ADVANCE SHEETS, 6

ISSUED OCTOBER, 1924

UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF AGRICULTURAL ECONOMICS
H. C. TAYLOR, CHIEF

ATLAS

OF

AMERICAN AGRICULTURE

PREPARED UNDER THE SUPERVISION OF
O. E. BAKER
AGRICULTURAL ECONOMIST, BUREAU OF AGRICULTURAL ECONOMICS

PART I

THE PHYSICAL BASIS OF AGRICULTURE

SECTION E

NATURAL VEGETATION

GRASSLAND AND DESERT SHRUB

BY
H. L. SHANTZ
PHYSIOLOGIST, BUREAU OF PLANT INDUSTRY

FORESTS

BY
RAPHAEL ZON
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CONTENTS.

THE NATURAL VEGETATION OF THE UNITED STATES.

INTRODUCTION.

The United States, which includes within its borders a wide range of climatic, physiographic, and soil differences, presents a very great diversity in natural vegetation. The vegetation ranges from the deciduous forests of the East to the sparse grasslands of the Great Plains, from the alpine meadows among the snow-capped peaks of the Rockies, Sierra, Cascade, and Olympic ranges to the subtropical forests of southern Florida, and from the luxuriant forests of the Northwest to the almost barren deserts of southeastern California. It is difficult to present a clear and coherent picture of such complex vegetation. Of the several proposed classifications some are based on purely geographic lines, other groupings are based on physiographic regions, and still others on the requirements of temperature or water. The present description is based largely on the distinctive features of the vegetation itself.

In classifying the vegetation no attempt has been made to correlate it with geography, physiography, or with climatic or other physical factors. The natural vegetation is the expression of environment, it is the integration of all climatic and soil factors, past as well as present, and, therefore, if it can be distinctly and clearly indicated, provides often a better basis for a classification of environments than any one factor or set of factors. The forms of vegetation here described are not merely aggregations of species but are biological communities characterized by certain similarity in their biological aspect, in their environment, in their past history, and in their ultimate development. The biological unit is thus made the basis of classification and the environment is measured in terms of vegetation, and not the vegetation in terms of temperature, moisture, evaporation, or any other factor. Since the attempt to correlate the vegetation with any one factor or set of factors has been avoided, the temptation to force the vegetation to correspond to the assumed controlling factors of its distribution has been done away with and the establishment of real differences in the vegetation itself made easier.

The natural vegetation of a country, when properly analyzed and classified, may serve a very concrete and practical purpose. As a new country becomes settled the natural vegetation must be replaced gradually by agricultural crops, orchards, pastures, and man-made forests. The suitability of the virgin land for various crops is usually indicated very clearly by the natural vegetation. After a correlation is established between the different forms of natural vegetation and various agricultural or forest crops, it provides a means of dividing the country into natural regions of plant growth, which can be used as indicators of the potential capabilities of the virgin land for agriculture and forest production.

In preparing the accompanying map, published vegetation studies and maps, local floras, soil, geological, land, military, and biological surveys, and Forest Service maps and reports have been consulted. The selected bibliography does not cover the sources from which this map is drawn. It is chosen to supplement the information here presented and lack of space alone has prevented the inclusion of many important papers. A large number of persons intimately acquainted with different regions have freely given advice and criticism.[1] Although the aim has been to make the map as accurate as possible, it must still be regarded as preliminary. If it will stimulate further and more detailed studies in the classification of the natural vegetation by states or smaller units, the work of preparing it will be fully justified. Such studies will make possible the preparation at some future time of a more accurate and detailed map of our natural vegetation. On a map of small scale and with lack of abrupt vegetation changes, the plant cover of certain localities, especially on the border line between two types, might be classified differently by different persons. It is necessarily a generalized map, and many may find that the vegetation represented does not exactly tally with that with which they are intimately familiar in certain localities. An attempt is made only to indicate such vegetation as gives character to the area, necessarily omitting smaller areas of type differing from that of the region. In discussing each unit of vegetation the more important variations have been considered, although they could not be indicated on the map itself. Not the least difficult task in preparing the map has been the classification of the vegetation and the determination how far the map should show subdivisions. Gradual changes in vegetation, such as occur in passing from the humid prairie to the arid grassland of the high plains, are as important as the more abrupt ones. Where such changes occur a wide transition zone is found. Transition zones have not been shown on the map, but the types have been separated by definite lines indicating as nearly as possible the division between the two areas.

[1] The authors are particularly under obligation to the following persons whose sympathetic criticism and suggestions greatly helped them in their work: A. E. Aldous, L. H. Bailey, O. E. Baker, C. R. Ball, C. G. Bates, H. H. Bennett, S. F. Blake, F. E. Clements, F. E. Cobb, John S. Cole, E F. Frothingham, F. C. Gates, David Griffiths, Roland Harper, A. S. Hitchcock, E. R. Hodson, T. H. Kearney, C. F. Korstian, W. E. McLendon, C. F. Marbut, F. J. Marschner, W. R. Mattoon, Edw. N. Munns, G. A. Pearson, R. L. Piemeisel, C. W. Piper, J. F. Preston, J. N. Rose, W. B. Safford, W. N. Sparhawk, J. W. Stokes, Geo. B. Sudworth, I. E. Tidestrom, J. J. Thornber, R. H. Weldman, and E. O. Wooton.

GENERAL OUTLINE OF THE VEGETATION.

The vegetation of the United States may be broadly divided into forest, grassland, and desert shrub.

The forest vegetation forms two broad belts, one extending inland from the Atlantic Ocean and the other inland from the Pacific Ocean. The eastern is relatively continuous, while the western is broken by many interspersed areas of nonforested land. In the region east of the Cascade-Sierra the forests are confined largely to mountain tops and high plateaus. The eastern portion of the western forest extends down over the Rocky Mountain range and divides the unforested portion of the United States into two broad strips, one of which lies east of the Rocky Mountains and the other between the Rockies and the Cascade-Sierra. Of these two belts the eastern constitutes the great grassland area, while the western constitutes the desert-shrub area. The desert area broadens out toward the south, and along the Mexican boundary forms a continuous strip extending from the Pacific Ocean to the Gulf of Mexico, interrupted only here and there at higher elevations.

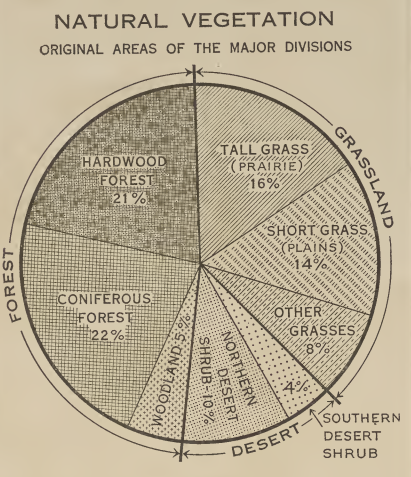

Figure 1.—The relative original areas of major divisions of vegetation in the United States.

FORESTS.

The forests of the United States include a variety of economically useful timber trees hardly equaled anywhere in the world. In the Tropics the forests are richer in species; in Russia there are larger areas of contiguous forests; but nowhere else can one find such a vast area of forests combined with such a large number of species. Leaving out of consideration species of limited distribution, such as those of semitropical origin found along the coast in southern Florida and those which overlap from the Mexican flora, as well as all species which do not exceed 1 foot in diameter, 700 or more arborescent species are known to occur within the limits of the United States. Of these, not less than 100 species are of recognized economic value and about 200 species may be considered in forest management.

The forests of the United States are divided into the Eastern or Atlantic and the Western or Pacific, which are effectually separated in the central part of the continent by grassland that acts as a barrier between the species of the two regions even more effectively than a body of water of the same extent. In the British possessions, north of the fiftieth degree of latitude, the two forest divisions come together in one great stretch of continuous subarctic forests, extending from the Atlantic to the Pacific. In the south the forests of the eastern and western regions are also united by a narrow strip of forest peculiar to the plateau of northern Mexico and possessing features common to both regions.

The Eastern forest is essentially broad-leaved in composition and of unbroken distribution, covering both valleys and mountains, while the Western forest, which is distinctly coniferous in character, is characterized by abrupt changes in type, and is interrupted by treeless valleys. Excluding tropical species, the Eastern forest has 200 species of broad-leaved trees, many of which cover large areas and are of immense value, while the Western forest has only about 100 broad-leaved species, few of which are of any considerable value. On the other hand, the Western forest has 65 species of conifers and the Eastern but 29. It is interesting to note that only a few species (*Abies balsamea*, *Picea canadensis*, *Picea mariana*, *Larix laricina*) are common to both regions.

The Eastern forest was formerly unbroken and comprised more than 1,000,000 square miles. Although an estimate of the present area of the Eastern forest can only be approximate, it may be said with some certainty that out of the original seemingly boundless supply there is left now, after a little more than 100 years of settlement, not more than 260,000 square miles of merchantable forest lands, about 500,000 square miles having been cleared for farm lands and settlements, and the remainder culled of its valuable timber, devastated by fire, or turned into almost useless brush land.

The further division of the 260,000 square miles of merchantable timber east of the one hundredth meridian falls into about 130,000 square miles predominantly of conifers and 130,000 square miles predominantly of broad-leaved trees. The Northeastern States have about 20,000 square miles, the Lake States 20,000 square miles, and the Southern States about 90,000 square miles of coniferous forests.

The Western forest still corresponds largely with its original natural limits, although large areas have already been made unproductive by unrestricted lumbering and by destructive fires which have swept over enormous areas. It now includes about 130,000 square miles of merchantable forest, of which about 65,000 square miles lie in the Cascade-Sierra and Coast Ranges in the States of Washington, Oregon, and California, and about the same amount in the Rocky Mountains.

The forests of the United States, therefore, are very unevenly distributed over the continent. Two-thirds of the forest is concentrated in the eastern part of the continent, while the remainder is found on the western side and is mostly coextensive with the Rockies and the Cascade-Sierra and Coast ranges.

The causes which have influenced the present position and density of the large bodies of forests must primarily be sought in the peculiar distribution of rainfall in this country. The region occupied by the Eastern forest is unbroken by any great mountain ranges, except in the Appalachian system, and is mainly composed of rolling country with good soil conditions. The moisture-laden winds from the Gulf of Mexico sweep inland to a great distance, the precipitation being heaviest during the growing period of the summer. The favorable distribution of rainfall, together with favorable temperature and good soil conditions, enables the hardwoods to reach their greatest development in this region and excludes the conifers almost entirely, or relegates them to sandy plains and benches, rocky slopes, inclement altitudes, and cold swamps. The low, rolling character of the region of Eastern forest and the fact that the prevailing winds in the growing season are from the south, southwest, and southeast, allows the rainfall and consequently the forest to be distributed much farther inland than on the western front of the continent. In the central portion of the continent, however, far from the moist ocean winds, the moisture is insufficient to support a dense forest, and grassland vegetation becomes dominant, the natural forest being found chiefly along watercourses. The fact, however, that the rainfall in the eastern portion of the prairie region is still sufficient to insure the growth of a heavy forest leads to the inference that it is not low precipitation which has prevented the growth of trees. The flatness of the prairies, the absence of a clearly developed drain-

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AND
FOREST SERVICE, W. B. GREELEY, FORESTER

NATURAL VEGETATION

GRASSLAND AND DESERT SHRUB - BY H. L. SHANTZ
FOREST VEGETATION - - - - - BY RAPHAEL ZON

WASHINGTON, D. C.
1923

FOREST VEGETATION (WESTERN)

- SPRUCE—FIR (NORTHERN CONIFEROUS FOREST) - - - N
- CEDAR—HEMLOCK (NORTHWESTERN CONIFEROUS FOREST):
  - WESTERN LARCH—WESTERN WHITE PINE - - - - - WP
  - PACIFIC DOUGLAS FIR - - - - - - - - - - - - - DF
  - REDWOOD - - - - - - - - - - - - - - - - - - - R
- YELLOW PINE—DOUGLAS FIR (WESTERN PINE FOREST):
  - YELLOW PINE—SUGAR PINE - - - - - - - - - - SP
  - YELLOW PINE—DOUGLAS FIR - - - - - - - - - - P
  - LODGEPOLE PINE - - - - - - - - - - - - - - - LP
- PIÑON—JUNIPER (S. W. CONIFEROUS WOODLAND) - - - PJ
- CHAPARRAL (S. W. BROAD-LEAVED WOODLAND) - - - C

DESERT SHRUB VEGETATION

- SAGEBRUSH (NORTHERN DESERT SHRUB) - SB
- CREOSOTE BUSH - - - - - - - - - - - - CB
  (SOUTHERN DESERT SHRUB)
- GREASEWOOD (SALT DESERT SHRUB) - - - GB

GRASS VEGETATION

- TALL GRASS (PRAIRIE GRASSLAND) - - - - - - - TG
- SHORT GRASS (PLAINS GRASSLAND) - - - - - - - SG
- MESQUITE GRASS (DESERT GRASSLAND) - - - - - DG
- MESQUITE AND DESERT GRASS SAVANNA - - DS
  (DESERT SAVANNA)
- BUNCH GRASS (PACIFIC GRASSLAND) - - - - - - BG
- ALPINE MEADOW (ALPINE GRASSLAND) - - - - A
- MARSH GRASS (MARSH GRASSLAND) - - - - - - MG

FOREST VEGETATION (EASTERN)

- SPRUCE—FIR (N. CONIFEROUS FOREST) - S
- JACK, RED, AND WHITE PINES - - - JP
  (NORTHEASTERN PINE FOREST)
- BIRCH—BEECH—MAPLE—HEMLOCK - BM
  (NORTHEASTERN HARDWOODS)
- OAK (SOUTHERN HARDWOOD FOREST):
  - CHESTNUT—CHESTNUT OAK—YELLOW POPLAR - OC
  - OAK—HICKORY - - - - - - - - - - - - OH
  - OAK—PINE - - - - - - - - - - - - - - OP
- CYPRESS—TUPELO—RED GUM - - - - CGT
  (RIVER BOTTOM FOREST)
- LONGLEAF—LOBLOLLY—SLASH PINES - LLP
  (SOUTHEASTERN PINE FOREST)
- MANGROVE (SUBTROPICAL FOREST) - - M

Scale 1:8,000,000
Kilometers 100 0 100 200 300 400 500
Statute Miles 100 0 100 200 300

PROFILE

SHOWING CHARACTER OF VEGETATION ALONG PARALLEL 39.N.

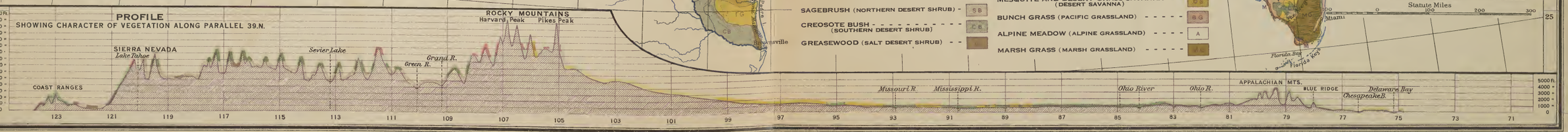


Figure 2.—Distribution of the main types of natural vegetation in the United States. The three major natural divisions of vegetation in the United States are forest, grassland, and desert shrub. The forest falls into two clearly marked regions, western and eastern. The western region comprises seven large forest subdivisions and two subdivisions of woodland. The eastern region comprises nine forest subdivisions. Within each of these large natural subdivisions there are many smaller distinct types not indicated on the map. Four-fifths of the forest was originally in the east. Of this original forest there remains now only about 10 per cent in virgin condition, 50 per cent having been cleared for farm land, 30 per cent cut over and now grown up to trees of sufficient size for saw logs or cordwood, and about 10 per cent cut over or devastated by fire and reduced to brushland. The western forest is about equally divided between the Rocky Mountains and the Cascade, Sierra Nevada, and Coast Ranges, and still includes nearly all its original area. The grassland vegetation falls into seven subdivisions and the desert shrub into three. About 70 per cent of the grassland east of the one hundredth meridian is now under cultivation, but in the west only about 10 per cent is under cultivation. Of the desert-shrub area about 2 per cent is under irrigation. The map indicates the great diversity of vegetation, as well as the value of the natural vegetation of the country. A comparison of this map with that of acreage of all crops (fig. 4) indicates also the agricultural potentialities of the remaining uncultivated land. The profile is a cross-section along the thirty-ninth parallel and shows the variation of vegetation with altitude and distance from the ocean, and direction of slope.

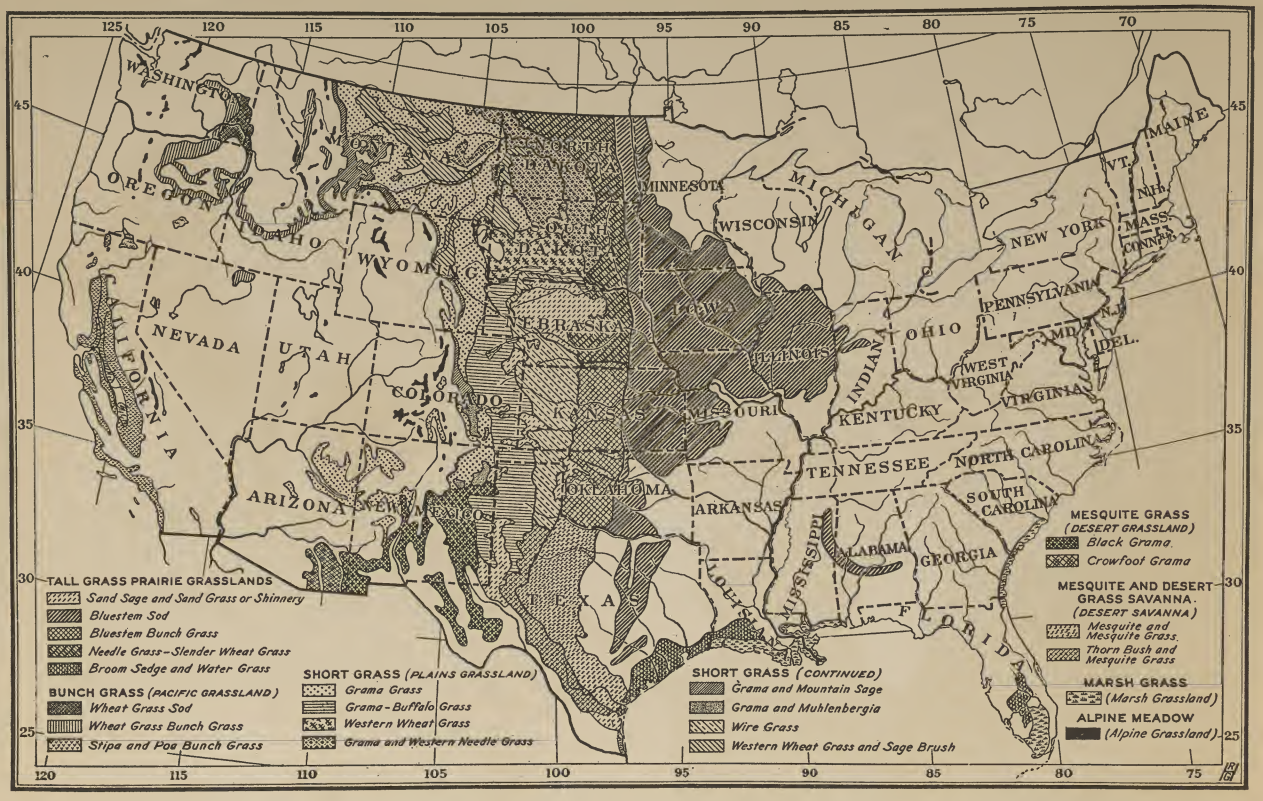
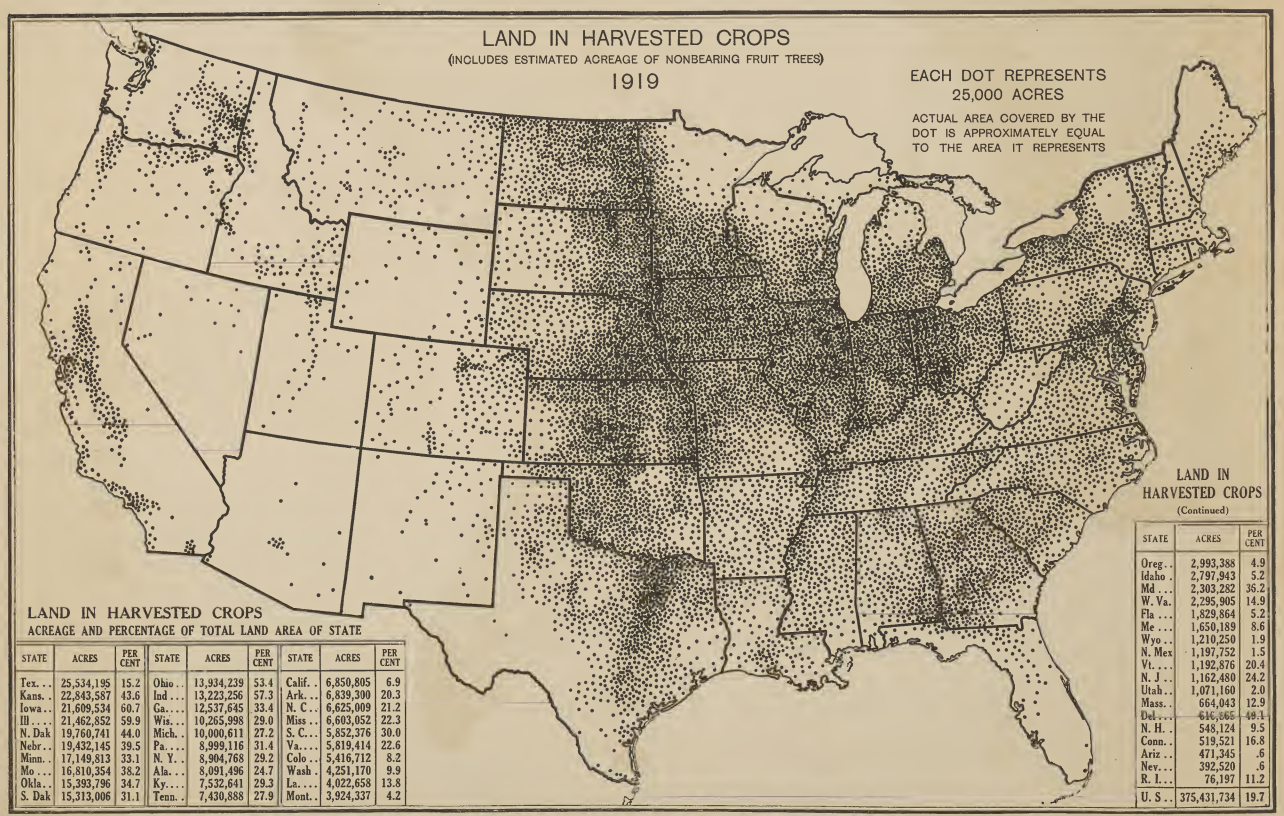


Figure 3.—Each of the five main grassland divisions, (1) the tall grass (prairie grassland), (2) the short grass (plains grassland), (3) the bunch grass (Pacific grassland), (4) the mesquite grass (desert grassland), and (5) the mesquite and desert-grass savanna (desert savanna), occupy large areas of land and consequently show many variations. The tall-grass vegetation may be subdivided on the basis of the dominant species into a number of types, the approximate distribution of which is shown on the map. The short-grass vegetation is similarly subdivided into types, eight of which are indicated on the map. In the bunch-grass vegetation three divisions are shown, two divisions in the mesquite grass, also two divisions in the mesquite and desert-grass savanna. The subdivisions not shown occupy small or restricted areas scattered throughout the main divisions, and the distribution can not be shown on a small-scale map.



