 inches to bedrock), loamy or clayey, never moist for as long as three consecutive months, and moderately sloping to steep. Class 1 areas also include some Aridisols (Calciorthids plus Torriorthents) that are gently sloping. The class 1 portion of the desert grasslands ecosystem is used as rangeland for livestock.

Class 2.—The grama-galleta steppe community of northern Arizona and New Mexico characterizes this productivity class. Herbage production averages 500–750 pounds per acre. Blue grama and galleta dominate this low to medium-tall grassland. Woody plants such as Mormon tea and succulents such as *Opuntia* and *Yucca* spp. occur more commonly than in the grama-tobosa prairie community. This community is highly responsive to rainfall, so production varies considerably. The soils are mainly Aridisols (Haplargids and other Aridisols plus Torriorthents) that are gently to moderately sloping and are never moist for as long as three consecutive months. This class also occupies some areas of Entisols (Torriorthents).

Less than one-third of class 2 land is pri-

vately owned, the remainder being in Indian reservations or held by the Federal Government. Most of the areas are native rangeland. About 2 percent of the land is used for irrigation or dryland farming.

Class 3.—The open grassland with low shrubs known as the galleta-three-awn shrubsteppe community of southeastern Utah characterizes this productivity class. Herbage production averages 250–500 pounds per acre. Three-awn, galletta, sand sagebrush, and Mormon tea are the major species. Numerous other species of grass, forbs, and woody plants occur, but less commonly. The soils are mainly Aridisols (Calciorthis plus Torriorthents) which slope gently or moderately and have a horizon in which large amounts of calcium carbonate or gypsum have accumulated. In Utah, class 3 areas also are on Entisols. The class 3 portion of the desert grasslands ecosystem is used as rangeland for cattle and sheep.

Class 4.—Some parts of the desert grasslands ecosystem occur on relatively shallow sandy

soils and are droughty. This situation occurs in grama-tobosa prairie areas and in galleta-three-awn shrubsteppe areas. These droughty areas characterize productivity class 4. The dominant species remain the same or almost the same as in class 1 and class 3, but herbage production drops to 0 to 250 pounds per acre and the vegetation is usually very sensitive to hard use. The soils are gently to moderately sloping Entisols that have no pedogenic horizon, are loamy or clayey, and have a regular decrease in organic matter content with depth. Class 4 areas are used as grazing lands for sheep and cattle.

HERBAGE PRODUCTION

A summary of herbage production in the ecosystem follows:

<i>Productivity class</i>	<i>Pounds per acre</i>	<i>Productivity class</i>	<i>Pounds per acre</i>
1	750–1,000	3	250– 500
2	500– 750	4	0– 250

NO. 41.—THE WET GRASSLANDS ECOSYSTEM

Physiography.—The wet grasslands ecosystem is characterized by the narrow belt (1–50 miles wide) of coastal wet prairies and marshes stretching from the Mexican border to Long Island, N. Y., exclusive of the coastline of Florida, Georgia, and the Carolinas. It is also characterized by the Everglades and the palmetto prairie of southern Florida, the tule marshes of the low fluviatile plain in the California Trough, and the flood plains of the Great Salt Lake and other lakes of the Intermontane Plateaus.

The coastal prairie is a plain of clay alternating with sands and is almost untouched by erosion, except for the steep-sided channels of transverse streams, whose bottoms may be 30 to 40 feet below sea level. The Everglades are a permanent swamp. The palmetto prairie, adjacent and to the north, is slightly drier. Both occupy an extensive, almost flat, marl and limestone shelf generally covered with a few feet of muck and a little sand. The tule marshes of central California are the result of the Sacramento and San Joaquin Rivers forming natural levees—at low altitudes (10 to 60 feet above sea level)—which entrap water along these rivers. There are numerous lakes along these rivers, and many have been drained and are used as cropland. These lakes, in the broad, flat silt floors of basins with internal drainage, are of the playa type.

Climate.—The wet grasslands ecosystem varies so greatly geographically that any general climatic description is of questionable

value. Rainfall in the Central Valley of California may be less than 10 inches; thus, the wet conditions in the “tule marshes” are due primarily to topography and runoff. Other areas in the ecosystem receive much more precipitation, which amounts to as much as 60 inches or more in the Everglades. The length of the frost-free season ranges from practically all year in extreme southern Texas and Florida to less than 200 days in the northern end of the ecosystem, on the upper Atlantic coast. Potential evaporation ranges from many times the rainfall in California to less than the annual rainfall in the eastern portion of the ecosystem. In the farflung coastal portions of the ecosystem, intrusion of salt water may have more effect on the vegetation than does climate or soil.

Vegetation.—The coastal prairies (marshes) are occupied by cordgrasses, including smooth cordgrass and saltmeadow cordgrass (the latter being more prevalent on the Atlantic coast), saltgrass, and a few forbs. The vegetation forms a medium-tall to very tall grassland, usually dense. The palmetto prairie and Everglades are dense, medium-tall to tall grasslands. There are scattered palms and shrubs on the palmetto prairie and scattered low to medium-tall broad-leaved evergreen trees and shrubs in the Everglades. The major species of the palmetto prairie are wire-grass and saw-palmetto. The major plants of the Everglades grassland are sawgrass and three-awns. The vegetation of the tule marshes is a tall graminoid vegeta-

tion consisting of tules and other bulrushes, cattail, and soft flag. Several species of sedges occur less commonly.

Fauna.—The fauna of the wet grasslands ecosystem varies as much as its geography. The ecosystem, especially its open-water and more marshy areas, serves as a seasonal home for tremendous numbers of migratory waterfowl. The Central Valley of California and the coastal marshes of Texas and Louisiana are prime examples. Endangered species, including the whooping crane, the Texas red wolf, and Attwater's prairie chicken, use the Texas coastal area, and the American alligator is a yearlong resident of the Gulf coast and the Everglades. Other endangered species that formerly made more use of the ecosystem are the Florida panther of the Southeast and the tule elk that once ranged into the California tule marshes. Most of the fauna are tolerant of a moist or wet environment. Many species from adjacent prairies and forests make extensive use of the wet grasslands. Fresh- and brackish-water fishes, reptiles, and amphibians are abundant and varied.

The Everglades has a wide variety of influent

species from adjacent palmetto prairie, cypress swamp, magnolia forest, and mangrove areas. A slight change in the water level causes marked changes in the habitat and the fauna. Among the many mammals are the white-tailed deer, Florida panther, black bear, raccoon, bobcat, opossum, skunks, bats, marsh and swamp rabbits, cotton rat, and fox squirrel. Avian fauna is very varied; many influent species are cited in descriptions of adjacent areas. Before the water level in much of the Everglades was lowered by drainage, the area was the home of large numbers of herons, egrets, limpkins, mottled ducks, Everglade kites, and other birds. Now the Florida great white heron is classified as rare. The Everglades kite is classified as endangered.

Soils.—Soils in this ecosystem are extremely varied, all soil orders found in the continental United States being represented. Entisols are prevalent in the Central Valley of California.

Land use.—Because of wide variations in site conditions, there is no consistent pattern of land use in this ecosystem. It is used for hunting, fishing, trapping, crop production, improved pasture, rangeland, and other purposes.



F-522880

Figure 32.—A forest of cabbage palmetto forms the background of this range area in the wet grasslands ecosystem in southern Florida.

Productivity Classes

Class 1.—Productivity class 1 is characterized by the southern cordgrass prairie community, which is the most productive vegetation unit in the wet grasslands ecosystem. The average herbage yield is 10,000 pounds per acre. Smooth cordgrass is the major species and is considered highly palatable to cattle. Other common plants are *Carex* spp., saltgrass, and tules. Forbs and shrubs range from none to few. The construction of "walkway" levees has greatly improved the accessibility of the rangeland to livestock.

The soils are mainly Histosols (plant residues that are moderately decomposed; gently sloping) and Mollisols (Haplaquolls plus Udipsamments and Humaquepts) which are wet and have a thick, nearly black surface horizon and gray subsurface horizons.

About 50 percent of the land of the southern cordgrass prairie is used for growing rice and tame forage, including alfalfa and grasses. This part of the ecosystem is also used for hunting, fishing, and trapping.

Class 2.—The Everglades characterizes productivity class 2. Herbage yields range from 6,000 to 9,000 pounds per acre. However, most of the herbage is Jamaica sawgrass, a species of little to no value for grazing by cattle. About 10 percent of the Everglades has been converted to pastures of desirable herbage, which yield approximately 8,000 pounds per acre. Other plants in native stands are three-awns, *Boehmeria cylindrica*, tules, and cattails. Woody plants occur in the bayheads, the most common being sweetbay and redbay.

The soils are mainly Histosols (plant residues moderately decomposed or highly decomposed; gently sloping) which are wet organic (muck) soils. About 50 percent of the 7,200 square miles of the area is in Indian reservations, National Parks, and game refuges. Hunting, fishing, and other recreational activities are major uses of much of the Everglades. About 5 percent is cropland, and 15 percent is in pasture.

Class 3.—The palmetto prairie and northern cordgrass prairie characterize this productivity class. Herbage yields range up to 6,000 pounds per acre—few data exist for the northern cordgrass prairie, so this is a broad estimate at

best. Most of the class 3 land is intensively developed for resorts and recreation. The major plants of the palmetto prairie community are wiregrass, hairawn muhly, creeping bluestem, miscellaneous bluestems, and saw-palmetto.

The soils are mainly Entisols (Psammaquents plus Haplaquads and Quartzipsamments) that are loamy fine sand or coarser material and are permanently or seasonally wet. Other soils of class 3 are Alfisols (Ochraqualfs plus Psammaquents) and Spodosols (Haplaquods plus Quartzipsamments) which are sandy and have mottles of iron and manganese compounds. Restricted drainage is a problem.

Most of the class 3 land is used for grazing by cattle. Thirty to 50 percent of the area in pastures has adequate water-control systems and a high cattle-carrying capacity. The trend is to more improved pastures. Winter vegetable gardens and citrus and other subtropical fruit orchards are increasing in importance.

Class 4.—The tall, graminoid vegetation of the tule marshes in the Sacramento and San Joaquin Valleys and on old beds of the Great Salt Lake and large lakes in Nevada characterizes this productivity class. Few data are available on yields of herbage. The major species are tules and other bulrushes and cattails. *Carex* spp. occur in some places.

The soils were primarily Histosols (highly decomposed plant residues) but are now classified as Entisols (Xerorthents plus Durixeralfs, Haploxeralfs, Xerofluvents, Paleixeralfs, and Haplaquolls) because of extensive draining and the use of the land for growing irrigated crops. Very few of the tule marshes remain. Those that do are in high demand as places for hunting ducks and geese. Most of the class 4 land is farmed. Important crops are asparagus, sugar beets, potatoes, corn and other grains, and hay—all grown within the levee systems which protect the land against flooding.

HERBAGE PRODUCTION

A summary of herbage production in the ecosystem follows:

Productivity class	Pounds per acre	Productivity class	Pounds per acre
1	9,000–12,000	3	3,000–6,000
2	6,000–9,000	4	0–3,000

NO. 42.—THE ANNUAL GRASSLANDS ECOSYSTEM

Physiography.—The annual grasslands ecosystem is characterized by the California steppe vegetation community, which occupies extensive areas in the Central Valley of California and along the Pacific Coast. This community is often referred to as the California annual or

foothill grasslands. These grasslands form a discontinuous zone between the upper limits of the valley floors and the western hardwoods ecosystem, which occurs mainly at elevations between 500 and 2,000 feet above sea level. The Sierra-Cascade Mountains are on the east, and

the California Coast Ranges are on the west. The California steppe occupies the lower foothills of these ranges. The foothills are rolling hills interspersed with numerous level valleys.

These lands have their origin in colluvial material from the mountain ranges and fans of alluvial material. The flow of alluvial and colluvial material is much stronger from the Sierra-Cascade Mountains on the east than from the Coast Ranges. Consequently, the accumulation is much greater and more extensive on the eastern side of the Central Valley than on the western side; it is more obvious in the San Joaquin Valley than in the Sacramento Valley. Numerous small springs and seeps occur throughout the ecosystem, the water table being close to the surface in the bottoms of valleys.

Climate.—Most of the annual grasslands ecosystem has a climate of hot, dry summers and mild, relatively moist winters. The length of the frost-free season is 250–300 days. Precipitation ranges from less than 10 inches at low elevations in the southern portion to more than 40 inches at the higher elevations at the northern border. Little rain falls in the summer. Up to three-fourths of the annual precipitation may fall in the period December–March. Potential evaporation during the warmest months is often many times the precipitation. These climatic conditions are extremely favorable for the growth of cool-season annuals, which make up practically all the herbage.

Vegetation.—The vegetation of the ecosystem is of grass life-form. Annual grasses, mostly introduced, dominate the cover. The dominant plants are wild oats, several species of brome, wild barley, and fescue. Perennial bunchgrasses, where they occur, include needlegrasses, creeping wildrye, and pine bluegrass. Perennials are scarce or absent at lower elevations and increase at the upper elevations of the ecosystem. Forbs, with the exception of filaree, are numerous but of secondary importance. Many people believe the prehistoric vegetation was perennial, but historical evidence is meager and reconstruction of the original perennial vegetation (if it were perennial), if it can be done at all, is accomplished only with complete protection and considerable effort. The earliest references, from the early 1800's, indicate that the California steppe was dominated by annual grasses. In this ecosystem, annual plants, with their short life cycle and rather shallow root system, have probably shown the most consistent and profitable response to range fertilization.

Fauna.—Intensive agricultural development has changed the fauna of the annual grasslands ecosystem. Many species have been eliminated or "moved up in the hills." The California grizzly, wolf, and pronghorn, or antelope, have long since disappeared, and the San Joaquin kit fox is classified as an endangered species.

Several species of mule deer occur in areas with brush. The California quail is now numerous mainly in areas where brush or rock outcrops provide cover. The mourning dove occurs throughout the area. Common mammals include the Beechy ground squirrel, cottontail, black-tailed jackrabbit, mice, and kangaroo rats. Many species, such as the coyote and bobcat, occur in, or enter from, the adjacent woodlands.