LAND IN HARVESTED CROPS

ACREAGE AND PERCENTAGE OF TOTAL LAND AREA OF STATE

STATE	ACRES	PER CENT	STATE	ACRES	PER CENT	STATE	ACRES	PER CENT
Tex.	25,534,195	15.2	Ohio	13,934,239	53.4	Calif.	6,850,805	6.9
Kans.	22,843,587	43.6	Ind.	13,223,256	57.3	Ark.	6,839,300	20.3
Iowa	21,609,534	60.7	Ga.	12,537,645	33.4	N. C.	6,625,009	21.2
Ill.	21,462,852	59.9	Wis.	10,265,998	29.0	Miss.	6,603,052	22.3
N. Dak	19,760,741	44.0	Mich.	10,000,611	27.2	S. C.	5,852,376	30.0
Nebr.	19,432,145	39.5	Pa.	8,999,116	31.4	Va.	5,819,414	22.6
Minn.	17,149,813	33.1	N. Y.	8,904,768	29.2	Colo.	5,416,712	8.2
Mo.	16,810,354	38.2	Ala.	8,091,496	24.7	Wash.	4,251,170	9.9
Okla.	15,393,796	34.7	Ky.	7,532,641	29.3	La.	4,022,658	13.8
S. Dak	15,313,006	31.1	Tenn.	7,430,888	27.9	Mont.	3,924,337	4.2

LAND IN HARVESTED CROPS
(Continued)

STATE	ACRES	PER CENT
Oreg.	2,993,388	4.9
Idaho	2,797,943	5.2
Md.	2,303,282	36.2
W. Va.	2,295,905	14.9
Fla.	1,829,864	5.2
Me.	1,650,189	8.6
Wyo.	1,210,250	1.9
N. Mex	1,197,752	1.5
Vt.	1,192,876	20.4
N. J.	1,162,480	24.2
Utah	1,071,160	2.0
Mass.	664,043	12.9
Del.	616,865	48.1
N. H.	548,124	9.5
Conn.	519,521	16.8
Ariz.	471,345	.6
Nev.	392,520	.6
R. I.	76,197	11.2
U. S.	375,431,734	19.7

Figure 4.—Land in crops in 1919. A comparison of this map with that of natural vegetation (Fig. 2) brings out a number of interesting correlations. The spruce–fir forest areas stand out as largely nonagricultural. This is also true to a less extent of the jack, red, and white pine areas of the North and of most of the western forests. The tall-grass area is the most valuable block of agricultural land in the United States. Next in importance is the area of oak–hickory forest which borders the tall grass on the east. The boundary line between the tall grass and the short grass is marked by a sharp decline in acreage of crops. In the West production without irrigation is greatest on the bunch-grass land of California and eastern Washington and Oregon. Irrigation agriculture is determined more largely by availability of irrigation water than by the relative productivity of the land, and is found in all the desert and grassland types of vegetation except the tall grass. Even in the tall-grass type irrigation is practiced in the production of rice.

age, and poor soil drainage of the wetter portion are, in large part, responsible for their treeless condition. Repeated fires undoubtedly pushed the forest back and extended its boundaries farther eastward. Forests have begun to work westward since the settlement of the prairies has broken up the virgin sod and prevented to a great extent the occurrence of prairie fires. West of the prairies lie the plains, which have always separated the two great forest regions, since the moisture is insufficient to develop forest growth.

The western coast forest is an excellent example of the effect which rainfall, here almost entirely of the cyclonic type, combined with topography, altitude, and temperature, has upon the forest. Nearly the entire region is mountainous, with a steep and high coast range almost at the water's edge. The prevailing winds are westerly and northwesterly, but the chief rain-bearing winds are southeasterly, southerly, and southwesterly, under the influence of passing cyclones, which are most frequent in winter and cause the strongest winds and heaviest rainfall in that season. Moisture thus brought in from the relatively warm ocean far to the south and southwest yields in the north over both mountains and valleys, and in the south principally over the mountains, low-hanging clouds, and much rain. Precipitation is heaviest in the northern part of the area, where cyclonic centers pass more frequently than in the south, and heaviest on the western flanks of the ranges, where the air is forced to rise over the mountains and to drop its excess moisture because of the expansional cooling resulting from its ascent. The eastern slopes are comparatively dry because the air is there descending. Such moisture as passes over one range unprecipitated helps to cause rain on the range next to the east if the ascent there is great enough.

Summer conditions are radically different, especially in the southern part of the area. The prevailing wind on the coast is westerly and northwesterly, and, coming from the relatively cool waters of more northern latitudes, brings only moisture enough to cause a belt of frequent fog and cloud limited almost entirely to the ocean slopes of the coast ranges. Summer cyclones, comparatively weak and few in number, bring a little rain to the outer coast in the north. In the south, where such cyclones are rare and rain is rarer still, the prevailing onshore winds are thoroughly "dried" over the sunny land, especially in the valleys, while an occasional hot wind from the continental interior still further emphasizes the dryness of the summer season. Thus the region is one of winter rains and summer droughts, except along the northern coast.

Figure 5.—An open oak stand (Chaparral) merging with California grassland. It is characteristic of most of the foothills and interior valleys of California and is found also in Arizona. Sequoia National Forest, Tulare County, Calif. Photographed by Alfred Gaskill.

Figure 6.—Chaparral composed principally of small-sized oak, ceanothus, and manzanita, characteristic of the foothills of southern California. It ranges from an impenetrable thicket of low shrubs to open oak stands. A fire line in the center. Southern California. Photographed by E. A. Sterling.

This combination of wet winters and dry summers determines the location and character of the forests. On the lowlands and valleys of the south the hot summers and the scant winter rainfall make forest growth impossible, leaving the land either to grasses or to desert shrubs which can adapt themselves to semiarid conditions. The mountains, having a precipitation that is greater and of longer duration, with much less evaporation, furnish better growing conditions, and usually are forested. Growth is in proportion to the altitude up to an elevation of from 8,000 to 9,000 feet. Above this, the winds and the severity of the winter, and possibly the decrease of precipitation, make conditions adverse to dense forests, the timber line occurring usually at about 10,000 feet.

It is a noticeable fact that nearly all the principal mountain ranges have their heavy timber on the slopes exposed to the prevailing wet winds, while the opposite sides are usually only scantily clothed with timber. This is most strikingly shown in the Sierra Nevada. The rain-bearing winds, striking the westerly slopes, precipitate a part of their moisture before they cross the summit. Thence as they travel downward and become heated they cease to precipitate and even absorb what little moisture there may be on these slopes. As a result, the eastern slopes are in general very different in character from the western, the latter receiving enough rain and snow to support a strip of magnificent forest. In western Washington and Oregon, on the other hand, and along the northern half of the California coast, the rainfall in winter and the fog and cloud in summer are unusually heavy, and as a result the forest growth is very dense, particularly in the redwood belt of California.

The Rocky Mountain region, being nearer the interior, receives less rain and snow than the Coast mountains and the Sierra Nevada, and the forest has a severer struggle with the elements. In the northern portions the forest is dense and well developed, but in general, as a result of unfavorable condition of growth, it is broken up into smaller areas and is more open than the typical Pacific coast forest. The southern Rockies derive much of their scanty moisture from the Gulf of Mexico.

Since hardwoods require for their development a high humidity and rainfall, especially in the growing season, they are largely absent from the western forest. The long, dry summer seasons of the western part of the continent prevent their development and yield the land to more hardy conifers. In the wet coast country the hardwood growth is more thrifty, and many species, such as maple, elder, oak, ash, and chinquapin, reach merchantable size; but, in comparison with the magnificent coniferous growth, they constitute an insignificant part of the forest.

GRASSLAND.

Lying between the western and eastern forest belts, and extending from Canada on the north to Mexico on the south, is the great grassland area, broken only by river courses and occasional buttes or low mountains.

Grasslands characterize areas in which trees have failed to develop, either because of unfavorable soil conditions, poor drainage and aeration, intense cold and wind, deficient moisture supply, or repeated fires. Grasses of one kind or another are admirably suited to withstand conditions of excess moisture, excess drought, and fires which would destroy tree growth.

Grasslands usually are well supplied with water in the surface soil during the growth period and do not depend to any extent upon deeply stored soil moisture. In fact, water in the deeper soil usually enables taller-growing plants, such as shrubs or trees, to replace the grasses. Grasses are, therefore, characteristic of regions of summer rainfall. A great profusion of showy flowering plants are usually found within the grasslands, and they often present a varied appearance during the early part of the season, due to plants which later play no very important part in characterizing the areas.

DESERT SHRUB.

Between the Rocky Mountains on the east and the Cascade-Sierra on the west, and extending from the Canadian to the Mexican boundary, lies the great inland desert, characterized largely by xerophytic shrubs. The deserts occupy the Great Basin, except for isolated mountain forests, most of the drainage basins of the Columbia, the Snake, the Colorado, and the Rio Grande, and small areas east of the Rockies drained by the Big Horn, Platte, and Arkansas rivers. In the south, near the Mexican boundary, the desert broadens out, reaching from the Pacific nearly to the Gulf of Mexico. It is interrupted here and there by intrusions of grasslands or at higher elevations by forests. This whole area is characterized by a deficient rainfall and an excessive evaporation rate. The perennial vegetation which gives character to the deserts consists principally of shrubs. In the south succulent plants become more important. The relatively small size of the plants, together with their small leaves well protected against excessive transpiration, the small amount of growth produced each year, and the wide spacing enable these plants to conserve the scanty moisture supply and continue their growth during the long rainless periods. Such dry periods may occur at any time of the year. The loss of moisture from desert or dry-land soils is almost entirely due to plant transpiration. A relatively small quantity is lost from the surface of the bare ground between the plants, except surface water immediately following rains. Wide spacing is, therefore, one of the most effective means of conserving a scant moisture supply.

DETAILED DESCRIPTION OF THE FOREST VEGETATION.

THE WESTERN FOREST REGION.

The western forests, with all their variety of species, their physiographic and climatic differences, can be classified into two units of woodland and three large natural units of timberland. The woodland divisions are:

- Chaparral, or southwestern broad-leaved woodland.
- Piñon–juniper (*Pinus–Juniperus*), or southwestern coniferous woodland.

The timberland divisions are:

- Western yellow pine–Douglas fir (*Pinus–Pseudotsuga*), or western pine forest.
- Cedar–Hemlock (*Thuja–Tsuga*), or northwestern coniferous forest.
- Spruce–fir (*Picea–Abies*), or northern coniferous forest.

These divisions correspond mainly to distinct regions, yet different divisions, often several of them, may occur within the same region but on different slopes or at different altitudes. Each is practically always associated with a distinct climatic belt. The description of these main divisions of forest vegetation begins with the belt which altitudinally is the lowest and therefore the driest. Each successive altitudinal belt corresponds to a moister and cooler climate. This is true of all the five divisions, with the ex-

Figure 7.—Piñon and one-seeded juniper forest. (Piñon–juniper). Characteristically open. The lowest belt of forest in most of the southwestern part of the United States. Santa Fe, N. Mex. All photographs not otherwise acknowledged were taken by H. L. Shantz.

Figure 8.—Pure western yellow pine forest. (Yellow pine–Douglas fir.) An open stand, usually with grass underneath, affording good grazing; the most extensive and commercially the most important type of the yellow pine–Douglas fir forests. Compare this forest with Figure 22, the southeastern pine forest. Coconino National Forest, Ariz. Photographed by A. G. Varela.

Figure 9.—Typical lodgepole pine forest. (Yellow pine–Douglas fir.) Characteristic dense stand. It comes in, as a rule, as a result of fires in Douglas fir and Engelmann spruce forests. Big Horn County, Wyo. Photographed by E. M. Griffith.

Figure 10.—Mixed forest of sugar pine, yellow pine, incense cedar, and white fir. (Yellow pine–Douglas fir.) A sequoia in the background; typical of the west slope of the Sierras, best developed yellow pine found in this type; also sugar pine and incense cedar. Most favorable climatic conditions for the growth of yellow pine. Sequoia National Park, Calif. Photographed by Alfred Gaskill.

ception of the cedar–hemlock division, which is confined to a distinct geographic region, namely, the Pacific Northwest.

WOODLAND.

The woodland, as has been noted, has two divisions, the chaparral and the piñon–juniper.

Chaparral. (Figs. 5 and 6.)

Chaparral is a mixed forest of stunted hardwood trees and shrubs. It occupies a belt below the yellow pine and above the desert shrub. Although this type of forest vegetation occurs throughout most of the foothills of the central and southern Rockies and the mountains of Arizona, Nevada, Utah, and California, it is most typical of southern Arizona and southern California. The chaparral belt sometimes alternates in the Rockies with the piñon–juniper belt, and often it forms a distinct fringe along the upper edge of the sagebrush belt. In southern California the chaparral belt occupies an area of about 5½ million acres. In some places in southern California chaparral extends to sea level and in others it reaches an altitude of 8,000 feet. There are about 116 different species which make up the chaparral belt, the bulk of which are found at elevations from sea level to about 5,000 feet.

The species composing the chaparral vary in the different regions. Thus, in the Rockies chaparral is mainly of scrub oak (*Quercus gambelii*) or mountain mahogany (*Cercocarpus parvifolius*) or juneberry (*Amelanchier*).

In southern California the following are the most important species:

Highland live oak (*Quercus wislizeni*), scrub oak (*Quercus dumosa*), holly-leaf cherry (*Prunus ilicifolia*), sumac (*Rhus laurina*), wild lilac (*Ceanothus hirsutus*), and manzanita (*Arctostaphylos glauca*).

The chaparral areas of southern Arizona are open groves of oak scattered over the desert grassland. In the lower belt of the interior valley of California a similar open oak type of savanna occurs on the foothills above the weed grass. Above the oak zone the dense shrub cover of manzanita, wild lilac, and oak brush form a broad belt below the coniferous forest. Nearer the ocean immense tracts are covered by a pure stand of *Adenostoma fasciculata*, which is the most important plant of the lower shrub types of chaparral along the Pacific coast of southern California. It occurs for the most part just above the southern desert shrub and below the oak-brush type of chaparral. It occurs most abundantly near the ocean, where, although subjected to extended periods of drought, it is never subjected to the extreme heat or dry air which is characteristic of the southern desert shrub.

The chief economic importance of chaparral lies in its watershed protection. The climatic conditions are similar to those of the piñon–juniper belt.

The chaparral, especially in southern California and Arizona, occurs on dry mountains which are ill-adapted to agricultural development. Citrus fruits are grown in so far as possible only in the relatively frost-free zone which occupies the low bench lands. The hilly land, because of its steeply rolling surface and its inaccessibility to irrigation water, has not been developed.

Piñon–Juniper. (Fig. 7.)

The piñon–juniper division forms a distinct woodland belt which, like the chaparral, is just below the yellow-pine zone. This belt is to portions of western Texas, to the foothills of the southern Rockies and of the mountains of Arizona and Nevada, and to the eastern slope of the Sierras, what chaparral is to the foothills of southern Arizona and southern California. In places it intermixes with the chaparral. Only a few areas of piñon-juniper are found north of latitude 44°. The principal species of juniper are the Rocky Mountain red cedar (*J. scopulorum*), Utah juniper (*J. utahensis*), the one-seeded juniper (*J. monosperma*), and alligator juniper (*Juniperus pachyphloea*), while piñon is represented by two species of piñon (*Pinus edulis* and *P. monophylla*). At the upper part of this belt piñon preponderates, while juniper is a little more abundant in the lower portions. It is often found mixed with western yellow pine and occasionally with stunted Douglas fir (*Pseudotsuga taxifolia*) at higher altitudes, and with so-called scrub oaks (*Quercus gambelii* and *Q. undulata*). In the south it occurs with a number of other small oaks and hardwoods, together with Mexican piñon (*Pinus cembroides*), Arizona cypress (*Cupressus arizonica*), and junipers. Over thousands of square miles piñon–juniper and sagebrush alternate, the former occupying rough broken country or shallow stony soil, while sagebrush occurs on the more level ground, which has a deep, uniform soil.

The area of land occupied by piñon–juniper, especially in the Great Basin, is very great. Economically these trees are important, since they form the chief source of timber for mine props, fence posts, and fuel for local use. The juniper–piñon belt is characterized by rather hot, dry summers, the annual rainfall being less than 20 inches. The moisture supply is inadequate for any save dry-land agricultural methods. The actual production of crops within this area is small, due largely to the rough, stony character of the land. Under irrigation good crops of cereals, alfalfa, fruits, and vegetables are produced on the better types of soil.

TIMBERLAND.

The timberland has three divisions: (1) Western yellow pine–Douglas fir, (2) cedar–hemlock, and (3) spruce–fir.

The Western Yellow Pine-Douglas Fir Forest.

This division of the timberland includes:

(*a*) The pure forest of western yellow pine of Arizona, New Mexico, southern Utah, the Black Hills of South Dakota, the eastern slope of the Cascades and the Sierras and the Columbia Basin, as well as the yellow pine stands throughout the central and southern Rocky Mountains, western Montana, western Idaho, and eastern Oregon (Blue Mountains).

(*b*) The western yellow pine–sugar pine–incense cedar forest of the Sierras in California.

(*c*) The Rocky Mountain Douglas fir forest.

To these may be added two other types of forest of a more temporary character which, if left undisturbed for a long period, would gradually give way to other types, namely, (*d*) the lodgepole pine (*Pinus contorta*) forests of Montana, Wyoming, and Colorado; and (*e*) the western larch–Douglas fir forests of northwestern Montana and northern Idaho.

It may seem at first too far fetched to include in the western yellow pine–Douglas fir division such apparently widely differing stands. Yet if we analyze the biological peculiarities of the species which make up these stands, their habitats, and trace their life histories after severe burns and logging, it becomes clear that a large number of the lodgepole pine stands in northern Wyoming and throughout the central Rocky Mountains, the western yellow pine–western larch–Douglas fir stands of northwestern Montana and northern Idaho, the sugar pine–incense cedar–western yellow pine forests on the west slope of the Sierras, and the Jeffrey pine forest mixed with white fir (*Abies concolor*) on the east slope, the pure forests of western yellow pine on the east slope of the Cascades, as well as those of Arizona, of the Black Hills and of northern Nebraska, all grow under more or less similar climatic conditions and occupy, as a rule, southern slopes or otherwise dry situations. At the two extreme ends of

the range of conditions peculiar to these forest units there may be found species which are also dissimilar in their climatic requirements. Thus, for instance, sugar pine (*Pinus lambertiana*), which is such a prominent component species of the sugar pine–yellow pine–incense cedar forests of California, will not grow in the dry, pure forests of yellow pine in Arizona, but on all intermediate situations all the species may be found growing together and are interchangeable one with another.