Common birds include the horned lark, western meadowlark, western kingbird, mockingbird, loggerhead shrike, house finch, lesser goldfinch, red-shafted flicker, and scrub jay. The rattlesnake is an important predator of rodents. The roadrunner feeds partly on reptiles. Other avian predators include the golden eagle, red-tailed hawk, and Cooper's hawk. A number of snakes and lizards are present. Additional species occurring in this ecosystem are found in the western hardwoods ecosystem.

Soils.—The soils of this ecosystem are mostly Entisols and Alfisols. In general, the Entisols are at the lower elevations of the Central Valley, and the Alfisols occur at slightly higher elevations, away from the valley floor. A small area of Aridisols occurs in the more arid southern portion of the San Joaquin Valley.

Land use.—The land at the lower elevations of what was the annual grasslands is mostly irrigated and makes up the bulk of one of the richest agricultural areas in the world—the Central Valley of California. At slightly higher elevations, some land is dry-farmed, but the area is mostly used for grazing by cattle. The area receives very heavy recreational pressure from nearby metropolitan areas, including Los Angeles and San Francisco.

Productivity Classes

Herbage production is greater on the northern than on the southern annual ranges of California. This is due mainly to more precipitation in the north. However, the productivity classes are basically the same for both areas. The herbage yields reported in the following paragraphs are based mostly on research at the San Joaquin Experimental Range of the USDA Forest Service, in the Sierra Nevada foothills. The Experimental Range, 25 miles north of Fresno, is in the southern part of the ecosystem. The ranges in this ecosystem are very responsive to rainfall, which varies considerably. Changes in the amount of rainfall can cause a variation of well over 100 percent in herbage production from year to year.

Class 1.—The vegetation of the swales characterizes this productivity class. Herbage yields range up to 4,400 pounds per acre. The swales comprise roughly 10 to 15 percent of the annual grasslands. The dominant plants are foxtail fescue, Mediterranean barley, clovers, filaree, and rushes. Considerable fluctuation in species



F-447499

Figure 33.—Rangeland in the annual grasslands ecosystem in California. Annual grasses dominate the ground cover; the trees are oak.

composition of the herbage may occur rapidly as a result of climatic fluctuation. This site is probably more stable than the other sites in this ecosystem and usually receives intense use for grazing.

The soils are mainly Entisols (dark gray, sandy clay loams with fairly good water-holding capacity, better than those of the slopes). The swales receive much seepage water, to the point of being saturated in wet winters.

Class 2.—The vegetation on the gentle slopes characterizes this productivity class, producing 2,200 to 3,300 pounds of herbage per acre. The vegetation of this class occupies the area just above the swales and is on a slope of 10 percent or less. This class makes up about 10 percent of the California steppe. The dominant plants in the southern portion are foxtail fescue, soft chess, Mediterranean barley, and clovers. Wild oats are dominant in the northern part. The land in this class, along with the swales, usually

receives the hardest grazing use.

The soils are Alfisols and Entisols (Xerorthents)—fine sandy loams that represent the transition from transported soils in the swales to soils developed in place on the slopes.

Class 3.—Open, rolling upland sites where herbage production averages 1,850 pounds per acre represent this productivity class. These sites are located on slopes with gradients of 10 to 25 percent and have a very open cover of trees and only scattered rock outcrops. Dominant plants are soft chess, foxtail fescue, filaree, and clovers. The soils are mainly Alfisols and Entisols (Xerorthents that are sandy loams, about 24 inches deep).

Class 4.—This productivity class is characterized by the vegetation on the rocky, brushy, rolling-to-steep sites where herbage yields average 1,000 pounds per acre. These sites have slopes of 25 percent or more and have numerous rock outcrops or many shrubs and trees. They

differ considerably from place to place, including some productive soils, as well as some thin sandy soils. This class makes up 60 to 75 percent of the California steppe. The dominant plants are red brome, soft chess, and filaree.

The soils are Alfisols (Haploxeralfs plus Xerorthents that are shallow and moderately sloping to steep).

HERBAGE PRODUCTION

A summary of herbage production in the ecosystem follows:

<i>Productivity class</i>	<i>Pounds per acre</i>	<i>Productivity class</i>	<i>Pounds per acre</i>
1.....	3,300-4,400	3.....	1,100-2,200
2.....	2,200-3,300	4.....	0-1,100

NO. 44.—THE ALPINE ECOSYSTEM

Physiography.—The alpine ecosystem occurs largely as an interrupted chain of stands on the highest peaks in the Rocky Mountain and Pacific Mountain Systems. Valley glaciers have sculptured most alpine areas and provided open, spectacular landscapes. Cirques, hanging tributaries, and various types of moraine are common.

Climate.—The climate is rigorous. The average monthly temperature may be 3° C in January and 50° C in July. Frost may occur any night during the summer. Precipitation is estimated to be 35-50 inches per year, falling

mostly as snow. Evaporation and wind movement are marked.

Vegetation.—Grasses and grasslike species of rather low stature predominate, but the number of associated forbs is large. Dwarf willows occur, in some places, on the moist soils of protected slopes and valleys.

Fauna.—The pika, pocket gopher, and yellow-bellied marmot are the only permanent mammalian residents of the alpine ecosystem. Summer visitors include mule deer, elk, mountain sheep, weasels, marten, chipmunks, and the golden-manteled ground squirrel. The only



F-386561

Figure 34.—Low grasses and grasslike plants predominate in the alpine ecosystem.

nesting birds are the horned lark, water pipit, black rosy finch, rock wren, white-tailed ptarmigan, and robin.

Soils.—The soils of this ecosystem commonly have no pedogenic horizons (Entisols), have weakly differentiated horizons (Inceptisols), or have a low supply of bases and an accumulation of amorphous materials in subsurface horizons (Spodosols). These cold soils normally belong in the cryic great groups. The terrain is sometimes referred to as “fragile,” because of the ease with which the soils can be displaced by horses’ hooves on recreation trails or water-eroded where ground cover becomes broken.

Land use.—This ecosystem provides summer grazing for sheep under careful management. Their deep snowpacks make areas in the ecosystem prime watersheds. The ecosystem provides opportunities for summer and winter recreation and habitats for wildlife.

Productivity Classes

Class 1.—Microtopography where moisture tends to accumulate characterizes this productivity class. Sedges and tufted hairgrass are characteristic dominants. Dwarf willows may form an overstory. Herbage production ranges from 900 to 1,200 pounds per acre. Eighty to 100 percent of the herbage could be considered to be forage, but only 40–50 percent should be used by grazing animals. Soils are normally members of the “Aqu” suborders, are seasonally wet, and are mottled with gray blotches.

Class 2.—Upper and lower slopes fall within this productivity class. Dominant plants include kobresia, sedges, alpine avens, tufted hairgrass, and American bistort. Herbage production is

about 600–900 pounds per acre, of which 40 percent could be used as forage. Soils range from Inceptisols on the upper slopes to Spodosols on the lower slopes.