All these forests, although apparently different in character, in reality partake of the same biological characteristics and have more or less similar conditions of growth, as do the two principal species which give character to these different forests, namely, western yellow pine and Douglas fir.

Pure yellow pine forest (fig. 8).—Of the three great types of forests which make up the western yellow pine–Douglas fir division, the pure forests of yellow pine are by far the most extensive and economically most important. They occur on dry, hot slopes or flats, mainly at low elevations from 3,500 to 4,500 feet, on the west slope of the Sierras, and on the east slope they occupy the entire timbered slopes, and consist largely of Jeffrey pine (*Pinus jeffreyi*), western yellow pine, and white fir. Pure yellow pine forests constitute by far the greater part of the forests containing most of the merchantable timber in Arizona and New Mexico. In the southern part of each of these States the belt lies between about 6,000 and 7,500 feet. At its upper edge Douglas fir and Engelmann spruce come in, and at about 9,000 feet dominate the stand. In the northern part of New Mexico these forests are nearly 1,000 feet higher. The curious fact that these forests occur at lower elevations in the southern part of the State of New Mexico is in some way connected with the level of the adjacent plains. Pure western yellow pine stands also occur in northern Nebraska at an elevation of 3,000 feet, and in the Black Hills at from 3,000 to 5,000 feet; also on south slopes and at all lower altitudes in eastern Washington, Oregon, and central Idaho between 2,500 and 4,500 feet, and in northwestern Montana and northern Idaho at the lower altitudes on warm, sunny exposures, low ridges, and rather dry benches and gravelly flats. The pure yellow pine forest, except in Washington, Idaho, Montana, Nebraska, and the Black Hills, occupies a belt that lies between the piñon-juniper woodland or chaparral below and Douglas fir or lodgepole pine above. It lies almost wholly within the "transition zone" as defined by biologists. It is not continuous, but often includes open grazing lands that give a parklike effect to the region. This effect is heightened by the comparative absence of underbrush and the presence of a more or less dense growth of grass and other herbaceous plants beneath the trees. The trees themselves are usually large, mature, growing in groups, or widely spaced, so that the sunlight reaches the ground in all parts of the forest with but little interference by the crowns. The typical forest litter of leaves, twigs, decaying stems, and branches is absent or found in small quantities near the base of the trees, and in many regions the only litter beneath the trees is a pile of dry cones, the accumulation of a number of seed years. These typical western yellow pine forests much resemble the open longleaf pine forests of the southeast and may, where the surface is not too rocky, be as easily traveled.

A forest fire or logging, as a rule, will not change the character of the forest; in other words, its natural cycle is western yellow pine following western yellow pine. Occasionally, however, after very severe fires, particularly at the upper and lower extension of the forest, the type of vegetation above or below may temporarily encroach on the burned or logged-off yellow pine forest. The alternation of aspen (*Populus tremuloides*) and pine in the Black Hills of South Dakota and of chaparral and pine in the southwest are good examples of such sequences of growth.

The climate of pure western yellow pine forests is that characteristic of hot and dry interior plateaus and mountains. This applies particularly to the Rocky Mountain form, which occurs in the central and southern Rockies, and occupies generally drier sites than the true *Pinus ponderosa*. Most of the area has a rainfall of from 20 to 30 inches. The forests occur in situations where the mean annual temperature ranges as low as 40° F., and the mean temperatures during the growing season from about 50° to 60° F. Maximum temperatures of 110° F. are not uncommon. The trees withstand winter temperatures as low as —30° F.

The land occupied by this forest has not been extensively used for agricultural purposes, as it lies at a rather high elevation and is characterized for the greater part by a short growing season. It occupies also uneven and stony soils. It is suitable, however, for crops adapted to cool weather and short seasons. The open parks in the pure yellow pine forests within Arizona and New Mexico offer the best "dry farming" possibilites in these States, though but little of the land is in cultivation when one considers it in relation to the entire area of yellow pine forests. Oats, barley, wheat and rye are the principal cereals, while potatoes and alfalfa are grown to a limited extent. Vegetables also can be grown within this area, although the total crop production on land occupied by western yellow pine is relatively small. Because of the open character of the forests and the grassy cover, this land is especially adapted to grazing.

The yellow pine–sugar pine–incense cedar forest (fig. 10).—Next in importance are the mixed stands, chiefly of sugar pine, western yellow pine, white fir, Douglas fir, and incense cedar (*Libocedrus decurrens*). This forest is confined largely to the west slopes of the Sierras and to the Coast Range in California, and presents probably the most favorable climatic conditions of the western yellow pine–Douglas fir division. Still, the limits of precipitation and temperature are not unlike those of the pure yellow pine stands. The average temperature during the growing season for the region ranges between 44° and 60° F.; for pure yellow pine stands it is between 50° and 60°. The annual precipitation of 20 inches practically limits both the pure western yellow pine forests and the mixed yellow pine–sugar pine-incense cedar forest, although the best development of the latter takes place when the rainfall is considerably above 20 inches. This forest varies in composition according to altitude, soil, and exposure, so that there can be distinguished several fairly distinct types. Thus, on moderately dry western slopes,

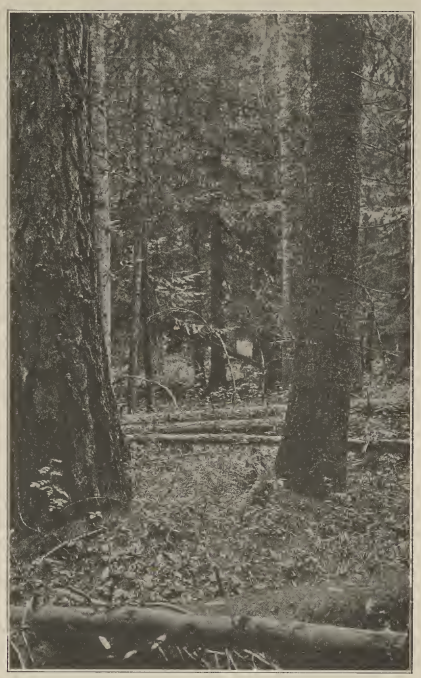


Figure 11.—Mixed forest—western larch and western white pine. (Cedar–hemlock.) The stand is about 140 years old. Western red cedar and hemlock are shown in the photograph to come in as an understory. Northwestern Idaho. Photographed by Austin Cary.

and especially on soils of serpentine formation on the western slope of the Sierras, the most prevalent type of forest is that of western yellow pine-incense cedar. Under the same conditions of temperature and soil, but at an elevation of 3,500 to 5,500 feet on the western slope of the Sierras, it is yellow pine–sugar pine. White fir plays a conspicuous part in all these types of forest, as well as in the pure yellow pine forests.

Agricultural development within the area has been limited largely by the unfavorable mountainous conditions of the land.

Rocky Mountain Douglas fir forest.[2]—Just above the yellow-pine belt there occur mixed stands of western yellow pine and Douglas fir. These are found in the central Rockies at elevations from 6,000 to 9,000 feet, chiefly on sandstone and granite soils; on the west slope of the Sierras on northwesterly slopes at elevations of from 4,500 to 5,500 feet; and in Arizona at elevations between 8,500 to 10,000 feet on the south slopes and between 7,500 feet and 9,000 feet on the north exposures. On cool northerly and northeasterly slopes, at altitudes of about 5,000 to 6,000 feet on the west slope of the Sierras and between 8,000 and 10,000 feet in the central Rockies, the mixed stands of yellow pine and Douglas fir become practically pure Douglas fir stands. Along the lower altitudinal limit of the lodgepole pine zone in the central Rockies, on south slopes and on dry rocky knolls, the Douglas fir mixes freely with lodgepole pine, giving rise to a mixed lodgepole pine–Douglas fir stand.

These several forest types, although distinct in composition and even in their altitudinal range, still belong to the western yellow pine–Douglas fir series. They are all characterized by the presence of Douglas fir as one of their principal species. Throughout the Rockies Douglas fir and western yellow pine alternate.

This forest belt receives slightly more precipitation than the pure western yellow pine belt. The annual precipitation in the Douglas fir zone in the Rockies is between 25 and 35 inches, largely in the form of snow. The summer and winter temperatures are, however, about the same as in the pure western yellow pine belt, and in general it is characterized by the same dryness of soil.

Lodgepole pine forest (fig. 9).—The lodgepole pine forests are chiefly characteristic of the Rocky Mountains, although they occur also in Idaho, Washington, Oregon, and California. In Colorado the best stands of lodgepole pine are usually found between 7,500 and 9,500 feet, in Wyoming between 7,000 and 9,000 feet, and in southwestern and central Montana between 6,000 and 8,500 feet. They occupy usually an altitudinal belt of from 2,000 to 2,500 feet in width. They often descend as low as 4,500 feet on northern exposures and go up as high as 11,500, as in Colorado, southern Wyoming, and California. This wide altitudinal range of lodgepole pine is due to the fact that it is a pioneer tree which invades ground left open by other species, chiefly as a result of fires. It occupies ground belonging both to Engelmann spruce and to Douglas fir. The present extensive lodgepole pine forests have undoubtedly been brought about to a large extent by burns which enabled the lodgepole pine to spread at the expense of Douglas fir and Engelmann spruce (*Picea engelmannii*). Lodgepole pine stands, therefore, occupy any intermediate zone on the line between the Douglas fir and spruce. They rarely go to the lowest and driest sites occupied by Douglas fir and only occasionally become alpine, generally at 8,000 to 11,000 feet in elevation. The lodgepole pine forests belong, therefore, to two divisions, the western yellow pine–Douglas fir and the spruce–fir. Those on the drier and southerly exposures and at altitudes below the natural altitudinal range of Engelmann spruce may be classed with the western yellow pine–Douglas fir forests. The bulk of the lodgepole pine forests must be placed in the western yellow pine–Douglas fir division, since they occur largely in the same climate as the western yellow pine and Douglas fir stands. Lodgepole pine forests occur where the annual average precipitation is 18 inches or more. The best developed stands occur where the precipitation exceeds 21 inches. This species endures for short periods extremes of temperature varying from approximately 100° F. to —55° F. The growing season in lodgepole pine areas is short. Killing frosts are likely to occur until about the middle of June, and the first autumn frost comes in late August or early in September. In their requirement for moisture and temperature, the lodgepole pine forests stand between Douglas fir, on the one hand, and Engelmann spruce and alpine fir (*Abies lasiocarpa*), on the other.

The lodgepole pine forests are economically the most important timber belts of that portion of the Rocky Mountains lying between northern Colorado and central Montana. They are the source of mine timbers, converter poles, railway ties for the transcontinental railroads, and of lumber to a small extent.

Western larch—Douglas fir forest.—In northwestern Montana and northern Idaho, on dry benches, as well as on southerly and southwesterly slopes, there occur mixed stands of western larch, Douglas fir, western yellow pine, and lodgepole pine. After burns, western larch occasionally forms practically pure stands, especially on fairly dry ridges and benches. On the more favorable sites it is gradually crowded out by the western white pine, which in turn is later replaced to a large extent by western red cedar, western hemlock, and lowland white fir. On the warmer southern slopes or the more shallow rocky soils Douglas fir and yellow pine enter in mixture with larch. On very dry, steep southern and southwestern slopes at lower altitudes the larch gives way entirely and western yellow pine forms pure forests.

Cedar-Hemlock Forest. (Figs. 11 and 12.)

This forest may be divided into two large units: (*a*) The western white pine and larch region of western Montana and northern Idaho, and (*b*) the Pacific Douglas fir of the western slope of the Cascades. These forests and the large number of minor forest types, although they differ in composition, have many

[2] Rocky Mountain Douglas fir is used not as a geographic term but to designate a form distinct from the Pacific Coast Douglas fir of Washington and Oregon.

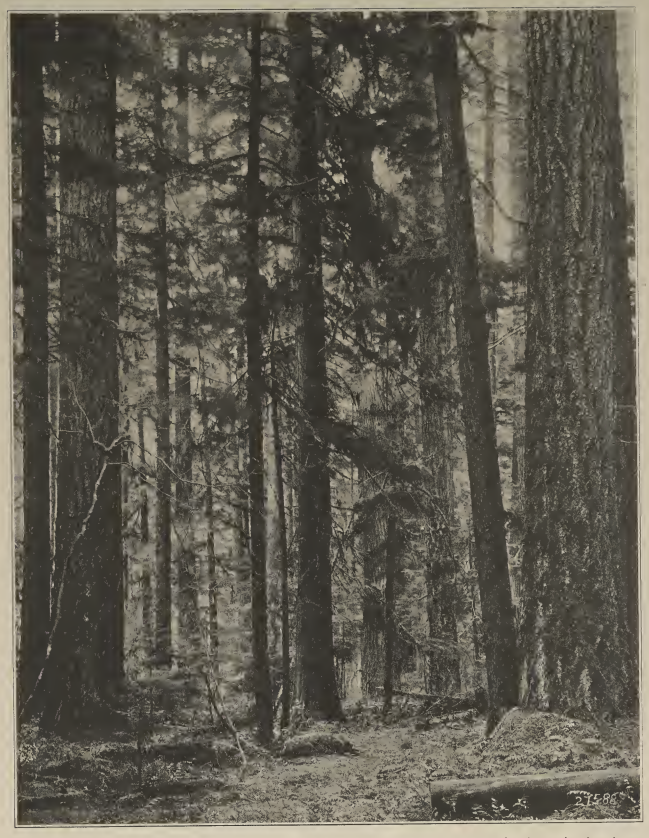


Figure 12.—Pacific Douglas fir forest. (Cedar–hemlock.) Western hemlock is shown in the photograph, entering as an understory. As a result of fires, the Douglas fir starts in pure stands. The hemlock begins to come in only after the ground is shaded and duff is accumulated on the ground. If left to itself the forest would gradually revert to hemlock. The present uniform Douglas fir stands are due to the large forest conflagrations of the past. Oregon. Photographed by F. G. Plummer.

Figure 13.—Engelmann spruce forest (Spruce–fir). The principal forest of high altitudes in the Rockies above lodgepole pine or Douglas fir forests. In the Cascades and Sierras true firs take its place, similar to the spruce–fir of the Northeast (see fig. 15). Uinta Mountains, Utah. Photographed by Edw. J. Ludkin.

common traits and gravitate toward the same ultimate forest—the western red cedar and hemlock (*Thuja plicata* and *Tsuga heterophylla*).

Western white pine-western larch (fig. 11).—This region is confined chiefly to northern Idaho and adjacent portions of Montana and Washington. In the Coeur d'Alene Mountains, the Cabinet Mountains, the western spurs of the Bitterroots, and the south end of the Selkirks in Idaho, extreme western Montana, and extreme northeastern Washington, the western white-pine forests predominate. Pure stands are not common. Occasionally, as the result of the accident of seeding or because it is an especially favorable site, western white pine (*Pinus monticola*) will form 80 to 95 per cent of the stand. Altitudinally, 4,500 feet may be assumed as the upper limit for western white-pine forests.

The western red cedar, the western hemlock, and the lowland white fir form usually an undergrowth in a white-pine forest. The cedar and hemlock commonly predominate on the more moist sites and lowland white and alpine firs on the drier. In some forests toward the upper limit of western white pine, especially in northwestern Montana, hemlock, lowland white fir, and cedar are scarce or absent, and Engelmann spruce forms the ultimate type. A study of the life history of these stands has shown that often after a severe burn the first tree to occupy the ground suitable to western white pine is the western larch (*Larix occidentalis*), which comes in as the pioneer tree, shades the ground, and thus affords the protection necessary for the western white pine to establish itself. The western white pine, soon after it becomes established under the shade of the larch, begins to crowd the latter, overtops it, and gradually exterminates all but the most vigorous specimens. Under the shade of the western white pine, larch, and red cedar, hemlock and lowland white fir (*Abies grandis*) begin to come up, and these eventually crowd out the white pine and become practically the sole occupants of the ground. Stages in this development can be found throughout the western white-pine region.

An average annual precipitation of about 30 inches is characteristic of the western white pine region as a whole. The bulk of the precipitation throughout the western white-pine region comes during the autumn, winter, and spring. The summer is relatively dry. Within the western white-pine region the days when the humidity is less than 20 per cent are very few, the average humidity for the dry summer season usually ranging from 30 per cent in the drier regions to 60 per cent or more in the more moist. The mean annual temperature varies from 41° to 51° F., and the mean July and August temperatures from 50° to 68° F.

The Pacific Coast Douglas fir (fig. 12).—This region is marked by a number of distinct forest types which also gravitate toward a western red cedar–hemlock forest. Thus on low, moderately humid slopes, from

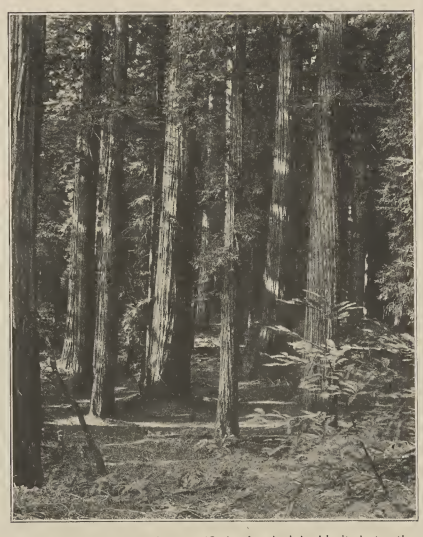


Figure 14.—Redwood forest. (Cedar–hemlock.) Limited to the coast region of California and Oregon; fast disappearing; occupies some potentially agricultural land. Bullcreek Flat, Dyerville, Calif. Photographed by R. T. Fisher.

sea level to 3,000 feet, there are found large stretches of pure Douglas fir. On exactly similar areas there occur mixed stands of Douglas fir–hemlock–cedar which are a further stage in the development of the pure Douglas fir. If it were not for the periodical occurrence of fires, the pure Douglas fir stands would give way to a forest in which western red cedar and hemlock would be the principal species. Both the western white-pine region and the Douglas fir region, although they have different starting points, in their ultimate development tend to become one type of forest and therefore biologically form virtually one large unit.

The Pacific Douglas fir region includes the forests of western Oregon and Washington, and occupies about 54,000 square miles. Up to date there have been utilized from this region nearly 135 billion feet of lumber, cut from something like 4 million acres. Of the total land area, most of which is in forest, 60 per cent of that in the State of Washington is capable of agriculture or grazing, while in Oregon one-third may be classed as tillable land. The climate is generally mild and uniform, with frequent fogs and gradual and moderate changes in temperature. The summers are cool and the winters mild, with an interval of six or seven months between killing frosts.

The so-called Sitka or Alaska spruce belt belongs also to the cedar–hemlock forest region. It occurs in coastal valleys and benches and is associated with western hemlock, western red cedar, and Douglas fir.

Within the cedar–hemlock area agricultural development is limited largely to the lower and more level lands in western Washington and Oregon, where a portion of the cedar and hemlock forests have been cut away or destroyed and the land cleared for agriculture. Oats, wheat, hay, and other forage crops are grown with success within this area. It is also productive of grain crops cut for hay, of clover, and miscellaneous tame grasses, of potatoes, cabbages, onions, and other vegetables, and of fruit. A large proportion of the hops grown in the United States are from this section.

Spruce–Fir Forest. (Fig. 13.)

The high altitude forests, whether of the Rocky Mountains, Cascades, Arizona, or the Sierras, have a similar biological physiognomy peculiar to spruce and alpine fir and may be grouped into one big unit. In the central Rockies, at elevations of from 7,500 feet to timber line (11,000 to 11,500 feet), the predominant stands of this forest are Engelmann spruce–alpine fir. In the mountains of Arizona, at elevations of from 10,000 to 11,500 feet, they are largely Engelmann spruce mixed with bristle-cone pine (*Pinus aristata*) and cork-bark fir (*Abies arizonica*). On the west slope of the Cascades, at moderate elevations, on all aspects, and at altitudes of from 3,000 to 4,500 feet, this type of forest consists largely of the true firs, noble fir (*Abies nobilis*) and red fir (*Abies magnifica*). In some places,

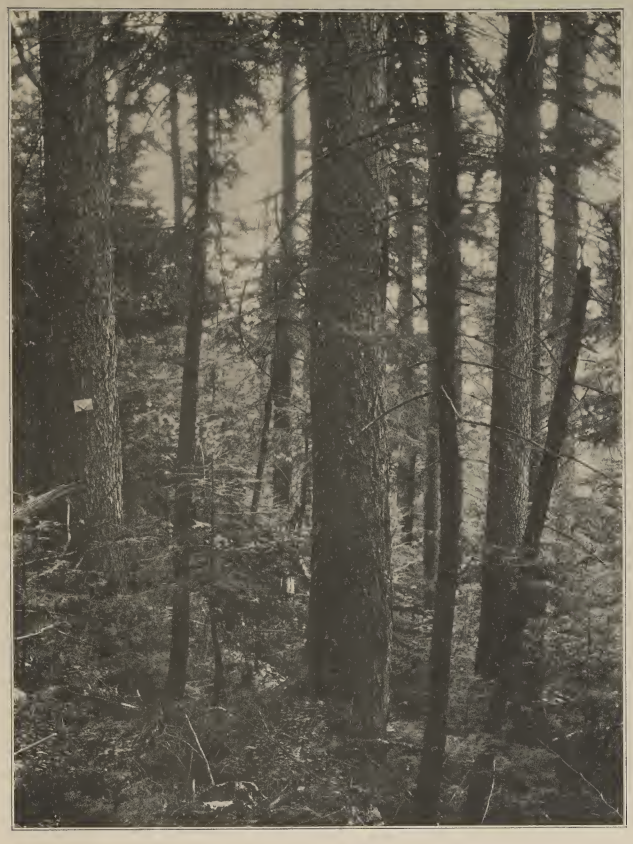


Figure 15.—Mature spruce forest. (Spruce–fir.) In its general aspect it is closely related to the alpine forest of the western mountains, with which it is connected by a more or less continuous belt at northern latitudes. It is best developed in Maine, New Hampshire, and northern New York, where it occurs both in swamps at low elevations and near the upper timber-line. In the Appalachian Mountains it occurs only at high elevations. Adirondack Mountains, N. Y. Photographed by A. Gaskill.

Figure 16.—A mixed stand of Norway and jack pines. (White–Norway–jack pines.) This forest is characteristic of the Lake States. Its appearance is not markedly different from that of the pure lodgepole pine stands of the Rockies and of the scrub pine stands in the southeast. Its composition varies according to the soil. On poor sandy soil jack pine predominates; the heavier soils were originally occupied by white pine, while on the intermediate soils Norway pine forms the principal species. Cass County, Minn. Photographed by A. Gaskill.

as on the Rainier National Forest, noble fir practically forms the timber-line tree. In the Cascades, at elevations of from 4,500 to 7,000 feet, the forest consists of alpine fir, white-bark pine (*Pinus albicaulis*), Lyall larch (*Larix lyallii*), and mountain hemlock (*Tsuga mertensiana*). In the Sierras this belt includes several types. Thus, on cool meadows, with plenty of moisture, varying in elevation from 5,500 to 6,500 feet, it is characterized by pure stands of lodgepole pine. From 7,000 feet to timber line it is made up of alpine fir and mountain hemlock. On northerly and northeasterly slopes in the Sierras, at an elevation above 6,000 feet, it is largely of pure red fir, and at the same elevation, but on less moist and cool situations, it is usually red fir mixed with white fir. These various types all have the biological characteristics typified by the spruce and fir. In most of these stands there are open parks and stream-side meadows which provide excellent summer grazing.

This belt is usually subject to heavy snowfall. The mean annual precipitation is over 30 inches and the temperature low both in summer and winter. The growing season is limited to the three months of June, July, and August, and near the timber line it is shortened to about eight weeks. Throughout the entire belt severe frosts are likely to occur every month in the year, although in Arizona studies have shown that the Engelmann spruce type is free from frost from June 15 to September 15. There has been little agricultural development in this type of forest. This is due chiefly to the unfavorable character of the land surface and to the cool climate and short growing season.

Other Forest Divisions.

Besides the main units, there are other forest communities which do not fit into any of these three large divisions, being remnants of some other forest units now extinct. Among these may be named the largest of these communities—the coast redwood—and such outstanding forest groves as Monterey pine and Monterey cypress which occupy very localized areas and all of which may be classed more or less with the cedar–hemlock series.

The redwood belt (fig. 14).—The redwood belt, although confined to a narrow strip of the humid coast of California, is of great economic importance. It stretches in the form of a belt 400 miles in length and averaging 20 miles in width from the southwest corner of Oregon to near Santa Cruz, California, with an outlier in Monterey County. Within this belt the redwood, although commonly the dominant tree, is usually associated on the slopes with Douglas fir, lowland fir, western hemlock, and tan oak. On the flats or river benches it forms pure stands. In Humboldt and Del Norte Counties of California the redwood forms the heaviest stands of timber in the world.

Figure 17.—Nearly pure stand of white pine. (White–Norway–jack pine.) About 120 years old; contains an admixture of white birch with an understory of balsam; on less sandy soils it is mixed with northern hardwoods. St. Louis County, Minn. Photographed by H. H. Chapman.

There are records of $2\frac{1}{2}$ million feet per acre and 480,000 board feet to a single tree. The redwood belt is characterized by a heavy rainfall in the rainy season and heavy fogs in the dry season, with slight changes of temperature during each day and during the year. The main portion of the redwood belt receives a seasonal average of over 50 inches of rain, but southward the average decreases rapidly, being about 30 inches in the Santa Cruz and Monterey County forests.

Practically the whole redwood belt, with the exception of two public parks, is under private ownership. Until recently the owners sought to convert the logged-off land into agricultural use. The high cost of clearing the land, together with the rapid growth of the trees and their sprouting capacity, proved the land to be more valuable for forest growth than agriculture. Much of this land may, therefore, be kept in forest.

EASTERN FOREST REGION.

In the East, because of the less mountainous surface, the natural divisions of the forest coincide chiefly with geographic regions rather than with altitudes, and therefore the line of demarcation between the several divisions into which the eastern forest may naturally be grouped is not as distinct as in the West. The nearest approach to altitudinal distribution of the several main divisions is found in the Appalachian Mountains. However, as in the West, the entire eastern forest vegetation may be classified into a comparatively few fundamental units. Seven main natural divisions are recognized:

(1) Spruce–fir (northern coniferous forest).
(2) White–Norway–jack pine (northeastern pine forest).
(3) Birch–beech–maple–hemlock (northeastern hardwood forest).
(4) Oak (southern hardwood forest).
(5) Cypress–tupelo–red gum (southern river bottom forest).
(6) Longleaf–loblolly–slash pine (southeastern pine forest).
(7) Mangrove (subtropical forest).

Spruce–Fir Forest. (Fig. 15.)

The spruce–fir forest is practically the same boreal coniferous forest which is characteristic of the high altitudes in the West, and which north of the fiftieth parallel merges with the eastern spruce–fir forests. This forest is found in the East both in swamps at low levels and at high altitudes in the mountains. In the low-lying, poorly drained areas, where soil is a muck or peat, spongy in texture, and often acid, the characteristic species are black spruce, balsam, tamarack, white cedar, and some red maple, giving rise to spruce–tamarack swamps, spruce-cedar swamps, or spruce-balsam swamps. At high altitudes it is composed largely of black spruce and balsam fir. On level or rolling flats bordering the swamps, lakes, and water-

Figure 18.—A mixed forest of birch, beech, maple, white pine, and hemlock. (Birch–beech–maple–hemlock.) It is confined largely to the Lake States, New England, New York, and Pennsylvania. Its boundaries are not always distinct from that of the northern pines, or even spruce and fir. Throughout the region of the northern hardwoods nearly pure stands of white pine or spruce are frequently found. As a rule, the sandy soils in the region are covered with pines, and the heavier soils with hardwoods. The familiar sugar-maple groves are a part of this forest. It is the chief source of the products of hardwood distillation. Adirondack Mountains, N. Y. Photographed by A. G. Varela.

Figure 19.—A mixed forest of yellow poplar and chestnut. (Chestnut–chestnut oak–yellow poplar.) The most valuable temperate hardwood forest in the world. It is not unlike the Pacific coast Douglas fir forest as regards annual precipitation, density of stand, and the development of the individual trees. The similarity is further heightened by the tendency at maturity to develop an understory of hemlock. It differs from the Pacific Douglas fir in part because of the summer rainfall to which may be assigned the preponderance of hardwoods in the Appalachian Mountains and the lack of which accounts for the absence of hardwoods in the Northwest. North Carolina. Photographed by F. G. Plummer.

courses the forest is made up of combinations of red spruce, birches, red maple, white pine, eastern hemlock, and balsam fir. This type of forest is in a large measure a transition between the swamp type and the type of mixed hardwood lands higher up. On the higher benches and the lower mountain slopes, where the soil is deep, fresh, and well drained, red spruce is an associate of hard maple, beech, and balsam fir, with a scattering of eastern hemlock, white pine, birch, cherry, and a variety of other species. The proportion of species in mixture depends on topographic conditions. The finest stands of pure red spruce are occasionally found on the steepest slopes in the region. Although the spruce–fir forest is found also throughout practically the entire birch–beech–maple–hemlock region, it is chiefly confined to the Northern States, where its upper altitudinal limit may be set at about 4,000 feet above sea level. It is also found in the mountains of North Carolina and Tennessee, but at increasingly higher altitudes. It finds its upper limit there between 5,000 and 6,000 feet.

The climatic characteristics and the agricultural importance of this forest division are about the same as that of its western extension. There is this difference, however, that the eastern spruce–fir forests, being to a large extent on low but level land, and therefore capable of being drained, offer greater agricultural possibilities than similar stands at high altitudes in the West.

White–Norway–Jack Pine Forest (Northeastern Pine Forest). (Figs. 16 and 17.)

The mixed pine forest of jack pine, Norway pine, and white pine is confined largely to the Lake States. Stands of pure white pine (fig. 17), or with some admixture of Norway pine, are found throughout the Northeastern States, chiefly on sandy soils. Stands of pure white pine, for instance, were found throughout the hardwood forests of the Adirondack region in New York, along the Hudson River, and in the Catskills. Pure white-pine stands occur on sandy plains and throughout the broadleaf forests which cover the remainder of the State. In Pennsylvania vast forests of white pine and eastern hemlock covered both flanks of the Allegheny Mountains; the headwaters of the Susquehanna River were heavily wooded with white pine. In New England white pine seldom formed solid bodies of large extent, but usually grew mixed with spruce and other conifers and hardwoods. Pine forests stretched along the valleys of the Connecticut and Merrimac Rivers and grew along the shores of Lake Champlain in western Vermont.

The most extensive and the densest white-pine forests in the country were found in Michigan. It was abundant in the northern part of the lower peninsula,

Figure 20.—A mixed forest of white oak, shagbark hickory, and pignut hickory. (Oak–hickory.) Originally it was the source of the most valuable white oak timber. Most of the virgin timber, however, in the northern and eastern part is now cut out and the land is devoted to agriculture. On the east this forest gradually merges with the chestnut–chestnut oak–yellow poplar forest, which now furnishes the bulk of the southern hardwoods. It is characteristic of dryer climatic conditions and extends farther into the prairie region than any other hardwood forest, finally giving way to the cottonwood, box elder, elm, and other trees along the water courses. La Porte County, Northern Indiana. Photographed by H. Foster.

where, on the sandy loam soils, it grew in immense, practically pure forests, and on the heavier loams interspersed among hardwoods. In the northern peninsula, especially in the basin of the Menominee River, it covered the sandy plains almost to the exclusion of other species.

In Wisconsin there were fewer pure stands of white pine except on gravelly or sandy soils. In mixture with hardwoods, however, white pine was very abundant.

In Minnesota white pine forests were confined to the northern and central portions of the State. They were not so extensive as those in Michigan, but were very prominent in mixture with hardwoods.

In the Lake States the composition of the stand depends on the character of the soil. On the poorer sandy soils and farthest north the stands consist almost exclusively of jack pine. On moderately poor sandy soils Norway pine occurs either pure or in mixture with jack pine, while on the richer soils and on well-watered sandy flats it is found in mixture with white pine and also northern hardwoods. The jack pine plains, like the lodgepole pine forests of the West, have been extending their area as a result of repeated fires. The original Norway pine formed at least 10 per cent in all jack pine stands, but as a result of fire this proportion has been decreased until most of the sandy plains are now pure jack pine.

The Norway pine–jack pine forests, which are particularly characteristic of Wisconsin, Minnesota, and Michigan, are not unlike the lodgepole pine forests of the northern Rockies. The climate of these northern pineries in the Lake States is characterized by an annual rainfall of from 25 to 35 inches and extreme temperatures of from —50° to 105° F. In some parts of this forest region frosts may occur every month in the year. The last killing frost, however, usually occurs about May 15 and the first autumn frost by September 20.

Birch–Beech–Maple–Hemlock Forest. (Fig. 18.)

This northern hardwood forest is found in greater or less abundance within the drainage systems of the St. Lawrence, the Great Lakes, and the upper Mississippi as far south as southern Minnesota; throughout northern New England, and southward along the northern and southern Appalachian Mountain ranges to extreme northern Georgia. The area occupied by the northern hardwoods is probably over 50,000,000 acres, nearly half of which is in the Lake States. It occupies the fresh, well-drained, fertile soils, and its more characteristic hardwoods are sugar maple and yellow birch. The geographical extent of the northern hardwood forest practically coincides with the range of yellow

Figure 21.—A mixed forest of shortleaf pine and oak (Oak–pine), most characteristic of the Great Piedmont Plateau. In a sense it is a transition zone between the oak forest to the north and the southern pineries to the south. In some respects it is similar to the mixed forest of northern hardwoods with northern pines to the north of the oak region. The type varies considerably in composition according to the altitude and proximity to the coast; loblolly pine and other southern pines enter into the composition. Garland County, Ark. Photographed by A. G. Varela.

Figure 22.—A mixed forest of longleaf pine, loblolly pine, and shortleaf pine (Longleaf–loblolly–slash pines), typical of the Coastal Plain, and varying in composition from pure stands of longleaf to a mixed pine forest in which several species of southern pines occur. The typical longleaf pine forest is not unlike the yellow pine forests of Arizona (see fig. 8). This forest is at present the only source of commercial naval stores in the country. It is also at present the chief timber-producing region in the United States. Georgia. Photographed by E. Block.

birch, and it centers about the region in which the white pine lumbering industry developed.

This northern hardwood forest is distinctly *humid*, and the composition of the forest is therefore influenced chiefly by *temperature*, except in its western extension, where moisture may be considered one of its limiting factors. The growing season within this forest is approximately five months, from May to September, inclusive. The average temperature for the growing season is about 61° F., while for the oak forest or so-called southern hardwoods it varies from 64° to 67°. During the growing season the total average precipitation in the northern hardwood forest is from 18 to 23 inches.

The birch–beech–maple–hemlock forest is of widely varying composition. It is found in a great variety of mixtures with spruce, fir, beech, sugar and red maples, white pine, and hemlock, and with scattered individuals or groups of other species, notably paper birch and aspen. Elm and basswood are also frequent components of this forest. In the Upper Peninsula of Michigan and in the northeastern part of Wisconsin the hardwoods are typical northern hardwoods, maple, yellow birch, and beech, with their characteristic associate, hemlock. In Minnesota this character of forest peters out, and what is known as the hardwood forest is almost exclusively popple, white birch, and occasionally basswood and maple of inferior development. The northern hardwoods occupy some of the best agricultural land of the northeastern United States. The principal crops in this region are timothy, clover, oats, barley, corn, especially for silage, potatoes and beans. Fruit, especially apples, strawberries, and bush fruits, are successfully grown, and where markets are available truck gardening has proven profitable.

The birch–beech–maple–hemlock forest in its biological characteristics is not unlike the western white-pine forests of northern Idaho and western Montana. Here the eastern white pine (*Pinus strobus*) takes the place of the western white pine (*Pinus monticola*). Hemlock also plays the same part as there, being the last stage in the development of the stand and coming in as an understory. The place of the western red cedar, however, is taken in the East by such hardwood species as sugar maple, beech, yellow birch, and the lowland white fir is represented by balsam fir. Were it not for the difference in the distribution of rainfall during the year, the composition of the forests of the two regions would possibly be even more closely similar.

The Oak Forest (Southern Hardwood Forest).

The lower slopes in the Appalachian region and the central Mississippi Valley support a hardwood forest in which the oaks make up the great body of the forest. It may therefore be characterized as the oak region. This hardwood forest is probably the largest hardwood

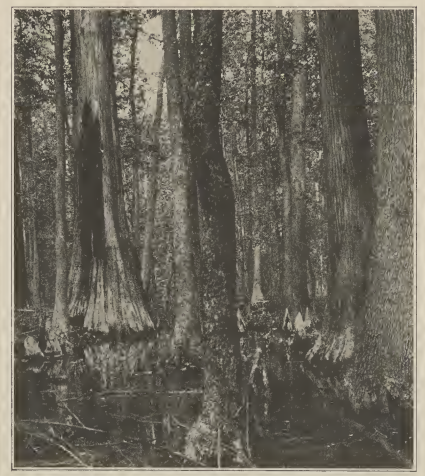


Figure 23.—A mixed forest of cypress and tupelo gum on low land. (Cypress–tupelo–red gum.) Few other forests present such a variety in composition as the bottom-land forest of the South. Where water stands for the larger part of the growing season, it is made up largely of cypress and tupelo gum. On the bottom lands where it is overflowed for only a few months or weeks there is, besides cypress and tupelo, ash, cottonwood, and white and red bays. On the dryer ridges within the bottom lands it resembles the hardwood forests of the vicinity, made up of red gum, black gum, ash, red maple, water oak, and hickory. New Dexter, Stoddard County, Mo. Photographed by Z. L. Bliss.

forest in the Temperate Zones of the world. Close to markets and surrounded by densely populated country it is recognized as the great center of the Nation's hardwood resources.

There is a certain parallelism between the oak region, particularly the eastern part of it, composed of chestnut, chestnut oak, and yellow poplar forests, and the Pacific coast Douglas fir. There is a similar heavy precipitation, density of stand, and development of the individual trees. If to this is added that hemlock and white pine are not lacking in the typical cove stands, the comparison becomes particularly strong. If the southern hardwoods, especially the southern Appalachian hardwoods, have the tendency at maturity to develop an understory of hemlock just as the northern hardwoods do, the two divisions of our hardwood belt may be considered as belonging to one forest unit just as do the western white pine-larch region and the Pacific coast Douglas fir. The life history, however, of most of the southern Appalachian stands is still imperfectly known. Therefore the present birch–beech–maple–hemlock forests and the oak region must be classed as two separate forest units.

This hardwood forest belt was originally continuous and of great luxuriance, but the greater part of it has now been cleared for agriculture or turned into brush land. There are still large areas, however, of virgin hardwood forest, particularly in the Appalachians, Tennessee, Kentucky, Missouri, and Arkansas.

Although greatly modified by repeated surface burning and heavy destructive culling, this region can still be clearly divided into three distinct areas:

The chestnut–chestnut oak–yellow poplar forest.

The oak–hickory forest.

The oak–pine forest.

Chestnut–chestnut oak–yellow poplar forest (fig. 19).—This forest is found throughout the greater portion of the highland extending from Pennsylvania into northern Mississippi and Alabama. It is best developed in the southern Appalachians, between and including the great Blue Ridge and Unaka Mountain systems. The region is generally mountainous, but not craggy, with steep slopes, narrow coves, ridges, and some high and broken or gently sloping land, which approaches table-land. The annual precipitation is from 50 to 70 inches, the heaviest coming in July and August. With much sunlight, evaporation is relatively rapid. The growing season is from five to six months long. Although chestnut, chestnut oak, and yellow poplar are the characteristic species of this forest belt and distinguish it from the hardwood belt west of it, many other kinds of trees are found in this forest; in fact, it contains probably a larger number of species than any other forest area in North America.

The oak-hickory forest (fig. 20).—In the western part of the oak region, embracing western Ohio, In-

diana, Missouri, and Oklahoma, and largely bordering on the prairies (fig. 25), the chestnut, chestnut oak, and yellow poplar gradually disappear and the forest becomes characteristically an oak-hickory forest. The oaks and the hickories, together with some ash, black walnut, elm, and box elder, are the species which push farthest into the prairie region. Hickory is particularly predominant in the lower Mississippi Valley in western Tennessee, eastern Arkansas, and northwestern Mississippi.

Oak–pine forest (fig. 21).—The broad Piedmont region lying between the Appalachians and the Atlantic Coastal Plain from Virginia to South Carolina, the northern half of Georgia, Alabama, Mississippi, and Louisiana, most of Arkansas, and through eastern Oklahoma and eastern Texas, is occupied by a mixed forest of pines and southern hardwoods. The principal pine is shortleaf, although scrub pine enters prominently in parts of Virginia and North Carolina, especially in old fields and on the poorer soils, dry pastures, and waste places. On the heavier, moister soils loblolly pine becomes the principal pine in mixture. Over the Northern Atlantic States this mixed oak–pine forest consists of shortleaf pine, pitch pine, chestnut oak, yellow oak, and red oak. From Virginia southward throughout the Piedmont section, lying between the Coastal Plain and the upper slopes of low mountains up to 2,500 feet, the forest is composed of upland oaks, hickories, and shortleaf pine. In the hilly and mountainous parts of Arkansas this mixed pine–hardwood forest is found at elevations from 1,000 to about 2,000 feet. West of the Mississippi River this forest is made up of shortleaf pine, oaks, and hickories, particularly yellow oak and bitternut and pignut hickories; on the dry ridges post and blackjack oaks; in the fresher soils white and red oaks, big–bud or mockernut hickory, and red gum.