Class 3.—This production class is found, generally, on ridge tops and convex land surfaces. The characteristic dominant plants include alpine avens, sedges, dryas, moss silene, and clovers. Herbage production ranges from 300 to 600 pounds per acre. No more than 10–15 percent of the herbage could be used for forage. In many places, the soils are shallow, stony, and coarse-textured. Pedogenic horizons are absent or weakly developed.

Class 4.—This productivity class occurs on the shallowest soils of the fell-field and the boulder-field. It may occasionally include wet areas where intensive frost action is taking place. Dominant plants of the boulder-field are lomatium, mountainsorrel, bluebell, sedges, and alpine avens. The dominant plants of the fell-field include sedges and such pulvinate species as alpine clover, Rocky Mountain railwood, and moss silene.

Herbage production in this productivity class varies from a few scattered plants to 300 pounds per acre. Forage is limited, but sheep wander into the rock-field during dry years to find such forage as bluebell.

HERBAGE PRODUCTION

A summary of herbage production in the ecosystem follows:

<i>Productivity class</i>	<i>Pounds per acre</i>	<i>Productivity class</i>	<i>Pounds per acre</i>
1.....	900–1,200	3.....	300– 600
2.....	600– 900	4.....	0– 300

Appendix A—General References

- Austin, M. E.
1965. Land resource regions and major land resource areas of the United States. USDA Soil Conserv. Serv., Agric. Handb. 296, 82 p.
- Daubenmire, R., and Jean B. Daubenmire.
1968. Forest vegetation of eastern Washington and northern Idaho, Wash. State Univ., Wash. Agric. Exp. Stn., Tech. Bull. 60, 104 p.
- Fenneman, N. M.
1931. Physiography of Western United States. 534 p. McGraw-Hill Book Co., Inc., New York.
- Kelsey, H. L., and W. A. Dayton.
1942. Standardized plant names. 675 p. J. Horace McFarland Co., Harrisburg, Pa.
- Küchler, A. W.
1964. Potential natural vegetation of the conterminous United States. (Manual and map). Am. Geogr. Soc. Spec. Publ. 36, 1965 rev., 116 p. New York.
- Little, E. L., Jr.
1953. Checklist of native and naturalized trees of the United States. USDA Forest Serv., Agric. Handb. 41, 472 p.
1971. Atlas of United States trees. Vol. 1. Conifers and important hardwoods. USDA Forest Serv., Misc. Publ. 1146.
- Lull, Howard W.
1968. A forest atlas of the Northeast. USDA Forest Serv., 46 p.
- Miller, D. W., J. J. Geraghty, and R. S. Collins.
1962. Water atlas of the United States. Water Inf. Cent., Inc., Port Wash., N.Y.
- Shelford, V. E.
1963. The ecology of North America, 610 p. Univ. Ill. Press, Urbana, Ill.
- U.S. Department of Agriculture, Forest Service.
1967. Section 74: geographic forest types. *In* Forest survey handbook. USDA Forest Serv. Handb. 4813.1, p. 74-74.2-3.
1973. The outlook for timber in the United States. USDA Forest Serv. Forest Resour. Rep. 20, 367 p.
- U.S. Department of the Interior, Geological Survey.
1967. Potential natural vegetation. USDI Geol. Surv., Natl. Atlas Sheet 90.
1969. Classes of land-surface form. USDI Geol. Surv., Natl. Atlas Sheet 62.
1969. Distribution of principal kinds of soils: orders, suborders, and great groups. USDI Geol. Surv., Natl. Atlas Sheet 86.
1969. Major forest types. USDI Geol. Surv., Natl. Atlas Sheet 182.
1969. Potential natural vegetation of Alaska. USDI Geol. Surv., Natl. Atlas Sheet 89.
1970. The national atlas of the United States of America. 417 p. USDI Geol. Surv., Wash.

Appendix B—References on Mammals and Birds

- Bent, Arthur Cleveland.
1961. Life histories of North American birds of prey. Part 1. 409 p. Dover Publ., Inc., New York.
1961. Life histories of North American birds of prey. Part 2. 482 p. Dover Publ., Inc., New York.
1963. Life histories of North American gallinaceous birds. 490 p. Dover Publ., Inc., New York.
- Cadbury, J., and A. D. Cruickshank.
1942. Breeding-bird census, climax red and white spruce forest. Audubon Mag. Sept.-Oct. 1942 Sect. 2:32.
- Ely, Alfred.
1939. North American big game. 533 p. Chas. Scribner's Sons, New York.
- Johnson, D. W., and E. P. Odum.
1956. Breeding bird populations in relation to plant succession on the Piedmont of Georgia. Ecol. 37:50-62.
- Kendeigh, S. C.
1946. Breeding birds of the beech-maple-hemlock community. Ecol. 27:226-245.
1961. Animal ecology. 468 p. Prentice-Hall, Inc., Englewood Cliffs, N. J.
- Palmer, Ralph S.
1954. The mammal guide. 384 p. Doubleday and Co., Inc., Garden City, N. Y.
- Rasmussen, D. I.
1941. Biotic communities of the Kaibab Plateau, Arizona. Ecol. Monogr. 11:229-275.
- Shelford, Victor E.
1963. The ecology of North America. 610 p. Univ. of Ill. Press, Urbana, Ill.
- Smith, W. P.
1944. Breeding bird census, white pine-hemlock forest. Audubon Mag. Sept.-Oct. 1944 Sect. 2:24. 24.
- Taylor, Walter P.
1956. The deer of North America. 668 p. The Stackpole Co., Harrisburg, Pa., and the Wildl. Manage. Inst., Wash., D.C.
- U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife.
1968. Rare and endangered fish and wildlife of the United States. USDI Bur. of Sport Fish., Resour. Publ. 34.

Appendix C—References Used in Describing Individual Ecosystems

WESTERN RANGE

SAGEBRUSH

- Beetle, A. A.
1960. A study of sagebrush: the section *tridentatae* of *Artemisia*. Wyo. Agric. Exp. Stn. Bull. 367.
- Fosberg, M. A., and M. Hironaka.
1964. Soil properties affecting the distribution of big and low sagebrush communities in southern Idaho. Am. Soc. Agron. Spec. Publ. 5, p. 230-236.
- Tisdale, E. W., M. Hironaka, and M. A. Fosberg.
1965. An area of pristine vegetation in Craters of the Moon National Monument, Idaho. Ecol. 46:349-352.
- _____, M. Hironaka, and M. A. Fosberg.
1969. The sagebrush region in Idaho: a problem in range resource management. Univ. of Idaho, Idaho Agric. Exp. Stn. Bull. 512, 15 p.