The great oak forests once occupied the best agricultural land in the eastern portion of the United States. The oak–hickory portion covered much of the fine farm land of Ohio and Indiana and extended up along the river bottoms in many of the central Mississippi Valley States. Winter wheat, corn, oats, and hay, mostly timothy and clover, are the principal crops grown in this region. Sweet corn, onions, and peas are grown locally in the northern portion, tomatoes and melons in the southern, while throughout the region apples, peaches, and bush fruits are produced. The chestnut, chestnut oak, and yellow poplar area is well adapted for general farming. Corn, wheat, oats, timothy and clover hay are grown in the northern portion. Apples and peaches are likewise produced in this area. The oak-pine lands of the Piedmont Plateau are somewhat similar in their agricultural productiveness to those indicated by the chestnut and tulip or yellow poplar, and are especially adapted to the production of tobacco and cowpeas. Corn, winter wheat, oats, and vegetables for home use are the important crops within this area, and in the southern portion cotton.

Longleaf–Loblolly–Slash Pine Forest (Southern Pineries). (Fig. 22.)

This forest occupies a belt which extends through the Coastal Plain from extreme southern Virginia to the Everglades in Florida and Trinity River in Texas. It is made up of 10 different species of pine, of which, however, the longleaf pine is the most abundant and occupies extensive areas. This forest, besides furnishing at present a large part of the timber cut of the country, is the source of the naval stores of the United States.

Although the region is one of heavy precipitation (from 40 to 60 inches), with a growing season covering from 6 to 12 months in a year, the sandy soil and the rapid evaporation make the vegetation resemble in many respects the pure forests of western yellow pine. The longleaf pine forest has the same open parklike character and the ground is covered with coarse grasses or low shrubs.

The principal crops grown in this region are cotton, corn, peanuts, sweet potatoes, and velvet beans. The production of winter vegetables is also important locally.

Cypress–Tupelo–Red Gum (Riverbottom Forests). (Fig. 23.)

The bottom-land areas are occupied by forest stands which near the Gulf coast are characterized by the presence of cypress, red gum, tupelo, yellow oak, overcup oak, and cow oak, and farther north by cottonwood, silver maple, white elm, river birch, sycamore, boxelder, and ash. In most of the river bottoms there are distinguished three situations, namely, the "glades," the "ridges," and the "back sloughs." The sloughs remain under water during the larger part of the growing season and their characteristic forest growth is cypress and tupelo gum. The glades are those parts of bottoms which are subject to overflow for from a few weeks to several months. They support a forest of cypress, tupelo, water ash, cottonwood, and white and red bays. The glades are often irregularly divided by lower ridges, seldom over 6 feet in elevation, and often sloping imperceptibly to the level of the glades. They support a forest made up of red gum, slash pine, overcup oak, water oak, hickory, black gum, ash, red maple, and honey locust. In the poorer drained swamps with highly acid soils tupelo usually is absent and the pond pine, or black gum and pine, make up the stand.

The Mangrove (Subtropical Forest). (Fig. 24.)

The mangrove (*Rhizophora mangle*) thickets, which cover hundreds of miles on the southern shores of Florida, are representative of the tropical forest vegetation. The principal areas occupied by it are the

Figure 24.—Mangrove thicket (Mangrove), typical of the moist subtropical forest along the Florida coast. It occurs on land submerged by salt tide-water, where it builds up a foundation for other species. Miami, Fla.

shoals lying between the keys and the mainland, which are composed of calcareous sediment, and the low southern and western borders of the Everglades. It occurs on shores and shoals that are overflowed generally by salt tidewater. In this respect it differs from cypress, in that the latter grows in localities that are overflowed at times by fresh water. In these localities and on tidewater islands as far north as latitude 29° it forms dense thickets. In places on the mainland shores the mangrove attains treelike dimensions, forming a tall trunk sometimes 2 feet in diameter. Mangrove thickets in the course of time build up a foundation for other species. Of these, black mangrove is the most important.

CORRELATION OF FOREST VEGETATION.

There is a similarity in distribution of these large forest units in the East. Taking the oak forest as the center, both north and south of it there is a forest

Figure 25.—A mixed forest of white elm, green elm, hackberry, box elder, and cottonwood along water courses in the prairie. (Tall grass and oak–hickory). The most western extension of the oak–hickory type. Fairport, Kans. Photographed by W. L. Hall.

of hardwoods mixed with pines. In the North the birch, beech, and maple—northern hardwoods—have a large admixture of white pine and hemlock; in the South the shortleaf pine and oak form a forest belt typical of almost the entire Piedmont region. Next to this mixed hardwood and pine belt, North and South, we come to pure pineries. In the North it is the white pine, Norway pine, and jack pine; in the South, longleaf, loblolly, and slash pines. Immediately north of the white pine, Norway pine, and jack pine forest we find the Arctic forest belt of spruce and fir, and south of the longleaf, slash, and loblolly pines we find the tropical fringe of mangrove.

One interesting feature of all these big units of vegetation is that while the smaller subdivisions of each unit may gradually change into one another and all gravitate to the ultimate type of the main division, the subdivisions of one division do not readily change into subdivisions of another division unless the climate in the division materially changes. Thus, for instance, the several subdivisions of the great central oak forest, both in the course of natural evolution and under the effect of fire, interference by man, insects, and other accidental causes, do gradually change one into another, and all gravitate, if left undisturbed for a long time, to a hardwood formation in which the oaks will form the predominant feature; yet as long as the climatic conditions remain the same, it is hardly possible to imagine, for instance, the chestnut–chestnut oak–yellow poplar forest ever turning into a longleaf–slash–loblolly pine forest, and the true test whether we are dealing with a fundamental natural unit of vegetation is this inability of smaller subdivisions to change into a subdivision of another main division.

SUMMARY OF FOREST VEGETATION.

Classification of forests of the United States into forest regions, subregions, and sites.

THE WESTERN FORESTS.

Forest region.	Subregion.	Association.	Sites.
Western yellow pine–Douglas fir.	Lodgepole pine.	Lodgepole pine–Douglas fir.	At the lower altitudinal limit of the lodgepole pine zone, on south slopes and on dry, rocky knolls.
		Lodgepole pine–Engelmann spruce.	At the upper altudinal limit of the lodgepole pine zone and on moist bottom lands along stream courses.
		Larch–lodgepole pine.	On flats and drier situations in northwestern Idaho.
	Pure yellow pine.	Pure yellow pine.	Occurs on dry, hot slopes or flats at low elevation, from 3,500 to 4,500 feet in California and on the east slope of the Sierras, where it consists of Jeffrey pine and white fir. Typical of Arizona and New Mexico. In the southern part of each of these States the belt lies between about 6,000 and 7,500 feet. At its upper edge Douglas fir and Engelmann spruce come in and above 9,000 feet dominate the stand. In the northern part of New Mexico these forests are nearly 1,000 feet higher. Also occurs in northern Nebraska and the Black Hills, in northern Nebraska at an elevation of 3,000 feet, and in the Black Hills from 3,000 to 5,000 feet. Also on south slopes and all lower altitudes in Washington and Oregon between 3,000 and 5,500 feet. In northern Montana and Idaho at the lower altitudes on warm, sunny exposures, low ridges, and rather dry benches and gravelly flats.
	Rocky Mountain Douglas fir.	Yellow pine–Douglas fir.	On northwesterly moderately cool slopes at moderately high elevations (4,500 to 5,500 feet) on the west slope of the Sierras. In Arizona this type occurs at elevations between 8,500 to 10,000 feet on the south slopes and between 7,500 feet and 9,000 feet on the north exposures; in the central Rockies at elevations from 6,000 to 9,000 feet, chiefly on sandstone and granite soils.
		Douglas fir.	On cool northerly and northeasterly slopes at elevations of about 5,000 to 6,000 feet on the moist slopes of the Sierras and at elevations between 8,000 and 10,000 feet in the central Rockies.
		Yellow pine–Douglas fir–larch.	On moderately westerly slopes throughout northwestern Idaho.
	Yellow pine–sugar pine–incense cedar.	Yellow pine–sugar pine.	On cool slopes, chiefly on clay, slates, quartzite, and limestone soils at elevations of 3,500 to 5,500 feet on the western slope of the Sierras.
		Yellow pine–incense cedar.	On moderately dry western slopes, especially on soils of serpentine formation on the western slope of the Sierras.
		Yellow pine–sugar pine–Douglas fir.	On cool slopes on clays, slates, quartzites, and limestones, at elevations of from 4,000 to 6,000 feet on the west slope of the Cascades.
Cedar–hemlock (*Thuja–Tsuga*).	Western larch–western white pine.	Pure western larch.	On flats and moderate northerly and northwesterly slopes in northwestern Idaho.
		White pine–Douglas fir–larch.	On moist northerly slopes, flats, and basins at various elevations up to the point where alpine fir and Engelmann spruce take possession throughout northwestern Idaho.
		White pine–larch–cedar.	Practically the same as for the previous one, except that it is in a more advanced stage of maturity.
	Pacific Douglas fir.	Douglas fir–hemlock–cedar.	On humid lower slopes and valleys from sea-level to 3,000 feet.
		Pure Douglas fir.	On lower slopes and valleys moderately humid, from sea-level to 3,000 feet.
		Sitka spruce.	Coastal valleys and benches from sea-level to 200 feet.
		True firs.	Middle altitudes on all slopes and aspects, from 3,000 to 4,500 feet, on the west slope of the Cascades.
Spruce–fir (*Picea–Abies*).		Alpine fir–white bark pine–Lyall larch.	At high altitudes above the commercial forest, from 4,500 to 7,000 feet, in the Cascades.
		Engelmann spruce–bristle-cone pine–cork-bark fir.	At elevations from 10,000 to 11,500 feet in the mountains of Arizona.
		Pure red fir.	At elevations above 6,000 feet on northerly and northeasterly slopes in the Sierras.
		Red fir–white fir.	At same elevation as that of red fir (6,000 feet), but on less moist or cool situations.
		Sub-alpine fir–hemlock.	From 7,000 feet to timberline in the Sierras.
		Lodgepole pine.	On cool meadows with plenty of moisture, varying in elevation from 5,300 to 65,000 feet, in the Sierras.
		Engelmann spruce–balsam fir.	At elevations from 7,500 to 10,000 feet, in the central Rockies.

Classification of forests of the United States into forest regions, subregions, and sites—Continued.

THE WESTERN FORESTS—Continued.

Forest region.	Subregion.	Association.	Sites.
Piñon-juniper.		Piñon-juniper.	In central Rocky Mountains, Rocky Mountain juniper (*Juniperus scopulorum*) and one-seed juniper (*J. monosperma*) are the chief species, often with some Gambel oak (*Quercus gambelii*) and western yellow pine. In Arizona and New Mexico piñon, Mexican piñon (*P. cembroides*), single-leaf piñon (*P. monophylla*), alligator juniper (*Juniperus pachyphloea*), one-seed juniper, Rocky Mountain juniper, and Utah juniper (*J. utahensis*) are the chief species, often with some Gambel oak and western yellow pine. In Utah, single-leaf piñon, Utah juniper, one-seed juniper, and Rocky Mountain juniper, often with some Gambel oak and western yellow pine. In California, single-leaf piñon and Utah juniper, often with some western juniper (*J. occidentalis*) and Jeffrey pine.
		Juniper.	In the northern Rocky Mountains juniper is the chief species, usually with some limber pine, western yellow pine, or Douglas fir; in California, juniper, often with some Jeffrey pine and western yellow pine; in Washington and Oregon, western juniper, often with mountain mahogany, and sometimes with a little western yellow pine.
Chaparral.		Oak.	In Arizona and New Mexico Emory oak (*Q. emoryi*), Arizona white oak (*Q. arizonica*), blue oak (*Q. oblongifolia*), and whiteleaf oak (*Q. hypoleuca*) are the chief species, often with some alligator juniper, Mexican piñon, and other species. In Utah, pretty scrubby Gambel oak. In California, black oak (*Q. californica*), California blue oak (*Q. douglasii*), canyon live oak (*Q. chrysolepis*) California live oak (*Q. agrifolia*), highland live oak (*Q. wislizeni*), valley oak (*Q. lobata*), and Garry oak (*Q. garryana*), often with some digger pine, madrofie, and occasionally knobcone pine, Coulter, Jeffrey, and western yellow pines, and other species.
		Digger pine.	A low foothill belt made up approximately of 40 per cent or more of digger pine, often mixed with various oaks, Coulter pine, western yellow pine, and other species. Occurs on any sites below the western yellow pine type.
THE EASTERN FORESTS.			
Spruce-fir.	Spruce-fir.	Spruce swamps.	Low lying, poorly drained areas, whose soil is a muck or peat, spongy in texture, and acid. The characteristic species are red spruce, black spruce, balsam, tamarack, cedar, soft maples.
		Spruce flats.	Spruce flats occupy the level and rolling flats bordering the swamps, lakes, and water courses. It is in large measure a transition between the swamp type and the type of the mixed hardwood lands, and in many respects exhibits the characteristics of each. Spruce, birch, soft maples, white pine, hemlock, and balsam are the characteristic trees in mixture.
		In mixture with hardwoods.	These occupy the best soil sites of the region, usually the benches and the lower mountain slopes. The soil is here best adapted to hardwood growth, is deep, of more or less even texture, fresh, and well-drained. Besides spruce, hard maple, beech, and birch predominate and there is a scattering of hemlock, white pine, soft maple, cherry, and a variety of other species. The proportion of spruce in mixture depends on topographic conditions. Transition to birch-beech-maple-hemlock forest.
Birch-beech-maple-hemlock (northern hardwood forest).		With mixture of spruce, balsam and hemlock (transition forest); with mixture of white pine or tamarack; with mixture of ash, elm, basswood, or red oak; with mixture of paper birch or aspen; with beech predominating; with yellow or black birch predominating; with sugar maple predominating.	Fresh, well-drained fertile soils within the drainage system of the St. Lawrence, the Great Lakes, and the upper Mississippi; throughout northern New England and southward along the northern and southern Appalachian Mountain ranges to extreme northern Georgia. It coincides with the range of yellow birch and centers about the region of best development of white pine. In Minnesota the beech and hemlock disappear and the forest is made up of aspen, white birch, basswood, and maple of inferior development.
White pine-Norway pine-jack pine.		Jack pine plains.	On the driest, sandiest soils.
		Pure Norway pine.	On dry, sandy soils, slightly better than those characteristic of the jack pine plains.
		Norway-white pine in mixture with hardwoods.	Usually on moderately moist, well-drained soil underlain with a clay subsoil.
Oak.	Chestnut-chestnut oak-yellow poplar.		*Cove.*—Poplar, hemlock, basswood, black birch, cucumber, ash, buckeye. *Most abundant*, probably chestnut. *Very abundant*, chestnut, oak, hickory, red oak, white oak, black gum, dogwood, sourwood, silver bell, white pine. There may be distinguished poplar cove, hemlock cove, white oak cove, etc. *Ridge.*—Pitch table-mountain, and short-leaf pines; chestnut, scarlet, and black jack oaks; chestnut; black gum. There may be recognized pine ridge, chestnut oak ridge, oak ridge. *Slope.*—A blending of above species, with heaviest proportion of chestnut and oaks. Upper slope resembles ridge, lower slope resembles cove.
	Oak-hickory.		The most eastern extension of the oak region. The oaks and the hickories, together with some ash and black walnut, are the farthest avant post in the prairie region.
	Oak—shortleaf pine.		Characteristic species are chiefly shortleaf pine as the predominating species, with varying amounts of black, chestnut, post, and Spanish oaks, pignut and mocker-nut hickories, and black jack oak, approximately in the sequence given above:

Classification of forests of the United States into forest regions, subregions, and sites—Continued.

THE EASTERN FORESTS—Continued.

Forest region.	Subregion.	Association.	Sites.
Oak—(Con.).	Oak—shortleaf pine.		On dry ridges (north)—shortleaf pine, chestnut oak, scrub and some pitch pine. On dry ridges (south)—shortleaf pine, post oak, black jack oak. On average rolling lands—shortleaf pine, black oak, pignut hickory, Spanish oak, mockernut hickory (lower), chestnut oak (drier and warmer), scarlet oak, black gum (generally scattering), dogwood and persimmon (understory). On low southern situations—shortleaf pine, loblolly pine, red gum, black gum, white oak.
Cypress-tupelo-red gum.		River swamps.	"Sloughs:" Cypress and tupelo. "Glade:" Cypress, tupelo, water ash, willow, cottonwood, white and red bays. "Ridge:" Red gum, slash pine, overcup oak, water oak, hickory, black gum, ash, red maple, honey locust.
		Sour swamps and cypress "ponds."	Poorly drained, highly acid soils. Cypress (*imbricata* or "pond" form), black gum, pond pine, slash pine, sour tupelo, southern white cedar, white and red bays.
		River bottom forest.	Along the larger streams and deeper narrow valleys in the upper Piedmont sections, the forest consists chiefly of hardwoods, red gum, willow and water oak, ash, shellbark, and other hickories, black and red gums, some yellow poplar and cucumber, persimmon, and dogwood.
			Shortleaf pine is prominent on the warm, south-facing and drier slopes mixed with black oak and post oaks, pignut and mockernut hickories. Toward the lower or southern margin of this forest formation loblolly pine occurs in increasing importance in mixture with shortleaf and the species belonging to the lower and more moist soils; most important in southeast Arkansas. South of Virginia longleaf pine enters and in central Alabama, northern and western Louisiana, and eastern Texas becomes an important member of the composition.
Longleaf-loblolly-slash pine.		Longleaf, slash, and loblolly pines.	On low marshy lands in the vicinity of the Gulf and Atlantic coast. Generally flat, with deep sandy soil lacking in humus, alternately very wet and dry. Undergrowth of wire grass and palmetto.
		Pure longleaf pine.	High pine land. This is a belt adjoining low marshy lands in the vicinity of the Gulf and Atlantic coast. Here practically pure stands of longleaf pine cover the sandy hills and plains, while the moist depressions bordering the creeks and streams are occupied by hardwoods, loblolly pine, and cypress. Broom sedge, turkey oak (*Q. catesbaei*), and bluejack oak (*Q. cinerea*) form the undergrowth.
		Longleaf pine in mixture with shortleaf and loblolly pines and hardwoods.	A broken and hilly country lying still farther inland from the coast. Here the longleaf pine mingles with shortleaf pine forests and mixed hardwoods of the uplands.
Mangrove.			Southern shores of Florida, overflowed generally by salt tidewater. Representative of the tropical forest vegetation.

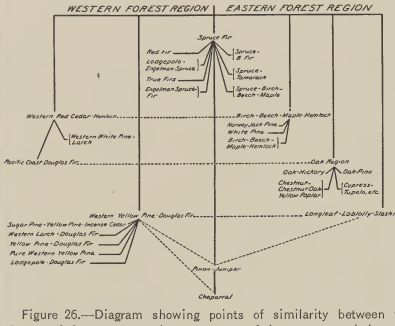


Figure 26.—Diagram showing points of similarity between the forests of the western and eastern parts of the country and the relationships of the different forests.

GRASSLAND VEGETATION.

The central grassland area may be divided into the tall grass (prairie grassland), lying for the most part east of the one hundredth meridian, the short grass (plains grassland) which lies to the west of this line, the mesquite grass (desert grassland), which lies south of the short grass and occupies much of the higher land of west Texas and the lower southern parts of New Mexico and Arizona, and the mesquite and desert grass savanna, which extends across Texas from the Red River southward to the Gulf of Mexico. Bunch grass (Pacific grassland) occurs on the higher plateaus and foothills of eastern Washington, Oregon, and western Idaho, also on the foothills and in the mountain valleys of California and Utah. The short grass extends on the south into the highlands of New Mexico and Arizona, while isolated areas of tall grass occur in east central Texas, the coast regions of Texas and Louisiana, and in portions of Mississippi, Alabama, and Florida. (Fig. 2.)

In addition to these types of grassland, the areas above timber-line on the high mountains of the Cascade-Sierra and Rocky Mountain ranges are occupied by alpine meadows, characterized by low grasses and sedges and a rich admixture of showy-flowered herbaceous plants.

On low, undrained land over which water stands to a depth of several inches during most of the year, such as is found in relatively restricted areas near the Gulf and Atlantic coasts and in Oregon and California, another type of grassland occurs which may be called marsh grassland. It is characterized by coarse, tall grasses, sedges, and rushes, and is often marked in Oregon and along the Gulf and Atlantic coasts by alkali or salt-water plants.

Although all of these areas are characterized by grassy plants, the species, the biological forms, and the conditions of climate and soil are quite distinct.