DESERT SHRUB

- Bleak, A. T., and N. C. Frischknecht.
1965. Problems in artificial and natural revegetation of the arid shadscale vegetation zone of Utah and Nevada. J. Range Manage. 18:59-65.
- Cable, Dwight R., and Fred H. Tschirley.
1961. Responses of native and introduced grasses following aerial spraying of velvet mesquite in southern Arizona. J. Range Manage. 14:155-159.
- Nichol, A. A.
1952. Natural vegetation of Arizona. Ariz. Agric. Exp. Stn. Tech. Bull. 127, p. 189-230.
- Reynolds, Hudson G., and S. Clark Martin.
1968. Managing grass-shrub cattle ranges in the Southwest. USDA Forest Serv., Agric. Handb. 162.
- Rosenzweig, Michael L., and Jerald Winakur.
1969. Population ecology of desert rodent communities: habitats and environmental complexity. Ecol. 50:558-572.
- Schmutz, Ervin M., Dwight R. Cabel, and John J. Warwick.
1959. Effect of shrub removal on the vegetation of a semidesert grass-shrub range. J. of Range Manage. 12:34-37.
- Turner, Raymond M., Stanley M. Alcorn, and George Olin.
1969. Mortality of transplanted saguaro seedlings. Ecol. 50:835-844.
- West, Neal E., and Kamal J. Ibrehim
1968. Soil-vegetation relationships in the shadscale zone of southeastern Utah. Ecol. 49:445-456.

SOUTHWESTERN SHRUBSTEPPE

- Cable, D. R.
1969. Competition in the semidesert grass-shrub types as influenced by root systems, growth habits, and soil moisture. Ecol. 50:27-38.
- Gehlbach, F. R.
1967. Vegetation of the Guadalupe escarpment, New Mexico-Texas. Ecol. 48:404-419.
- Goebel, C. J., and C. W. Cook
1960. Effect of range condition on plant vigor, production, and nutritive value of forage. J. Range Manage. 13:307-313.

- Humphrey, R. R.
1933. The desert grassland: a history of vegetational changes and an analysis of causes. Bot. Rev. 24: 193-252.
- Jameson, D. J.
1962. Effects of burning on a galleta-black grama range invaded by juniper. Ecol. 43:760-763.
- Leithhead, H. L.
1959. Runoff in relation to range condition in the Big Bend-Davis Mountain section of Texas. J. Range Manage. 12:83-87.
- Paulsen, H. A., and F. N. Ares.
1961. Trends in carrying capacity and vegetation on an arid southwestern range. J. Range Manage. 14:78-83.
- _____,
1962. Grazing values and management of blackgrama and tobosa grasslands and associated shrub ranges of the Southwest. USDA Forest Serv., Tech. Bull. 1270, 56 p.
- Potter, L. D., and J. C. Krenetsky.
1967. Plant succession with released grazing on New Mexico range lands. J. Range Manage. 20:145-151.
- Thomas, G. W., and V. A. Young.
1954. Relation of soils, rainfall, and grazing management to vegetation—western Edwards Plateau of Texas. Texas Agric. and Mech. Univ., Texas Agric. Exp. Stn. Bull. 786.
- Whittaker, R. H., and W. A. Niering.
1965. Vegetation of the Santa Catalina Mountains, Arizona: a gradient analysis of the south slope. Ecol. 46:429-452.
- ### CHAPARRAL-MOUNTAIN SHRUB
- Same as southwestern shrubsteppe.
- ### PINYON-JUNIPER
- Same as southwestern shrubsteppe.
- ### MOUNTAIN GRASSLANDS
- Costello, D. F.
1954. Vegetation zones in Colorado. In *Introduction to The manual of the higher plants of Colorado*, by H. D. Harrington. Sage Book Co., Denver, Colo.
- Daubenmire, R. F.
1942. An ecological study of the vegetation of southeastern Washington and adjacent Idaho. Ecol. Monogr. 12 (Jan.): 53-79.
- Hurd, Richard M.
1961. Grassland vegetation in the Bighorn Mountains, Wyoming. Ecol. 42 (3): 459-467.
- Johnson, W. M.
1962. Vegetation of high altitude ranges in Wyoming as related to use by game and domestic sheep. Univ. of Wyo., Agric. Exp. Stn. Bull. 387.
- Mueggler, W. F., and C. A. Harris.
1969. Some soil and vegetation characteristics of mountain grasslands in central Idaho. Ecol. 50 (4): 671-678.
- Pickford, G. D., and E. H. Reid.
1942. Basis for judging subalpine grassland ranges of Oregon and Washington. USDA, Circ. 655, 37 p.

Strickler, Gerald S.

1961. Vegetation and soil condition changes on subalpine grassland in eastern Oregon. USDA Forest Serv. Res. Pap. PNW-40, 46 p. Pac. Northwest Forest and Range Exp. Stn., Portland, Oreg.

MOUNTAIN MEADOWS

Crane, B. K.

1950. Condition and grazing capacity of wet meadows on the east slope of the Sierra-Nevada Mountains. *J. of Range Manage.* 3(4):303-307.

Pickford, G. D., and E. H. Reid.

1942. Guides to determine range condition and proper use of mountain meadows in eastern Oregon. USDA Forest Serv. Range Res. Rep. PNW-3, 19 p. Pac. Northwest Forest and Range Exp. Stn., Portland, Oreg.

Saunderson, H. R.

1967. Herbage production on high Sierra-Nevada meadows. *J. Range Manage.* 20(4):255-256.

DESERT GRASSLANDS

Same as southwestern shrubsteppe.

ANNUAL GRASSLANDS

Bentley, J. R., L. R. Green, and K. A. Wagon.

1958. Herbage production and grazing capacity on annual-plant range pastures fertilized with sulphur. *J. Range Manage.* 11:133-140.

_____ and M. W. Talbot.

1951. Efficient use of annual plants on cattle ranges in the California foothills. USDA, Circ. 870, 52 p.

Burcham, L. T.

1956. Historical backgrounds of rangeland use in California. *J. Range Manage.* 9:81-86.

Conrad, C. E., E. J. Woolfolk, and D. A. Duncan.

1966. Fertilization and management implications on California annual-plant range. *J. Range Manage.* 19:20-26.

Duncan, D. A., and L. O. Hylton, Jr.

1970. Effects of fertilization on quality of range forage. In *Range and wildlife habitat evaluation—a research symposium*, p. 57-62. USDA, Misc. Publ. 1147.

Green, L. R., K. A. Wagon, and J. R. Bentley.

1958. Diet and grazing habits of steers on foothill range fertilized with sulphur. *J. Range Manage.* 11:221-227.

Heady, H. F.

1958. Changes in a California annual plant community type. *Ecol.* 39:402-416.

1961. Continuous vs. specialized grazing systems: a review and application of the California annual type. *J. Range Manage.* 14:182-193.

1964. Palatability of herbage and animal preference. *J. Range Manage.* 17:76-82.

Jones, M. B.

1960. Response of annual range to urea applied at various dates. *J. Range Manage.* 13:188-192.

McNaughton, S. J.

1968. Structure and function in California grasslands. *Ecol.* 49:962-972.

Naveh, Z.

1967. Mediterranean ecosystems and vegetative types in California and Israel. *Ecol.* 48:445-459.

Ratliff, R. A., and H. F. Heady.

1962. Seasonal changes in herbage weight in an annual grass community. *J. Range Manage.* 15:146-149.

Reppert, J. N., M. J. Morris, and C. A. Graham.

1962. Estimation of herbage on California annual-type range. *J. Range Manage.* 15:318-323.

Stoddart, L. A., and A. D. Smith.

1955. Range management. 433 p. McGraw-Hill Book Co., Inc., New York.

Wagon, K. A., H. R. Guilbert, and E. H. Hart.

1959. Beef cattle investigations on the San Joaquin Experimental Range. *Calif. Agric. Exp. Stn. Bull.* 765, 71 p.

Walker, C. F., and W. A. Williams.

1963. Responses of annual-type range vegetation to sulphur-fertilization. *J. Range Manage.* 16:64-69.

William, W. A., C. M. McKell, and J. N. Reppert.

1964. Sulphur fertilization of an annual-range soil during years of below normal rainfall. *J. Range Manage.* 17:1-5.

Wood, W. E.

1950. Rangeland use in California. *J. Range Manage.* 50:204-212.

ALPINE

Johnson, P. L., and W. D. Billings.

1962. The alpine vegetation of the Beartooth Plateau in relation to cryopedogenic processes and patterns. *Ecol. Monogr.* 32:105-135.

Paulsen, H. A., Jr.

1960. Plant cover and foliage use of alpine sheep ranges in the Central Rocky Mountains. *Iowa State Coll., J. Sci.* 34:731-748.

Pond, F. W., and D. R. Smith.

1971. Ecology and management of subalpine ranges on the Big Horn Mountains of Wyoming. *Univ. of Wyo., Wyo. Agric. Exp. Stn., Res. J.* 53, 24 p.

Smith, D. R.

1969. Vegetation, soils, and their interrelationships at timberline in the Medicine Bow Mountains, Wyoming. *Univ. of Wyo., Wyo. Agric. Exp. Stn., Sci. Monogr.* 17, 13 p.

U.S. Department of Agriculture, Forest Service.

1958. Timber resources for America's future. USDA Forest Serv., Forest Resour. Rep. 14, 713 p.

WESTERN FOREST

DOUGLAS-FIR

Daniel, T. W., and M. E. Ensminger.

1945. Grazing on cutover lands of western Washington. *State Coll. of Wash., Wash. Agric. Exp. Stn., Pop. Bull.* 179.

Franklin, J. F., and C. T. Dyrness.

1969. Vegetation of Oregon and Washington, USDA Forest Serv. Res. Pap. PNW-80, rev. 1973. 1. . . Northwest Forest and Range Exp. Stn., Portland, Oreg.

_____ and C. T. Dyrness.

1973. Natural vegetation of Oregon and Washington. USDA Forest Serv. Gen. Tech. Rep. PNW-8, 417 p. Pac. Northwest Forest and Range Exp. Stn., Portland, Oreg.

Reid, E. H., L. A. Isaac, and G. D. Pickford

1938. Plant succession on a cutover, burned, and grazing Douglas fir area. USDA Forest Serv. Res. Note PNW-26. Pac. Northwest Forest and Range Exp. Stn., Portland, Oreg.

PONDEROSA PINE

Costello, D. F., and H. E. Schwann.

1946. Conditions and trends on ponderosa pine ranges in Colorado. USDA Forest Serv. Rocky Mt. Forest and Range Exp. Stn., Fort Collins, Colo., and Rocky Mt. Reg. Off., Denver, Colo.

Garrison, G. A.
1965. Changing conditions in northwest forested ranges. *Proc. Soc. Am. Foresters* [Denver, Colo.] 1964: 67-68.

1969. Challenge of forest grazing in Pacific Northwest. *In* Abstracts of papers at 22nd annual meeting, Amer. Soc. of Range Manage. [Calgary, Alberta, 1969]. p. 31. Amer. Soc. of Range Manage.

Pearson, H. A., and D. A. Jameson.

1967. Relationship between timber and cattle production on ponderosa pine range: the Wild Bill Range. USDA Forest Serv. Rocky Mt. Forest and Range Exp. Stn.

Pickford, G. D., and E. H. Reid.

1948. Forage utilization on summer cattle ranges in eastern Oregon. USDA, Circ. 796, 27 p.

Reid, E. H.

1948. Forest grazing in the Pacific Northwest. *Proc. Soc. Am. Foresters* 1947:296-302.

1964. Forage production in ponderosa pine forests. *Proc. Soc. Am. Foresters* [Denver, Colo.] 1964.

Rummell, R. S.

1951. Some effects of livestock grazing on ponderosa pine forest and range in central Washington. *Ecol.* 32(4): 594-607.

WESTERN WHITE PINE

Same as Douglas-fir and ponderosa pine.

FIR-SPRUCE

Same as Douglas-fir and ponderosa pine.

HEMLOCK-SITKA SPRUCE

Franklin, J. F., and C. T. Dyrness.

1969. Vegetation of Oregon and Washington. USDA Forest Serv. Res. Pap. PNW-80, rev. 1973. Pac. Northwest Forest and Range Exp. Stn., Portland, Oreg.

LARCH

Same as Douglas-fir and ponderosa pine.

LODGEPOLE PINE

Same as ponderosa pine.

WESTERN HARDWOODS

Same as annual grasslands.

GREAT PLAINS

SHINNERY

Allred, B. W.

1949. Distribution and control of several woody plants in Texas and Oklahoma. *J. Range Manage.* 2:15-29.

Lotspeich, F. P., and M. E. Everhart.

1962. Climate and vegetation as soil forming factors on the Llano Estacado. *J. Range Manage.* 15:134-141.

Stoddart, L. A., and A. D. Smith.

1955. Range management. 433 p. McGraw-Hill Book Co., Inc., New York.

Weaver, J. E., and F. E. Clements.

1938. Plant ecology. 601 p. McGraw-Hill Book Co., Inc., New York.

TEXAS SAVANNA

Box, T. W.

1960. Herbage production in four range plant communities in south Texas. *J. Range Manage.* 13:72-76.

1961. Relationships between plants and soils of four communities in south Texas. *Ecol.* 42:794-810.

Fanning, C. D., C. M. Thompson, and Dean Isaacs.

1965. Properties of saline range soils of the Rio Grande Plain. *J. Range Manage.* 18:190-193.

Johnston, M.

1963. Past and present grasslands of southern Texas and N.E. Mexico. *Ecol.* 44:456-466.

McMahan, C. A., and C. W. Ramsey.

1965. Response of deer and livestock to controlled grazing in central Texas. *J. Range Manage.* 18:1-7.

Stoddart, L. A., and A. D. Smith.

1955. Range management. 433 p. McGraw-Hill Book Co., Inc., New York.

Thomas, G. W., and V. A. Young.

1954. Relation of soils, rainfall, and grazing management to vegetation—western Edwards Plateau of Texas. Texas Agric. and Mech. Univ., Texas Agric. Exp. Stn. Bull. 786.

Thorp, B. C.

1926. Structure of Texas vegetation east of the 98th meridian. Univ. of Texas Bull. 2606.

PLAINS GRASSLANDS

Bjugstad, A. J., and W. C. Whitman.

1970. Significance of reduced plant vigor in relation to range condition. *J. Range Manage.* 23:181-184.

Holscher, C. E., and E. J. Woolfolk.

1953. Forage utilization by cattle on northern Great Plains ranges. USDA, Circ. 918.

Houston, W. R.