The short grass characteristic of the high plains develops in a region of early spring and summer rainfall. The average annual precipitation ranges from 12 to 22 inches. The moisture during ordinary years does not penetrate more than 2 feet below the surface. This enables the grasses to grow only a comparatively short time following rains, and they then pass into a drought rest period, which is relatively long in the south and short in the north. Often they do not fruit during the whole summer because of drought. The tall grass and the short grass are distinct in habit of growth, both in height of plant and depth of root penetration, although the latter is largely a response to the soil-moisture conditions, since even the short

Figure 27.—A bluestem sod characteristic of the great prairie grass region of Illinois, Iowa, and Missouri. (Tall grass.) Bluestem predominates. In spring great quantities of flowers are produced, especially shooting stars, phloxes, violets, and spiderworts, which later are not pronounced features of the grass cover. This vegetation is characteristic of a rich soil, and the land has proven most valuable for agricultural use. Savanna, Ill. Photographed by H. C. Sampson.

grasses will penetrate to great depths if the soil is moist. The tall grasses grow in a region where the soil moisture is distributed to a depth of 2 feet or more. Their growth, as a rule, is not limited by deficient moisture supply, as is usually the case with short grass. The line of demarcation between the tall grass and the short grass is not distinct, since the change in climatic conditions is very gradual, due to the absence of a definite topographic division between the two. A series of wet years will swing the apparent division line westward and a series of dry years will swing it eastward. Notwithstanding the gradual change from one type to the other, these types represent widely different climatic, soil, and soil-moisture relations, and the agricultural significance of the two is quite distinct. It is chiefly a matter of moisture supply; but this is influenced by the conditions favoring water loss and by the permeability of the soil. The tall grass pushes farther west on sandy soil, while the hard lands favor the eastern extension of the short grasses. Heavy grazing also favors the eastern extension of the short grasses.

The division line between the short grass and tall grass corresponds to rather sharp soil differences. It is correlated with the depth below the surface of the layer of carbonate accumulation which marks the depth of the periodically moist layer of surface soil. Below this layer of carbonate accumulation the soil is permanently dry except during occasional years of unusually heavy rainfall. Where the depth of moist soil is less than 2 feet, the short-grass type of vegetation predominates. Where greater than about 30 inches, or where lacking entirely, the prairie type of grassland

Figure 28.—A scattered growth of bluestem bunch-grass with a variety of other plants occupying the interspaces. (Tall grass.) The western extension of this grassland occurs on sandy land, while farther east it occupies loam soils. It covers most of the sandhills lying within the plains grassland area. There is less available moisture than on the bluestem sod. Bluestem bunch-grass is intermediate between the bluestem sod and the wire grass farther west. When the soil is not too sandy, bunch-grass land has proven valuable for winter-wheat production. Cope, Colo.

Figure 29.—A dense growth of grasses, principally needle grass and slender wheat grass. (Tall grass.) Many herbaceous plants develop among the grasses, and at times this type presents a much more varied appearance than is here shown. In the eastern portion of the area the Andropogons are more abundant. This vegetation has been plowed up in large part and the land used for the production of spring wheat and other crops. The type is characteristic of excellent agricultural land, especially adapted to small-grain crops. Edgeley, N. Dakota. See note to Fig. 7.

occurs. The important point here is the depth of soil periodically moistened by rainfall and the total moisture supply available. Short grass characterizes areas where each season all available soil moisture is consumed by plant growth. All available soil moisture is also consumed along the western edge of the tall-grass formation. Over the tall-grass area as a whole, however, moisture during the rainy period penetrates so deep into the soil that it is not all recovered and brought to the surface by the plants. Consequently the carbonates are carried down or entirely away with the drainage water.

By far the sharpest soil boundary line, that of the disappearance of the layer of carbonate accumulation in the subsoil, lies well within the area characterized as prairie grassland. This soil boundary corresponds in a general way with the eastern boundary of the needle-grass and slender wheat-grass association and the Bluestem bunch-grass association. East of this line the moisture penetrates below the reach of plant roots. Under these conditions there is no dry subsoil between the moist surface soil and the water table. The soil moisture supply is great enough to support a tree vegetation, but on account of the drought of the autumn and late summer, grass fires have swept the area and destroyed the young trees as rapidly as they were produced. Farther west, where the moisture penetration extends to a few feet only in depth, where the subsoil is permanently dry and there is a distinct accumulation of carbonates at a depth varying from 2 to 4 feet below the soil surface, the tall grasses still find sufficient moisture to maintain themselves. This is a true grassland, probably not dependent on prairie fire for its maintenance. To the west the depth of soil moisture becomes less than 2 feet and the tall grasses disappear because of insufficient moisture supply. This is due directly to decreased rainfall and indirectly to the competition of the short grasses. In general, the short grass grows on a shallow soil with a layer of carbonate accumulation at a depth of 1 to 2 feet. The vegetation boundary between the tall-grass and the short-grass formation is of great agricultural importance, since it separates the highly productive farm lands of the prairies from the less productive ranch lands of the plains, except where it swings west around sand hills.

The mesquite grassland differs from the tall grass in having, like the short grass, a deficient moisture supply. Unlike the short grass, however, it is limited to a much warmer climate and for the most part receives its moisture supply from late summer rains. In other words, the short grass farther north usually starts growth in the spring as soon as temperature conditions are favorable. The rains generally come before that period. The mesquite grass, on the other hand, usually passes through a long, dry, hot rest period and begins growth as a result of summer rains. The mesquite and desert grass savanna is similar to the mesquite grass area, but has a higher rainfall and a deeper layer of periodically moistened soil.

The bunch grass develops in a region of deficient moisture supply, but in a region where there is considerable storage of water in the soil during the winter rest period. This is the chief difference between the bunch-grass and short-grass regions. Both pass into a drought rest period much earlier in the summer than the tall grass. With increased summer rain this region would become tall grass; with decreased summer rain, sagebrush; and with decreased winter rain and a slight increase in summer rain, short grass.

The alpine meadows contrast sharply with the tall and short grass types in length of growth season, which here is determined by temperature alone, and not by moisture conditions. Even during the growing season the temperature is low and the supply of moisture sufficient to maintain continuous growth.

The marsh grass is supplied with an abundance of water during the greater part or all of the year.

The growth period of the alpine meadows and the marsh grass, and to a great extent the tall grass, is determined by temperature, the desert grassland by moisture supply, and the short grass by both temperature and moisture supply. The tall grass and marsh grass have relatively long periods of growth, the short grass, mesquite grass, and alpine meadow relatively short growth periods.

Grassland areas of limited extent occur within the boundaries of the forest and desert shrub types. In

Figure 30.—A practically pure stand of slough grass. (Tall grass.) These sedge prairies occur on much of the lowlands of the eastern prairie region and are composed of sedges, rushes, water grasses, and an admixture of semiswampy herbaceous water plants. Savanna, Ill. Photographed by H. C. Sampson.

the north desert shrub wild rye (*Elymus condensatus*) often forms continuous grasslands along the river bottoms. It forms a dense cover of large bunches 4 to 5 feet high and occupies unusually good agricultural land. In the southern desert area Sacaton (*Sporobolus wrightii*) occupies a similar position. Salt grass (*Distichlis spicata*) and tussock grass (*Sporobolus airoides*) will be discussed under the heading *Salt Desert Shrub*.

The grasslands of the United States may be divided, therefore, into seven general types:

Tall grass, or prairie grassland.
Bunch grass, or Pacific grassland.
Short grass, or plains grassland.
Mesquite grass, or desert grassland.
Mesquite and desert grass, or desert savanna.
Marsh grass, or marsh grassland.
Alpine meadow, or alpine grassland.

TALL GRASS (PRAIRIE GRASSLAND).

Tall grass (figs. 27 to 30) characterized the great prairie region of the Mississippi Valley and the small isolated prairies through the eastern part of the United States and along the Gulf coast. The area was dominated by tall, luxuriant, and relatively deep rooted grasses. With these grasses were found a large variety of herbaceous flowering plants. The prairie was one of the most distinctive features noted by the emigrants the West. During the spring growing period the crossing from the East to the mountainous regions of prairie had the appearance of a veritable flower garden, composed of phloxes, shooting stars, violets, spiderworts, and other showy plants, almost to the exclusion of the more important but slower growing and less highly colored grasses.

This original vegetation has now been almost entirely replaced by cultivated crops.

Over much of the area the moisture supply comes largely during the growing period and varies from about 20 to 40 inches. The soil moisture extends to a depth of several feet in the drier portions and to ground water in the moister sections. Over most of the area the subsoil is permanently moist, but along the western edge the subsoil is permanently dry and the soil is moistened only to a depth of from 2 to 4 feet. During late summer and fall the moisture supply within reach of the grass roots is often entirely exhausted by the luxuriant growth of grasses, and droughts occur. During drought periods the area has in the past been repeatedly burned by fires started either by Indians, travelers, or lightning. The wet prairies, or sedge prairies, because of their low, swampy character, poor drainage, and aeration, have remained treeless. These grassland areas were often burned over in late summer or winter, and fires have doubtless been a factor in preventing forest growth on adjacent land. In many places fires in the forests themselves have destroyed the trees and enabled the grasses to establish themselves. In the eastern portion of the area fires have in all probability protected the grassland from the encroachment of the forests. Aided by high winds, these fires swept with great rapidity across the grasslands of the prairies and plains, and early settlers and travelers could find safety only by starting back fires, since the broad band of burning grass, often 100 or 200 yards across, made it impossible to pass through the flames to the burnt areas of safety behind. Trees and shrubs are killed by fires, and as a consequence the grasses are able to maintain themselves on land which would support a good forest growth if the trees were adequately protected. Since the settlement of these lands and the consequent checking of the prairie fires, tree growth has been gradually extended, either by planting or natural seeding, and trees now grow throughout the whole prairie region.

Within the area covered by this type of vegetation lies the most valuable body of agricultural land in the United States (fig. 4). The Corn Belt lies largely within this area, in Illinois, Iowa, eastern Nebraska, Kansas, and Missouri. Cotton is produced without fertilizers on the prairies of Texas and southern Oklahoma. Winter wheat is a most important crop in the west central portion of the prairie area. Spring wheat production is confined largely to the prairies of North Dakota, South Dakota, and Minnesota. Barley is produced in large quantities on the prairies of North Dakota, South Dakota, Minnesota, and Iowa, and oats on the prairies of Illinois, Iowa, Minnesota, eastern North Dakota, South Dakota, and Nebraska, and also in the prairie sections of Missouri, Oklahoma, and Texas. Flax culture is most important on the prairies of North

Figure 31.—A sod cover formed largely by wheat grass and little bunch-grass. (Bunch-grass.) A profusion of coarse plants, such as gentians, composites, and umbellifers give a varied appearance to this grassland. Wheat fields are shown in the background. Pullman, Wash.

Figure 32.—An open bunch-grass cover characterized by wheat grass. (Bunch grass.) Many plants from both the wheat-grass sod and the adjacent desert shrub occur in this vegetation. Conditions are more adverse in the bunch grass than in the sod. Near Pendleton, Oreg.

and South Dakota and Minnesota; and although the center of production of timothy and clover hay lies farther eastward, great quantities are also produced in the eastern portion of this prairie area. This region also produces great quantities of wild prairie hay. Alfalfa grown without irrigation is confined largely to the prairies of Kansas, Nebraska, and Oklahoma. The coastal prairies of Texas and Louisiana produce most of the rice grown in the United States.

The tall grass vegetation may be subdivided into the following communities (fig. 3). In the following sections the communities discussed in the larger type are true climax and are known as associations; those in smaller type are developmental for the most part and are associes.

Bluestem sod grass.
Bluestem bunch grass.
Needle grass–slender wheat grass.
Sedge prairie.
Sand sage-sand grass.
Shinnery.
Broom sedge-water grass.

Bluestem sod grass (fig. 27).—This is the most extensive of any of the tall-grass divisions. It occurs over the greater portion of Illinois, Iowa, and eastern Kansas, and also in Missouri, Oklahoma, and Texas, and in western Minnesota and eastern North Dakota, South Dakota, and Nebraska. (Fig. 3.) The prominent grasses are bluestem (*Andropogon furcatus*), bunch grass (*Andropogon scoparius*), and Indian grass (*Sorghastrum nutans*), accompanied by other species. With these grasses there occur at times a great profusion of flowering plants. Of this type was the great prairie of the Mississippi Valley, in crossing which explorers traveled for many days through luxuriant fields of grass.

Over this area the soil is unusually rich, of good texture, and dark color, the result of its high humus content. The surface soil within the reach of the deep-rooted grasses is dried out each year, but the subsoil is permanently moist. The rainfall of 20 to 40 inches comes largely in early spring and summer. In late summer and fall occur droughts, which were doubtless largely responsible for the destructive prairie fires of the region. These droughts were probably as much the result of the luxuriant growth and consequent rapid expenditure of moisture as the lack of rainfall. Much of the best agricultural land of the United States was formerly covered by this type of vegetation (fig. 4). The central portion of this area includes a large part of what is now generally known agriculturally as the Corn Belt.

Bluestem bunch grass (fig. 28).—In passing westward the moisture supply becomes more deficient and plants assume the bunch habit of growth. In central Kansas and Oklahoma (fig. 3) this type is made up largely of bunch grass (*Andropogon scoparius*), together with grasses of the bluestem sod type and a slight admixture of the short grasses of the plains. In appearance this type is more varied than the bluestem sod and presents an open mixed cover. The type extends along the boundary line of short and tall grasses from Nebraska to Texas, and occurs as isolated areas farther west on sand lands and stony open ground. In places bunch grass is practically pure, tending to dominate the area. Conditions for general agriculture are not as good in this type as in the bluestem sod, owing principally to the lesser moisture supply. The average annual precipitation is usually 20 to 30 inches. The surface layer of moist soil is from 2 to 4 feet in depth and there is no loss of moisture to the subsoil, which is permanently dry. The greatest winter-wheat areas in the United States lie within the area marked by this vegetation.

Needle grass slender wheat grass (fig. 29).—Farther north, in Nebraska, the Dakotas, and Minnesota (fig. 3), needle grass (*Stipa spartea*) and slender wheat grass (*Agropyron tenerum*) become relatively more important. This type forms a dense sod cover, but the plants are not as vigorous as the bluestem sod grasses farther south. The rainfall is also somewhat less (18 to 30 inches), but at the same time the evaporation is also less. The soil is dark and is moist to a depth of 3 feet or more. The subsoil in much of the area is permanently dry. Here, as in the bluestem sod, herbaceous plants play a prominent rôle. The greatest spring-wheat area in the United States has developed on land characterized by this type of vegetation.

Sedge prairie (fig. 30).—Farther eastward, on the lower swampy, poorly drained lands, wet prairies or sedge prairies become prominent. Their vegetation is made up of sedges, rushes, and coarse grasses, such as bluejoint (*Calamogrostis canadensis*), reed canary grass (*Phalaris arundinacea*), slough grass (*Spartina michauxiana*), sedges, rushes, and semiaquatic herbs. This grassland merges gradually into the true marsh grassland, and is probably treeless because of its swampy condition. It can not be made productive agriculturally without drainage.

Sand sage–sand grass.—At the western edge of the bluestem bunch-grass land and extending out into the short grass, mostly in South Dakota, Nebraska, Colorado, Kansas, and Texas, large sandhill areas occur. These are covered either with bunch-grass or with sand sage–sand grass. The latter varies greatly in appearance. Among the prominent plants are sand sage (*Artemisia filifolia*), sand grass (*Calamovilfa longifolia*), and the grasses of the bluestem bunch-grass type. The moisture supply is even less here than on the bluestem bunch-grass type, but the loose soil and open cover enable plants to continue growing during long periods of drought. The open vegetation cover contains in addition to grass a large number of other plants. The soil is far too light for safe cultivation, owing to the danger of blowing when denuded.

Shinnery.—Similar sand areas in Texas, Oklahoma, and New Mexico are covered with bunch grass associated with shin oak (*Quercus havardii*). This oak seldom exceeds 3 feet in height and forms a dense low shrubby growth. This vegetation, locally called shinnery, represents a transition to the southern desert shrub, since on many of the sandhills it is interspersed with mesquite.

Broom sedge–water grass.—Near the Gulf coast, from Texas to Florida, are extensive coastal prairies of broom sedge–water grass, dominated largely by water grass (*Paspalum* sp.), switch grass (*Panicum virgatum*), broom sedges (*Andropogon glomeratus, A. saccharoides*), and bluestem (*A. furcatus*), all of which can persist in a wet soil. This vegetation corresponds more nearly to the sedge prairie than to any other and at the lower margin merges almost imperceptibly with the marsh grasslands of the coast. In addition to the grasses many showy flowering plants occur. The rainfall is heavy, ranging from 30 to 60 inches annually. These lands have proven to be valuable for grazing and for cotton and rice culture.

BUNCH GRASS (PACIFIC GRASSLAND).

This grassland is composed of bunch grasses, occurring chiefly in the Western States—California, Oregon, Washington, Idaho, Montana, and Nevada. In Oregon, Washington, and California it occupies extensive areas, and in the Palouse region forms a relatively dense stand. Throughout the northern Great Basin this bunch grass type occurs at higher elevations below the conifer zone. It is characterized by a rich display of flowering plants. The condition under which bunch grass develops is that of a moisture supply insufficient for a dense stand of grasses. The rainfall varies from 10 to 25 inches. Some of the moisture supply comes during the growing season, but at the beginning of the growing season moisture is usually present to a depth of several feet in the soil. If rainfall were confined to the growing period, short grasses would develop, and if a still greater proportion fell during the winter rest period it would give way to sagebrush.

Although this type occurs in Arizona, New Mexico, Colorado, and Utah, it becomes of importance only in Washington, Oregon, and California. In Washington and Oregon it indicates the best wheat land of the Northwest. All of the area is valuable grazing land, and in California especially the bunch grasses have long since disappeared as a result of overgrazing, and only the weed grasses remain. Even in the Northwest the bunch grasses are being rapidly killed out by overgrazing.

The bunch-grass vegetation may be divided into the following communities:

Wheat-grass sod.
Wheat-grass bunch.
Stipa–Poa–bunch grass.

Wheat grass sod (fig. 31).—In the eastern portion of Oregon and Washington (Palouse region) (fig. 3), where the moisture conditions are more favorable, this grass produces a sod which contains, in addition to wheat grass (*Agropyron spicatum*), the little bunch grass (*Festuca idahoensis*), poa (*Poa sandbergii*), and balsam root (*Balsamorrhiza sagittata*). During the early spring and summer this area presents a luxuriant and varied appearance, due largely to the prominence of plants with large, showy flowers and leaves. The rainfall is from 15 to 25 inches. Within the area marked by this type lie the best wheat lands of the Northwest.

Wheat-grass bunch (fig. 32).—In the western portion of the northwest prairie, where the moisture supply is deficient, or the soil less able to hold available water, due to its shallow or rocky character, this plant cover presents an open bunchlike appearance. It is composed of wheat grass (*Agropyron spicatum*) either alone or mixed with poa (*Poa sandbergii*) and conspicuous herbaceous plants. This type marks the transition from the wheat-grass sod to the sagebrush desert. It occurs in areas receiving from 15 to 20 inches of precipitation, and is widely distributed, especially in the northern portion of the Great Basin (fig. 3). It is interesting to compare the behavior of such grasses as wheat grass (*Agropyron spicatum*) and bunch grass (*Agropyron scoparius*). Both are sod formers when sufficiently supplied with water, and both assume the bunch habit under more arid conditions. In both cases the cause is a deficient moisture supply which causes grasses, as well as shrubs and trees, to develop only in open stands. Overgrazing is rapidly reducing this grassland to the weed-grass type discussed below.

Stipa–poa bunch grass (figs. 33 and 34).—The great central valleys of California, the San Joaquin and Sacramento, also the Salinas and other valleys along the west coast, were first settled by the Spaniards and devoted to stock raising. On the arrival of the settlers from the Eastern States the natural vegetation of this area did not differ essentially from its present condition. Along the streams were scattered groves of live oak (*Quercus agrifolia* and *Q. wislizenii*) and valley oak (*Quercus lobata*), and the areas between were occu-

Figure 33.—California needle grass on land protected from grazing. (Bunch-grass.) This open stand of perennial bunch grasses probably represents the original grassland of the central valleys of California. It is very similar to the bunch-grass vegetation of Oregon and Washington, which is also giving way as a result of overgrazing to introduced annual grasses. For this reason the California grassland has been included with the grasslands of Oregon and Washington in the bunch-grass division. Perris, Calif.

Figure 34.—A luxuriant growth of annual brome grasses (chiefly Bromus rubens). (Bunch-grass.) Wild oats and filarees are often important. Growth usually takes place in the winter or early spring, and the plants soon ripen seeds and remain as a dry dead cover throughout the remainder of the year. Porterville, Calif. Photographed by A. W. Sampson.

pied by weedy vegetation consisting largely of annual brome grasses (*Bromus rubens*, *B. hordeaceus*, *B. tectorum*), filaree (*Erodium cicutarium*), wild oats (*Avena fatua* and *A. barbata*), fox tail (*Hordeum murinum*), bur clover (*Medicago hispida*), and many other weedy plants (fig. 34). The wheat-grass bunch type of Oregon and Washington is being reduced to this weedy condition where the original grasses are entirely killed out by overgrazing. Such seems to have been the history of the California grassland, and perennial grasses persist in sheltered or protected areas. These are chiefly California poa (*Poa scabrella*) and California needle grass (*Stipa pulchra*) (fig. 33), which seem to represent the original plant cover. The stages in the reduction of this bunch-grass type to the present weed-grass type is not yet known to science. E. O. Wooton has recently observed the following stages, which the sheepmen of the region confirm: The original (1) bunch-grasses, lupines, clovers, and borages gradually give way as a result of overgrazing, to (2) wild oats and bur clover, and these in turn to (3) filaree, (4) fox tail, and finally to (5) red brome (fig. 34). At present this grassland is characterized largely by weedy annuals. Following the winter rains these short-lived grasses produce a luxuriant carpet, dotted by many showy flowering plants such as California poppy (*Eschscholzia california*). The vegetation matures early and remains during a long summer rest period in a dried condition. The winter rains cause the seeds to germinate, producing the later winter and early spring growth.