1961. Some interrelations of sagebrush, soils, and grazing intensity in the northern Great Plains. *Ecol.* 42:31-38.

Larson, F., and W. Whitman.

1942. A comparison of used and unused grassland mesas in the Badlands of South Dakota. *Ecol.* 23: 438-445.

Reed, M. J., and R. A. Peterson.

1961. Vegetation, soils, and cattle responses to stocking and grazing on northern Great Plains ranges. USDA, Tech. Bull. 1252, 79 p.

Smoliak, S.

1956. Influence of climatic conditions on forage production of shortgrass rangeland. *J. Range Manage.* 9:89-91.

Weaver, J. E., and F. E. Clements.

1938. Plant ecology. 601 p. McGraw-Hill Book Co., Inc., New York.

PRAIRIE

Aikman, J. M.

1955. Burning in the management of prairie in Iowa. *Iowa Acad. Sci. Proc.* 62:53-62.

Buttery, R. F.

1960. Grazed glades can grow good grass. *J. Range Manage.* 13:234-235.

Costello, D. F.

1969. The prairie world. 242 p. Crowell Co., New York.

Ehrenreich, J. H.

1959. Effect of burning and clipping on growth of native prairie in Iowa. *J. Range Manage.* 12:133-137.

_____ and J. M. Aikman.

1963. An ecological study of the effect of certain management practices on native prairie in Iowa. *Ecol. Monogr.* 33:113-130.

Hopkins, H. H.

1951. Ecology of the native vegetation of the loess hills in central Nebraska. *Ecol. Monogr.* 21:125-147.

Hulbert, T.

1969. Fire and litter effects in undisturbed bluestem in Kansas. *Ecol.* 50:874-877.

Kelting, R. W.

1954. Effects of moderate grazing on the composition and plant production of a native tall-grass prairie in central Oklahoma. *Ecol.* 35:200-207.

- Kucera, C. L., and J. H. Ehrenreich.
1962. Some effects of annual burning on central Missouri prairie. *Ecol.* 43:334-336.
_____ and S. C. Martin.
1957. Vegetation and soil relationships in the glade region of the southwestern Missouri Ozarks. *Ecol.* 38:285-291.
- Martin, S. C., and J. S. Crosby.
1955. Burning and grazing on glade range in Missouri. USDA Forest Serv. Tech. Pap. CS-147. Cent. States Forest Exp. Stn., Columbus, Ohio.
- Porter, C. L.
1966. An analysis of variation between upland and lowland switchgrass, *Panicum virgatum* L., in central Oklahoma. *Ecol.* 47:980-992.
- Vogel, W. G., and A. J. Bjugstad.
1968. Effects of clipping on yield and tillering of little bluestem, big bluestem, and Indiangrass. *J. Range Manage.* 21:136-140.
- Weaver, J. E., and F. E. Clements.
1938. Plant ecology. 601 p. McGraw-Hill Book Co., Inc., New York.

EASTERN FOREST

WHITE-RED-JACK PINE

- Braun, E. L.
1950. Deciduous forests of eastern North America. Blakiston Co., Philadelphia, Pa.

SPRUCE-FIR

Same as white-red-jack pine.

LONGLEAF-SLASH PINE

- American Society for Range Management, Southern Section.
1955. Range resources of the South. Univ. of Ga., Ga. Agric. Exp. Stn. Bull. N. S. 9, 31 p.
- Duvall, V. L., and Norwin E. Linnartz.
1967. Influences of grazing and fire on vegetation and soil of longleaf pine-bluestem range. *J. Range Manage.* 20:241-247.
_____ and L. B. Whitaker.
1964. Rotation burning: a forage management system for longleaf pine bluestem ranges. *J. Range Manage.* 17:322-326.
- Gansner, D. A.
1965. Missouri forests. USDA Forest Serv. Resour. Bull. CS-2. Cent. States Forest Exp. Stn., Columbus, Ohio.
- Grelen, H. E., and V. L. Duvall.
1946. Common plants of the longleaf pine-bluestem range. USDA Forest Serv. Res. Pap. SO-23, 96 p. South. Forest Exp. Stn., New Orleans, La.
_____ and E. A. Epps, Jr.
1967. Season of burning affects herbage quality and yield on pine-bluestem range. *J. Range Manage.* 20:31-33.
- Hottel, J. B., and A. F. Arnold.
1965. Crop, pasture, timber, and livestock enterprises for the Boston Mountain and Ozark Highland areas of Arkansas. Univ. of Arkansas, Agric. Exp. Stn. Rep. Ser. 135.
- Nelson, T. C., and W. M. Zillgitt.
1969. A forest atlas of the South. 27 p. USDA Forest Serv. South. Forest Exp. Stn., New Orleans, La.
- Pearson, H. A., L. B. Whitaker, and V. L. Duvall.
1971. Slash pine regeneration and regulated grazing. *J. Forestry* 69:744-746.
- Society of American Foresters.
1954. Forest cover types of North America. 67 p. Soc. of Am. Foresters, Wash., D. C.
- Sternitzke, H. S.
1960. Arkansas forests. 58 p. USDA Forest Serv. South. Forest Exp. Stn., New Orleans, La.

LOBLOLLY-SHORTLEAF PINE

- Duvall, V. L., and Norwin E. Linnartz.
1967. Influences of grazing and fire on vegetation and soil of longleaf pine-bluestem range. *J. Range Manage.* 20:241-247.
_____ and L. B. Whitaker.
1964. Rotation burning: a forage management system for longleaf pine-bluestem ranges. *J. Range Manage.* 17:322-326.
- Grelen, H. E., and V. L. Duvall.
1946. Common plants of the longleaf pine-bluestem range. USDA Forest Serv. Res. Pap. SO-23, 96 p. South. Forest Exp. Stn., New Orleans, La.
_____ and E. A. Epps, Jr.
1967. Season of burning affects herbage quality and yield on pine-bluestem range. *J. Range Manage.* 20:31-33.
- Pearson, H. A., L. B. Whitaker, and V. L. Duvall.
1971. Slash pine regeneration and regulated grazing. *J. Forestry* 69:744-746.

OAK-PINE

Same as loblolly-shortleaf pine.