Land in this area, when irrigated, is used for alfalfa, rice, and sugar beets, and is good for fruit, including grapes, apricots, and peaches, as well as citrus, figs, and other semitropical fruits. The dry farm lands produce barley and wheat, much of which is cut green for hay.

SHORT GRASS (PLAINS GRASSLAND).

Short grass characterizes the Great Plains lying east of the Rocky Mountains and for the most part west of the one hundredth meridian (fig. 2). The grasses are low-growing (figs. 35–39) and shallow rooted, owing to a low precipitation, 12 inches in north central Montana to 22 inches in western Texas, which falls largely just preceding and during the growing season. In most cases it does not penetrate more than 2 feet before it is exhausted by the grass cover. A layer of carbonate accumulation in the soil at a depth of from 8 to 20 inches marks the depth of the periodically moist surface soil layer. There is no storage of available soil moisture from year to year and the subsoil is permanently dry. The growth of deep-rooted plants, therefore, is not possible. The frost-free period varies from about 100 to 200 days, but the growth season of the short grasses seldom exceeds 90 days. Grama grass, which is more characteristic of the north, requires about 100 days to complete its growth and produce seed, while buffalo grass, which is limited to the south, has a much shorter growing season of about 40 days. Moisture is the limiting factor, and the buffalo grass in Colorado may bloom either in June or August, depending upon the distribution of the moisture supply. During dry years this great expanse presents the appearance of an endless carpet, while in wet years taller plants develop on the short-grass sod and give to it a more mixed appearance.

Dry farming has been undertaken in nearly all parts of the short-grass region, but it has proven profitable only in the less arid portions. Under irrigation the soil generally is productive and has been most successfully employed in growing cereals, alfalfa, sugar beets, potatoes, and other vegetables. This region is not thickly settled. Although most of the land has been taken up, less than one-eighth was in harvested crops in 1919. Probably nearly a twentieth was crop failure or lying idle or fallow.

In the east-central portion corn is an important crop and is usually grown in rotation with winter wheat. Spring wheat is grown in North and South Dakota, Montana, northwestern Nebraska, and eastern Wyoming. Of the cereals, wheat, barley, and oats are most successfully grown in the northern portions, while sorghums and corn are the principal crops in the south. In the extreme northern portion flax and potatoes are important. The northern portion is given over more particularly to grain production and the southern portion to coarse forage. The most valuable agricultural

Figure 35.—Western wheat grass on sod composed of buffalo grass and grama grass. (Short grass.) During favorable years it is important as hayland, as shown by the shocks in this picture, but during dry years little or no hay is produced. It is limited largely to the clay, or gumbo, lands of South Dakota and adjacent States. Phillip, S. Dak.

land in this section lies in the northern and eastern portions, since drought is more severe in the south and west.

The short-grass vegetation may be subdivided into several associations, including the following:

Grama grass.
Grama-mountain sage.
Grama-Muhlenbergia.
Galleta grass.
Grama-buffalo grass.
Wire grass.
Western wheat grass.
Grama-western needle grass.

Grama grass (fig. 36).—The grama-grass area on the west is separated from the mixed grama and western needle grass and grama-buffalo grass areas on the east by a line running near the North Dakota-Montana boundary, cutting west of the Black Hills, and extending down close to the mountains in Colorado. This area also includes the higher valleys in Colorado, New Mexico, Arizona, and isolated spots in Utah (fig. 3). The vegetation is dominated largely by grama grass (*Bouteloua gracilis*, formerly called *B. oligostachya*), which often constitutes an almost pure sod. Prominent spring flowers are the white mountain lily (*Leucocrinum montanum*), pasque flower (*Pulsatilla hirsutissima*), phlox (*Phlox hoodii*), wild onion (*Allium textile*), and ground daisy (*Townsendia exscapa*). Over the northern portion of the area mountain sage (*Artemisia frigida*) is prominently associated with the grass. In Montana and Wyoming grama grass often alternates with the sagebrush type, and is modified by the abundant admixture of nigger wool (*Carex filifolia*) and June grass (*Koeleria cristata*). In the south, in Colorado, Texas, and New Mexico, where the soil is rocky or where the short grasses have been damaged by overgrazing, it is often modified by an admixture of match weed (*Gutierrezia sarothrae* and several allied species). The grama-grass type marks the portion of the short-grass area which has the lowest evaporation and the coolest, shortest season, but which has a relatively low rainfall. This is an important grazing section, and in the northern portion grain farming has developed in many localities.

Grama grass and mountain sage.—Along the mountain front grama grass (*Bouteloua gracilis*) is often mixed with a great variety of plants which are more typical of the mountain grasslands. Among these may be mentioned mountain sage (*Artemisia frigida*), nigger wool (*Carex filifolia*), yarrow (*Achillea millefolium*), Eriogonums of various species, Pentstemons, wild roses, and lupines. These characterize an area in which the rainfall is greater than that of the adjacent grama-grass land. The soils are often not well developed but consist of loose granitic gravels. Where land is level and favorable for cultivation conditions are much better than in the grama-grass area farther east. The small grains, spring wheat, oats, barley, and rye, are the chief crops grown in this area.

Grama grass and Muhlenbergia.—In the southern portion of the grama grass area, especially in Colorado and New Mexico near the mountains, conditions become so extreme as to temperature and drought, that grama grass gives way in part to *Muhlenbergia gracillima*. With this often occurs the cane cactus (*Opuntia arborescens*). This associes characterizes land of inferior production, even as grazing land, and of doubtful value for crop production.

Galleta grass.—The grassland dominated by galleta grass (*Hilaria jamesii*) covers extensive areas in northern New Mexico and Arizona, and pushes far into the Utah desert. The grass forms an open sod cover, often practically pure, and when dormant it usually presents a uniform light-colored appearance. At a distance it can be detected from the winter-fat areas of the northern desert only by the slightly yellow tint of the dried foliage. During a series of dry years it often replaces sagebrush and is in turn replaced by sage during periods of more favorable moisture supply. This community represents the greatest extension of the short-grass land into the Great Basin area. It covers land not unlike that described as sage or rabbit brush land, and can not be distinguished on the basis of moisture relation and alkali content from sage land. It is probably the best grazing land in the southern portion of the northern desert shrub, with the possible exception of areas covered by winter fat.

Grama–buffalo grass (fig. 37).—This type extends over western Nebraska, Kansas and Oklahoma, eastern Colorado and New Mexico, and the Panhandle of Texas (fig. 3), and is dominated by almost equal quantities of grama grass (*Bouteloua gracilis*) and buffalo grass (*Bulbilis dactyloides*). It occurs as a uniform open sod, and is the most typical short grass of the

Figure 36.—A good sod of grama grass and nigger wool, with occasional plants of June grass and western needle grass. (Short grass.) The prominent flowering plants are the wind flower, bitter root, mountain lily, and townsendia. This grassland is most important in Montana and along the western edge of the Great Plains. Over much of this area small grains are grown during normal and favorable years. Glendive, Mont.

Figure 38.—A grama grass–western needle grass cover with conspicuous perennials, such as silvery psoralea and purple corn-flower. (Short grass.) This type is intermediate between the needle grass–slender wheat grass of the prairie and the grama grass of the plains. Mandan, N. Dak.

Figure 37.—A pure, even cover of grama and buffalo grass interrupted uniformly by small patches of bare ground. (Short grass.) A pure short-grass cover indicates soil moistened only to a depth of 1 or 2 feet. Akron, Colo.

Figure 39.—A close stand of wire grass. (Short grass.) The taller wire grass obscures the grama and buffalo grass which form the bulk of the sod. This grassland lies between the pure short grass on the west and the bluestem bunch-grass on the east. Hays, Kans.

plains grassland. Although many other plants occur in this association, typical areas, except during wet years, appear as a pure open sod. The annuals, including plains plantain (*Plantago purshii*), annual fescue (*Festuca octoflora*), pennyroyal (*Hedeoma hispida*), and beggar's tick (*Lappula occidentalis*), are short-lived and seldom more than an inch or two high, and the perennials are also, for the most part, low-growing plants. During exceptionally wet years weeds, such as horseweed (*Erigeron canadense*) and gumweed (*Grindelia squarrosa*), and taller perennial grasses, such as western needle grass (*Stipa comata*) and sand sporobolus (*Sporobolus cryptandrus*), develop a cover of taller plants. Within this area, especially in the north, the small grains do fairly well in medium or wet years, but fail in dry years. The sorghums and short-season corns also do fairly well. Fall wheat is grown in the northern and eastern portions.

Farther east, where the rainfall is greater, or on lighter land, where moisture penetrates rapidly, tall plants become more abundant. These are chiefly wire-grass (*Aristida longiseta*) and psoralea (*Psoralea tenuiflora*), which indicate conditions somewhat more favorable for crop production than a pure even sod of short grass. Two types, modifications of this, and transitions to the prairie type, are the wire-grass and the wheat-grass types. The soapweed (*Yucca glauca*) is one of the most prominent plants on this type of grassland on the Staked Plains of Texas.

Wire grass (fig. 39).—This type consists of a more or less open cover of grama and buffalo grass with a scattered growth of wire grass (*Aristida longiseta*) and many other deeper-rooted plants, such as psoralea (*Psoralea tenuiflora*), bush morning-glory (*Ipomoea leptophylla*), etc. It forms a belt between the grama-buffalo grass of the plains grassland and the bunch grass of the prairie grassland, and is most extensive in Nebraska, Kansas, and Texas. During wet years the deeper-rooted plants thrive best, but during dry years they often fail to grow. Here the conditions for crop production are more favorable than on the pure grama-buffalo grassland.

Western wheat grass (fig. 35).—This grassland is characterized by an even sod of grama and buffalo grasses and a scattered growth of western wheat grass (*Agropyron smithii*). During favorable years, when the wheat-grass fruits abundantly, prairie hay is cut from this type. It presents a more luxuriant appearance than pure short-grass and produces a heavier crop of forage. As a rule it contains fewer nongrasslike plants, and often occurs as a practically pure cover. This type is distributed over the unusually heavy gumbo soils derived from Fort Pierre shales in South Dakota, Nebraska, and Colorado (fig. 3), and occurs locally over a much wider range. Agriculturally land of this type does not differ greatly from land of the grama-buffalo grass type.

Grama–western needlegrass (fig. 39).—In western North Dakota and portions of South Dakota (fig. 3) grama (*Bouteloua gracilis*), with an admixture of the taller-growing western needlegrass (*Stipa comata*), constitutes a large percentage of the grass cover. The attending moisture conditions are more favorable than under pure grama, and the vegetation is much more varied in appearance. Needlegrass when in fruit is much more noticeable than grama, and the whole area at times looks somewhat like the needlegrass–slender wheat grass of Minnesota. This type is intermediate between the grama of the plains grassland and the needlegrass–slender wheat grass of the prairie grassland. Many plants from both the short grass and the tall grass areas are found here. Purple cone-flower (*Echinacea angustifolia*), silvery psorale (*Psoralea argophylla*), and June grass (*Koeleria cristata*) are the most prominent plants, with the exception of the dominant grasses. Under cultivation land characterized by this type is more productive than any other short-grass type.

MESQUITE GRASS (DESERT GRASSLAND).

This grassland occurs in Texas, New Mexico, and Arizona and extends southward far into Mexico (fig. 3). It is characterized by a growth not conspicuously different (figs. 40 to 42) from the short grass of the plains. The growth period in this grassland does not begin in the spring as in the plains grassland, but as a result of summer rains in July or August, which start the drought-dormant perennial grasses into growth. The evaporation is excessive, the temperature high, and the annual rainfall low, ranging from 12 to 18 inches. The grass cover is usually even and more open than the short grass, and the soil-moisture supply is usually utilized soon after the rainfall. Growth is relatively rapid and the grasses soon become dry in places. In this condition they furnish excellent forage. On most of this land the conditions for dry farming are not as good as on the short-grass land. The dry, hot summer, with the growth period limited to the hotter months of July, August, and September, restricts dry-land production to the sorghums and similar warm-weather crops, and assures the almost certain failure of small grains. Areas of pure grassland are not great in extent, and much of the surface is covered by scattered desert shrubs such as mesquite, creosote bush, yuccas, black brush, and cat's claw. The Emory oak of the chaparral type (*Quercus emoryi*) often occurs on the grassland, forming open savannas.

Figure 40.—Black grama, tobosa grass, and yucca. (Mesquite grass.) This grassland is either pure or has scattered plants of yucca, mesquite, or creosote bush. Moisture conditions are very adverse. The growth period commences after the summer rains and continues until checked by drought. Northwest of Hope, N. Mex.

Figure 41.—Crowfoot and six-weeks grama grass. (Mesquite grass.) The appearance is that of a short crop of cereal. Growth is rapid and follows summer rains. The grass is soon cured in place by drought and forms excellent pasture. Santa Rita, N. Mex.

This grassland may be subdivided as follows:

Black grama.
Crowfoot grama.
Curly mesquite.
Tobosa grass.

Black grama (fig. 40).—The most extensive community is that of the black grama (*Bouteloua eriopoda*). It seldom occurs as an unmixed grassland, but over its surface are usually scattered yucca (*Yucca elata*), mesquite, creosote bush, black brush, or cat's claw. It occupies most of the sandy or gravelly slopes lying between the river bottoms and the foothills in New Mexico, and it is common in Texas and Arizona (fig. 3). It does not form a close sod, but a relatively open grass cover.

Crowfoot grama (fig. 41.)—In southeastern Arizona (fig. 3) crowfoot grama (*Boutelona rothrockii*) characterizes the greater portion of the grassland. This plant is erect in growth, and it forms an even stand which during good years can often be cut for hay. It is often associated with other species of *Bouteloua* and *Aristida*. Areas occupied by this type are often free of shrubby growth, but for the most part the mesquite, cat's claw, and chollas from the adjacent deserts occur on these grasslands. On eroded or overgrazed areas six-weeks needle-grass (*Aristida adscensionis*) and six-weeks grama (*Boutelona aristidoides*) are prominent. Like black grama, the crowfoot grama is excellent forage.

Curly mesquite.—Curly mesquite (*Hilaria belangeri*) forms a close sod grassland in southeastern Arizona, which resembles very closely the buffalo-grama sod of the high plains. It occurs over rolling country at rather high elevations and is often accompanied at the upper elevations by scattered oaks (*Quercus emoryi*). This is excellent grazing land. In Texas this type is almost always marked by scattered trees of mesquite, opuntia and other plants. The grass cover is somewhat more mixed in this section and is often composed partly of buffalo grass (*Bulbilis dactyloides*) and a number of other grasses, chiefly species of *Aristida* and *Bouteloua*.

Tobosa grass.—Tobosa grass (*Hilaria mutica*) occurs throughout the range of the desert grassland and marks the heavy or impervious soils, especially in depressions where drainage water stands after a rain. It occupies extensive areas at the bottoms of the basins and in distribution can be separated with difficulty from the desert shrub.

While green it is regarded as good forage, but the plants soon become dry and woody. False needle grass (*Scleropogon brevifolius*) is often abundant in tobosa-grass areas.

Figure 42.—A curly mesquite-grass sod with an occasional tree of mesquite and cholla. (Desert savanna.) This grassland in general aspect is somewhat similar to the short grass of the plains. The grasses subsist on the moisture stored in the surface soils, while the trees draw their moisture supply largely from the sub soil. The grasses are chiefly curly mesquite with aristidas and gramas. Big Springs, Tex. Photographed by A. J. Olmstead.

MESQUITE AND DESERT-GRASS (DESERT SAVANNA).

This type consists of a short-grass cover over which are scattered small trees or thorn bushes. Both the beginning and the end of the growth period are usually determined by available moisture. Temperature plays almost no part in limiting the growth of the natural vegetation. The distribution of water throughout the season is somewhat similar to that in the desert region. The rainfall is relatively heavy, but the high temperatures and the high-saturation deficit of the air subject the plants to extreme drought conditions. There is a tendency over much of the area for the greatest rainfall to come in the spring and summer, during the period of greatest growth. Portions of the area have a rainfall of less than 20 inches, but in the east it runs to as high as 30 inches. The evaporation rate is high.

This savanna occurs in Texas south of the Red River and mostly south and east of the Plains border. (Figs. 2 and 3.) It also extends over the lower southwest portion of the high plains in Texas.

Two divisions may be recognized within the area here considered: The thorn-bush and mesquite-grass associes and the mesquite and mesquite-grass association. In the western portion the mesquite trees are small, and there are many other small thorny trees and bushes which occur at intervals over an open grass cover. Much of the land is rough and broken and the vegetation partly in a developmental stage. This area may be designated the thorn-bush and mesquite-grass associes. Farther east the rainfall is heavier, the trees larger, and the grass cover much denser. This type may be distinguished as the mesquite and mesquite-grass association.

Mesquite and mesquite grass (fig. 42).—Mesquite and mesquite grass constitute one of the most distinctive types of Texas vegetation. The trees may be either scattered or close together to form an open forest. They often give the appearance of an orchard of small fruit trees. Mesquite (*Prosopis juliflora*) is the dominant tree, although others occur. In many places, especially in the south, prickly pear (*Opuntia lindheimeri*) is almost as plentiful as mesquite. Grasses are abundant, chiefly curly mesquite (*Hilaria belangeri*), buffalo grass (*Bulbilis dactyloides*), and species of Aristida and Bouteloua. Mesquite is often damaged by drought.

In general appearance this association suggests an abundant water supply, followed by extreme drought. The soil is not deep, the layer of carbonate accumulation occurring, in general, at a depth of 1½ to 2½ feet. Although the rainfall is relatively heavy, 20 to 30 inches, it does not penetrate deeply into the soil and is rapidly absorbed and transpired by the growing plants.

This association forms a band about 150 miles wide extending from the Gulf of Mexico on the south to the Red River on the north. This band in the central portion is bent westward to Martin County, Tex. The larger mesquite trees and much denser grass cover distinguish this association from the thorn-bush and mesquite-grass associes. This is because the available moisture is greater in the mesquite and mesquite-grass area. On the north mesquite is apparently limited by low temperatures and on the east by the oak forests. Mesquite here grows on a dark soil with a layer of lime accumulation at about 2½ feet. The oaks grow on sandier land of lighter color where the zone of carbonate accumulation has disappeared.

This area is suitable for grazing and the mesquite trees furnish both fence posts and firewood. Mu h of this land has been put under cultivation. Cotton is the principal crop, although grain sorghums are important, especially in the north, and corn throughout the area.

Thorn-bush and mesquite grass.—In the thorn-bush and mesquite grass associes thorn bushes and cacti, as well as mesquite, are scattered over a sparse desert-grass cover. The soil is always visible because of the sparse vegetation.

The cover in this association is composed of curly mesquite grass (*Hilaria belangeri*), buffalo grass (*Bulbilis dactyloides*), species of Aristida, and other desert grasses. Small mesquite trees (*Prosopius juliflora*) are scattered over this grass cover, and with these are associated thorn bushes and cacti of various types.

This associes extends in a narrow strip from the Gulf of Mexico near the mouth of the Rio Grande River northwest to the southeast corner of New Mexico and across and up the southeast border of the high plains into Cottle and Motley Counties, Tex. On the western edge this type passes either into southern desert shrub, in which case the grasses disappear and a shrubby, open growth takes its place, or into desert grassland, in which case the trees and shrubs disappear, leaving the grasses dominant.

The high water requirement in this hot climate and the long drought period make this type of doubtful agricultural value. Attempts have been made to grow cotton and grain sorghums in the better portions,

MARSH GRASS (MARSH GRASSLAND).

Marsh grassland occurs in scattered areas in many portions of the United States. The most important areas occur in the central valleys of California, along the Gulf and Atlantic coasts, and in the Everglades of Florida. (Figs. 2 and 3.) They may be classified roughly into salt marsh and fresh marsh. For the most part the salt marsh lies along the coast, although in Oregon and California the inland marshes are often developed in alkali areas and a sharp distinction between salt and fresh marshes can not be made. The fresh marshes are characterized largely by Indian rice (*Zizania aquatica* and *Z. palustris*), cat tail (*Typha latifolia*), and tule (*Scirpus validus*) (fig. 44), and in Florida by saw grass (*Cladium jamaicense*) (fig. 43); while the salt marshes are marked by marsh grass (*Spartina alternifolia* and *S. patens*) along the coast. The principal places where marsh-grass lands have been used for agricultural purposes are in California, where the islands or deltas of the San Joaquin and the Sacramento have been diked off, drained, and made into

Figure 43.—Sawgrass marsh. (Marsh grass.) Hummocks in background. The great coast marshes are inundated at high tide by salt water, but have not become excessively saline. In many places, such as the Everglades, the water-supply is practically entirely fresh. There is great variation in the botanical composition of the marshes, but the type shown in the picture is very extensive. Near Detroit, Fla.