OAK-HICKORY

- Bazzaz, F. A.
1968. Succession on abandoned fields in the Shawnee Hills, southern Illinois. *Ecol.* 49:924-936.
- Bjugstad, A. J., and H. S. Crawford.
1967. Cattle in the woods or woods in the pasture. USDA Forest Serv. Res. Note NC-23. North Cent. Forest Exp. Stn., St. Paul, Minn.
_____ and A. V. Dalrymple.
1968. Behavior of beef heifers on Ozark ranges. Univ. of Mo., Mo. Agr. Exp. Stn. Bull. 870.
_____ D. A. Murphy, and H. S. Crawford.
1968. Poor returns from Ozark woodland grazing. USDA Forest Serv. Res. Note NC-60. North Cent. Forest Exp. Stn., St. Paul, Minn.
- Caplenor, D.
1968. Forest composition on loessal and non-loessal soils in west-central Mississippi. *Ecol.* 49:322-331.
- Clarkson, R. B.
1966. The vascular flora of the Monongahela National Forest, West Virginia. *Castanea* 31:1-119.
- Crawford, H. S., and A. J. Bjugstad.
1967. Establishing grass range in the southwestern Missouri Ozarks. USDA Forest Serv. Res. Note NC-22. North Cent. Forest Exp. Stn., St. Paul, Minn.
_____ and R. G. Leonard.
1965. The Sylamon deer study. Proc. 17th Annu. Conf., Southeast. Assoc. Game and Fish Comm., p. 9-13.
- Davis, A. M.
1967. Rangeland development through brush control in the Arkansas Ozarks. Univ. of Arkansas, Agric. Exp. Stn. Bull. 726.
- Ehrenreich, J. H., and J. S. Crosby.
1960. Forage production on sprayed and burned areas in the Missouri Ozarks. *J. Range Manage.* 13:68-69.
_____ and J. S. Crosby.
1960. Herbage production is related to hardwood crown cover. *J. Forestry* 58:564-565.
_____ and R. A. Ralston.
1963. Forage and timber production alternating on shallow soils in the Ozarks. Proc. Soc. Am. Foresters [Boston, Mass.], p. 80-83.
- Halls, L. K., and H. S. Crawford.
1960. Deer-forest habitat relationships in North Arkansas. *J. Wildl. Manage.* 24:387-395.
_____ and H. S. Crawford.
1965. Vegetation response to an Ozark woodland spraying. *J. Range Manage.* 18:338-340.

- R. A. Read, and H. S. Crawford.
1960. Forage and ground-cover conditions in unmanaged Ozark forests. *South. Forest Res.* 1:1-16.
- Hottel, J. B., and A. F. Arnold.
1965. Crop, pasture, timber, and livestock enterprises for the Boston Mountain and Ozark Highland areas of Arkansas. Univ. of Arkansas, Agric. Exp. Stn. Rep. Ser. 135.
- Hough, A. F.
1965. A twenty-year record of understory vegetation changes in a virgin Pennsylvania forest. *Ecol.* 46: 370-373.
- Jones, A. S., and E. G. Patton.
1966. Forest, "prairie," and soils in the Black Belt of Sumter County, Alabama, in 1832. *Ecol.* 47:75-80.
- Martin, S. C.
1955. The place of range livestock in the Missouri Ozarks. *J. Range Manage.* 8:105-111.
- Murphy, D. A., and J. H. Ehrenreich.
1965. Effects of timber harvest and stand improvement on forage production. *J. Wildl. Manage.* 29: 734-739.
- Pearson, P. R.
1962. Increasing importance of sugar maple on two calcareous formations in New Jersey. *Ecol.* 43:711-718.
- Ray, H. C., and M. Lawson.
1955. Site characteristics as a guide to forest and grazing use in the Ozarks. *J. Range Manage.* 8: 69-73.
- Read, R. A.
1951. Woodland forage in the Arkansas Ozarks. *J. Range Manage.* 4:391-396.
- Sherman, R. W.
1967. Economics of sawtimber production in Appalachia, Ohio. Ohio Agric. Res. and Dev. Cent. (Wooster, Ohio), Res. Circ. 152.
- Society of American Foresters
1954. Forest cover types of North America. 67 p. Soc. Am. Foresters, Wash., D. C.
- Sternitzke, H. S.
1967. East Texas post oak region. USDA Forest Serv. Resour. Bull. SO-11. South. Forest Exp. Stn., New Orleans, La.
- Whittaker, R. H.
1962. Net production relations of shrubs in the Great Smoky Mountains. *Ecol.* 43:357-377.
1966. Forest dimensions and productions in the Great Smoky Mountains. *Ecol.* 47:103-121.
- OAK-GUM-CYPRESS**
- Beals, E. W., and J. B. Cope.
1964. Vegetation and soils in an eastern Indiana woods. *Ecol.* 45:777-792.
- Blomquist, H. L.
1940. Introduction to the grasses of North Carolina. 8 p. [Mimeographed] Duke Univ., Durham, N.C.
- Caplenor, D.
1968. Forest composition on loessal and non-loessal soils in west-central Mississippi. *Ecol.* 49:322-331.
- Golley, F., H. T. Odum, and R. F. Wilson.
1962. The structure and metabolism of a Puerto Rican red mangrove forest in May. *Ecol.* 43:9-19.
- Halls, L. K.
1970. Growing deer food amidst southern timber. *J. Range Manage.* 23:213-215.
- Lemon, P. C.
1945. Wood as a substratum for perennial plants in the Southeast. *Am. Midl. Nat.* 34:744-749.
- Porter, C. L., Jr.
1967. Composition and productivity of a subtropical prairie. *Ecol.* 48:937-942.
- Williams, R. E., J. T. Cassady, L. K. Halls, and E. J. Woolfolk.
1955. Range resources of the South. Univ. of Ga., Ga. Agric. Exp. Stn. Bull. N.S.-9, 31 p. [In cooperation with South. Sect., Am. Soc. for Range Manage.]
- ELM-ASH-COTTONWOOD**
- Beals, E. W., and J. B. Cope.
1964. Vegetation and soils in an eastern Indiana woods. *Ecol.* 45:777-792.
- Ganser, D. A.
1965. Missouri forests. USDA Forest Serv. Resour. Bull. CS-2. Cent. States Forest Exp. Stn., Columbus, Ohio.
- Society of American Foresters.
1954. Forest cover types of North America. 67 p. Soc. of Am. Foresters, Wash., D.C.
- MAPLE-BEECH-BIRCH**
- Same as white-red-jack pine.
- ASPEN-BIRCH**
- Same as white-red-jack pine.
- WET GRASSLANDS**
- Halls, L. K.
1957. Grazing capacity of wiregrass-pine ranges of Georgia. *J. Range Manage.* 10:1-5.
- Porter, C. L.
1967. Composition and productivity of a subtropical prairie. *Ecol.* 48:937-942.
- Rummell, R. S.
1957. Beef cattle production and range practices in south Florida. *J. Range Manage.* 10:71-78.
- Shelford, V. E.
1963. The ecology of North America. 610 p. Univ. of Ill. Press, Urbana, Ill.
- Shiflet, T. A.
1963. A conservation program for grazing woodlands in the Southeast. *J. Range Manage.* 16:18-21.
- Southwell, B. L., and R. H. Hughes.
1965. Beef cattle management practices for wiregrass-pine ranges of Georgia. Univ. of Ga., Ga. Agric. Exp. Stn. Bull. N.S. 129.
- Williams, R. E.
1958. Practical range management in the South. *J. Range Manage.* 11:270-274.
- , J. T. Cassady, L. K. Halls, and E. J. Woolfolk.
1955. Range resources of the South. Univ. of Ga., Ga. Agric. Exp. Stn. Bull. N.S. 9, 31 p. [In Cooperation with South. Sect., Am. Soc. for Range Manage.]
- Yarlett, L. L.
1965. Control of saw palmetto and recovery of native grasses. *J. Range Manage.* 18:344-345.
- , and R. D. Roush.
1970. Creeping bluestem (*Andropogon stolonifer* (Nash) Hitchc.). *J. Range Manage.* 23:117-122.