Figure 44.—Pure tule marsh. (Marsh grass.) This is the most prominent type in the western marshes. Often the water is relatively rich in soluble salt. This type is extensive in the Klamath Lake region of Oregon and characterizes large areas in both the San Joaquin and Sacramento Valleys. Klamath Lake, Oreg.

very fertile farm areas, especially for the production of asparagus, onions, potatoes, and barley hay. In southern Louisiana, where land of this type is being drained and used for rice production, and in the Everglades, where an attempt is being made to develop muck land into hay and truck farms, the land has been greatly modified by drainage.

ALPINE MEADOW (ALPINE GRASSLAND).

The alpine type occupies much of the mountain land above the timber line (figs. 2 and 3), and is dominated by rock sedge (*Carex rupestris*), alpine nigger wool (*Carex elynoides*), alpine fescue (*Festuca brachyphylla*), and a great variety of alpine plants, most of which are attractive to botanists as well as to tourists. During early summer it often presents a mass of bright colors, due to the blooming gentians, primroses, saxifrages, foreget-me-nots, painted-cups, buckwheats, lupines, polygonums, erigerons, etc. (fig. 45). The flora is especially rich, and many species essentially Arctic occur. The total area in the United States is relatively small, although Colorado, the northern Rockies, and the Cascade-Sierras have rather large areas of this type. The area shown on the map includes also the great rock-fields, which have only cliff plants and lichens, and the snow fields and glaciers, which are devoid of vegetation.

DESERT SHRUB VEGETATION.

The desert shrub, with all its variations of plant cover, may be reduced to three general types:

Sage brush, or northern desert shrub.
Creosote bush, or southern desert shrub.
Greasewood, or salt desert shrub.

The Great Basin region in Utah, Nevada, and Oregon and similar areas in northern New Mexico, Arizona, and California may be characterized as sagebrush desert (fig. 2). The characteristic plants are small deciduous shrubs, deep-rooted for the most part, capable of enduring long periods of rest due either to drought or cold, and with growth limited by available water and favorable temperature. Cacti are characteristically absent from this desert. The rainfall is rather evenly distributed througout the year and for the most part is low, varying from 5 to 15 inches. The character of the vegetation indicates usually the amount of water available for growth. Throughout the area drought may occur at almost any time, and the plants, although well adapted for extreme drought, are often killed by prolonged dry periods. The appearance of the vegetation is monotonous, and the traveler is impressed by the great expanse of pure stands of a single species.

The southern portion of the Great Desert may be characterized as the creosote-bush desert (fig. 2). The evergreen creosote bush is as prominent in the southern desert as the sagebrush in the northern desert. Mesquite ranges throughout this southern area, although it is relatively more important in the eastern part. Yucca, cacti, and spiny desert shrubs are often prominent. The water supply varies greatly, and prolonged droughts may occur at any time. In the drier portion the average rainfall may be as low as 2 inches per year, with droughts lasting from 2 to 6 months, or in extreme cases for a year or more. In other sections the rainfall may be as much as 20 inches and have a fairly even distribution. In this region there are two rainy periods, one in winter and one in summer (with a tendency toward a spring and fall maximum in the southeastern portion), and growth is limited by moisture supply and little or not at all by low temperatures.

The appearance of this desert is markedly different from that of the northern desert. On the whole the plants are larger, more luxuriant, and more widely spaced. Many of them are succulent or evergreen and hold their leaves during the long periods of drought. In the southern portion, especially in the regions of comparatively high rainfall, such as southeastern Arizona, New Mexico, and Texas, this type is mixed with the desert grassland area. On the west this desert merges gradually into chaparral.

Figure 45.—Alpine grassland made up of grasses and sedges, with many low-growing, showy flowering plants. (Alpine meadow.) Timber line shown below. The flowers in the foreground are Polygonum bistortoides and painted brush (Castilleja occidentalis). Above Lawn Lake, Colo. Photographed by Wiswall Brothers.

At lower elevations than the sagebrush and the creosote-bush deserts is the greasewood desert, bordering the drainage channels and occupying undrained basins, especially those underlain by artesian water (fig. 2). This type differs from other desert types in being limited largely to wet or subirrigated land containing a high percentage of soluble salts. Its most characteristic plant is the greasewood, which presents to the eye during periods of active growth a deep-green luxuriant appearance. Most of this desert is characterized by green, fleshy-leaved plants, and to one unaccustomed to alkali deserts it seems much less desert like than the drier areas of sagebrush or creosote bush of higher elevations. Over most of its area this desert is limited to tracts only a few miles across, and only the larger districts can be indicated on the map.

SAGEBRUSH (NORTHERN DESERT SHRUB).

This group is characterized by a scattered open stand of deciduous shrubs, almost all of which have small leaves of a light or silvery color. (Figs. 46 to 50.) The plants are woody and seldom exceed 50 years in age. The plant cover usually consists of a single perennial species, the individual plants of which are unusually uniform in size and general habit. These great expanses of silver or ash colored vegetation present a monotonous appearance.

Of the three types of desert vegetation, sagebrush is the most extensive. Although at high altitudes sagebrush extends to the Mexican boundary, it occurs only as small isolated patches south of latitude 34°. From latitude 37° north to the Canadian line most of the lower valley or basin land between the Cascade-Sierra on the west and Continental Divide on the east is occupied by this type of vegetation. It also occurs in the upper part of the Rio Grande basin and in the Bighorn, Laramie, and Casper basins in Wyoming. In a somewhat modified form it pushes far into the grassland areas of the Great Plains, especially in Montana and Wyoming, where it occurs as a dwarfed sagebrush alternating with grassland, especially in the Yellowstone, Missouri, North Platte, and Bighorn drainage basins. It also occurs in Colorado along the eastern base of the mountains, especially in the valley of the Arkansas.

This northern desert shrub type pushes into the short grass type of vegetation chiefly as sagebrush; into the bunch grass (wheat-grass bunch) as sagebrush, bitterbrush, or scabland sage; into the piñon-juniper as sagebrush or small sage; and into the southern desert as shadscale. As a rule the line of demarcation is not sharp between the sagebrush and piñon-juniper, but sharp alternations occur, the sagebrush usually occupying the better type of soil and the piñon-juniper the more rocky soils. The desert shrub extends into the drier valleys east of the Rocky Mountains in the north, while the short grass pushes into the desert areas west of the mountains, especially in the south.

This great area of sagebrush desert is characterized by rainfall which is comparatively uniform throughout the year, being least during the months from July to September. Over much of the area the rainfall is less than 10 inches and in very little, if any, of the area does it exceed 15 inches. The rainfall comes largely during the long winter rest period and finds its way deep into the soil. Many of the characteristic plants are deep-rooted. The evaporation rate is relatively high and the total amount of annual growth small. The frost-free period varies from 90 to 150 days, but the growing period is usually much shorter on account of drought. This great unit of vegetation is by no means uniform and may be subdivided into several types dominated by a practically pure stand of a single perennial species.

Agriculture in the northern desert is limited to local areas. The best of the sagebrush land has been utilized for grain production under dry-farm methods, while a considerable area in many of the larger valleys of Idaho, Utah, and Nevada has been put under irrigation. Both winter and spring wheat, oats, barley, and rye are grown. Alfalfa is one of the most important crops of

Figure 46.—A pure stand of sagebrush about 4 feet high and resembling an open miniature forest. (Sagebrush.) Annuals form the bulk of the associated species. Sagebrush is the most important plant of the northern desert shrub vegetation. It draws its moisture-supply from both the surface and deep soil layers. Growth is confined to spring and early summer, the plants passing the later summer and fall in a leafless drought-rest condition. During extreme drought sagebrush is often killed. The plants here illustrated range from 30 to 50 years in age. A thrifty growth of sagebrush indicates the best type of land found in the Great Basin region—a deep soil free from harmful amounts of salt. Land of this type may produce fair crops of wheat under dry farming. Nephi, Utah.

Figure 47.—Small sage about 18 inches high. (Sagebrush.) The conditions in this type are more adverse than in sagebrush. The soil is usually shallow and stony, unfavorable for cultivation. Small sage is difficult to distinguish from poorly developed sagebrush. In general the plants are smaller, less silvery and more yellowish in color. Small sage land is seldom used for crops, and its value for grazing depends upon the amount of grass growing between the small sage plants. Ely, Nev.

the region, and sugar beets and potatoes are also extensively grown. Much of the best irrigated fruit land of the intermountain region, which is especially productive of apples, peaches, and similar fruits, is found on land previously growing sagebrush, shadscale, or salt-sage. The development of irrigated land has been determined up to the present time more largely by the practical problems attending the application of water than by the physical condition of the soil or the presence or absence of alkali. As grazing land the winter-fat and the bud-sage areas are important sources of forage. All of the area is grazed, especially in winter, but much of the forage value lies in the relatively unimportant or secondary species of grasses and other forage plants. Overgrazing, and the resulting reduction of fire risk and the conservation of soil moisture in the subsoil, has greatly extended the sagebrush desert into the grassland area.

The sagebrush desert shrub is divided into three main associations, under each of which may be grouped a number of the more important minor communities:

Sagebrush (*Artemisia tridentata*):
- Small sage (*Artemisia nova*).
- Scabland sage (*Artemisia rigida*).
- Little rabbit brush (*Chrysothamnus stenophyllus*).
- Bitterbrush (*Purshia tridentata*).
- Big rabbit brush (*Chrysothamnus nauseosus*).
- Coleogyne (*Coleogyne ramosissima*).
- Chamiso (*Atriplex canescens*).
- Match weed (*Gutierrezia sarothrae*).

Shadscale (*Atriplex confertifolia*):
- Winter fat (*Eurotia lanata*).
- Hop sage (*Grayia spinosa*).
- Bud sage (*Artemisia spinescens*).

Salt sage (*Atriplex corrugata* and *A. nuttallii*):
- White sage (*Kochia americana vestita*).

Sagebrush (fig. 46).—The most important plant of the northern desert shrub is sagebrush (*Artemisia tridentata*). It occupies most of the higher land which is free from alkali, well drained, easily penetrated, and moistened by natural rainfall or by flood waters to a depth of from 4 to 18 feet. This type is best developed in the northern and more elevated portion of the area and within the region where the rainfall is from 10 to 15 inches. It is characteristic of the great alluvial fans and plateaus, ranging principally from 4,000 to 7,000 feet elevation in the central and southern portion of the area and from 1,000 to 2,000 feet in the Columbia Basin. It occupies much of the desert lands of Washington, Oregon, Idaho, Wyoming, Montana, Colorado, Utah, Nevada, northern New Mexico, Arizona, and northeastern California. It ranges from the Canadian boundary on the north to the Mexican boundary on the south, where it occurs in relatively restricted areas at high elevations, and in California usually well up above the chaparral and next to the yellow-pine belt.

The sagebrush cover is usually a pure open stand, the plants being from 3 to several feet apart and varying in height from 2 to 7 feet. In general appearance this type represents a diminutive forest with silvery foliage and little undergrowth. Growth is confined largely to spring and early summer. In late summer and fall sagebrush passes into a drought-rest condition, during which it drops its leaves gradually. At such times the bare stems appear dark in color, and the name "black sage" is often applied to it. During periods of extreme drought sagebrush is often killed over large areas. During rainy periods annuals spring up and grow until the moisture supply of the surface soil is exhausted. These consist largely of the introduced annual brome (*Bromus tectorum*), filaree (*Erodium cicutarium*), and similar desert species. The sagebrush roots are well developed at the surface and extend also in good soil to a depth of 4 to 18 feet. A good, even stand of large sagebrush indicates land upon which crops can be successfully grown by dry-farm methods. Much of the land under irrigation, especially by the small private irrigation systems in which the water is taken directly from the mountain streams and utilized on the adjacent land, was originally characterized by this type of vegetation. Small, old plants, or a stunted, gnarled appearance of the sagebrush, indicates either harmful amounts of alkali in the second or third foot of soil or a water supply so limited that plants can not develop to their full size.

Small sage (fig. 47).—Within the area usually dominated by sagebrush there occur a large number of

Figure 48.—A pure open stand of little rabbit brush. (Sagebrush.) The plants are bright yellow in color when in flower and are usually about 18 inches high. There are few associated plants. Little rabbit brush is most extensive in Utah, and is characteristic of a loose, alkali-free soil, not differing markedly from sagebrush land. Lindyl, Utah.

minor divisions. In Oregon and Idaho and more elevated portions of Utah and Nevada, Wyoming, and Colorado, where soil-moisture conditions are less favorable, due to greater run-off caused by a less disintegrated soil, shallow stony land, or a heavy adobe, sagebrush gives way to small sage (*Artemisia nova*).

This change is seldom due to less rainfall. In general appearance the type is quite distinct from well-developed sagebrush. Very poor sagebrush is distinguished from it only with difficulty. The plants, not as tall as sagebrush, are less silvery and more yellowish in color, and do not have the appearance of a miniature forest. The stand is usually pure, scarcely any other prominent perennials occurring in this type. As agricultural land this type is of doubtful value, due to the rocky and shallow soil, and its value as grazing land depends entirely upon the small amount of grass and other herbage which develops in the interspaces.

Scabland sage.—In Washington and Oregon the lava outcrops known as scabland are occupied by scabland sage (*Artemisia rigida*), a low-growing gnarled bush seldom exceeding 2 feet in height. During the wet spring period many flowering herbs appear in this type. The climatic conditions are similar to those of the wheat-grass or sagebrush areas of the region. Land occupied by this type is entirely unsuited for agriculture and inferior to the adjacent areas of wheat grass or sagebrush as grazing land.

Little rabbit brush (fig. 48).—In the southern portion of the area, in Utah and Nevada, little rabbit brush (*Chrysothamnus stenophyllus* and related species) occupies large areas to the exclusion of almost all other plants. During the summer when the flowers are in bloom, such areas present a uniform bright-yellow expanse often extending for many miles. The plants are, as a rule, not over 12 to 18 inches in height. On soils poorly supplied with water they are often only a few inches high. The amount of growth indicates roughly the quantity of soil moisture available each season for plant growth. The type occurs on rather light land which is free from alkali, and indicates conditions a little less favorable for dry farming than sagebrush. In places where drought or fire has killed out the sagebrush this type of vegetation often develops. Only during favorable years will sagebrush replace this type.

Bitterbrush.—On sandy or loose volcanic soils or poorly disintegrated rocky soils in the northern and western portions of this desert, bitterbrush (*Purshia tridentata*) characterizes large areas. It is found for the most part at higher elevations and near the yellow-pine zone. The large, dark-green plants present an appearance quite different from sagebrush. The conditions do not differ essentially from those on sagebrush land, except that the soil is more loose and sandy.

Big rabbit brush.—Where sagebrush has been destroyed, or on sandy land in the northern portion of the desert, big rabbit brush (*Chrysothamnus nauseosus*) is often dominant. It indicates conditions not essentially different from those of sagebrush. The plants are very light in color, with relatively inconspicuous leaves, grow rapidly, and are short-lived. Late in the season they are covered with yellow flowers which hide the stems and foliage almost entirely.

Coleogyne.—At the southern edge of the sagebrush desert coleogyne (*Coleogyne ramosissima*) often becomes one of the most prominent features of the desert shrub. On the highlands west and east of Death Valley, also across Nevada at the thirty-seventh parallel, it forms the boundary between the northern and southern desert, mingling with northern types on the upper or northern boundary and with the tree yuccas on the lower or southern boundary. It does not occur in alkali soil, but on alluvial fans or sandy soil, where the total rainfall is quickly absorbed and available for plant growth. This land is suitable only for irrigation agriculture.

Chamiso.—Chamiso (*Atriplex canescens*) occurs in many places either in a pure stand or as scattered plants over a Galleta grass cover. In distribution it occurs in the southern portion of the northern desert shrub, but is more abundant in the southern desert shrub, to which it apparently belongs. Chamiso often occupies sandy land, although it has been found in a pure stand on heavier land containing some alkali.

Match weed.—Large tracts of land throughout the desert are marked by a cover of match weed (*Gutierrezia sarothrae* and related species). Such lands have been either burned, plowed, overgrazed, or disturbed in some way, and match weed represents only an early perennial stage in the revegetation. These vast areas may have been originally sagebrush land, shadscale land, or any other permanent type. As an indicator it is of little practical value, although the best and most luxuriant growth is usually on sagebrush land and the poorer growth on shadscale or salt-sage land. This type also occurs on short-grass lands and lands of the southern desert when the original vegetation is disturbed or destroyed. Its natural habitat seems to be the shallow soils of the western and southern edge of the short-grass area.

Figure 49.—A pure open stand of shadscale plants about 1 foot high. (Sagebrush.) One of the most extensive types of the northern desert shrub. The few associated plants contribute little to the general appearance. In growing condition or in dormant condition the plants are ash-gray in color, blending with the desert soil. The branches are rigid and the individual plants tend to form low hummocks. This is the most important type of the southern part of the Great Basin, where the temperature is higher and the rainfall lower than on sagebrush land. The soil indicated by shadscale is usually shallow or heavy and strongly saline in the deeper layers, and is, consequently, not suitable for dry-farming. Lund, Utah.

Figure 50.—Mats of salt sage with plants about 5 inches high. (Sagebrush.) The small, widely spaced mats blend with the desert soil and give a barren appearance. Next to the barren salt flats, this is the scantiest desert vegetation. Salt sage occurs on land from which the run-off is large, the moisture conditions being even more severe than on shadscale land. The rains penetrate usually only a few inches, and alkali is often found to the very surface. Near Grand Junction, Colo.

Shadscale (fig. 49).—The shadscale (*Atriplex confertifolia*) covers an extensive area in Utah and Nevada, and occurs less abundantly in Wyoming, Colorado, southern Idaho, Oregon, and eastern California. In relatively small isolated areas it pushes south into New Mexico, Arizona, and into the Mohave Desert of California. It usually lies below the sagebrush and just above the salt-desert shrub. Where ground water lies at a depth of several feet, greasewood often occurs as scattered widely spaced plants on land otherwise characterized by shadscale. This is one of the most common mixed types of the northern desert region. Shadscale also comes in contact with the short grass east of the mountains in Colorado and in New Mexico and Arizona. It probably covers more land in Nevada and Utah than does the sagebrush. The rainfall is less than over sage land and the heavy character of the soil much more conducive to high run-off. As compared with sagebrush land the moisture conditions are much more extreme. The root system is much shallower than that of the sagebrush, due to the more limited water supply. During periods of extreme drought this plant is often killed over large areas. Like the sagebrush, it is characterized by a practically pure stand.

In contrast with the silvery foliage of the sagebrush, the shadscale is gray, and the whole landscape presents an appearance of extreme monotony. In autumn the plants change to a reddish-brown color, and during the favorable years a heavy crop of seed is produced. The plants are hemispherical and usually scattered evenly over the surface of the soil, but never produce a dense stand. Between the plants the soil usually is bare. The plants vary in height from 6 inches to 2 feet. If the soil is especially poor and the rainfall unusually light, the plants may be only a few inches high. On relatively good soil the plants may be 2 feet high. This type indicates harmful amounts of alkali at a depth of 1 or 2 feet or a soil poorly supplied with water with a hardpan at the same depth. This land is unsuitable for dry farming, but where the soil is not too shallow it can be made productive under a proper system of irrigation.

Winter fat.—Within the zone occupied by the shadscale, occurring on similar soil and under similar climatic conditions, are a number of minor groups. Winter fat (*Eurotia lanata*) covers hundreds of square miles in Nevada and Utah. The plants are usually small, almost white in color, and rather widely spaced. Areas can be detected at great distances because of the uniform white or light-gray color, which at a distance appears like snow. The plants are shallow rooted and often grazed almost to the ground. This plant occupies land almost as heavy as that covered by shadscale, but which contains only a small amount of alkali. It is one of the most valuable forage plants of the Great Basin region, and is especially highly prized by sheepmen. Although the pure areas are most extensive in Nevada and Utah, it is a common plant over a much wider range and contributes much to the forage resources of the intermountain region. Agriculturally this is similar to the shadscale land.

Hop sage.—Under conditions intermediate between shadscale and sagebrush large areas occur which are occupied by hop sage (*Grayia spinosa*). During the winter this shrub presents very much the appearance of sagebrush, with which it is often mixed. It is found most commonly in the northern portion of the area.

Bud sage.—Bud sage (*Artemisia spinescens*) is especially prominent in Nevada and occurs throughout Utah, Colorado, and the Northwest. It occupies rather limited areas and does not differ markedly from the shadscale in its distribution. It is especially valued by sheepmen. Sheep which, during the winter, have grazed on winter fat are first moved to areas of bud sage because the young shoots of this plant produce excellent forage and constitute the principal feed in the early spring.

Salt sage (fig. 50).—Salt sage (*Atriplex corrugata*, *A. nuttallii*, and allied species) ranges somewhat farther north than shadscale and occupies especially large areas in Wyoming, Colorado, and Utah. It occurs in small areas in Montana, Idaho, Oregon, and California. In Montana, Wyoming, and Colorado it pushes out into the short-grass areas, but never becomes dominant over large areas east of the mountains. Great expanses are covered with this ash-colored low-growing plant, which forms large mats and is seldom more than a few inches high. The total amount of growth produced on this type is small, and the landscape presents to the eye a relatively larger amount of bare ground from which the plant is not readily distinguished at a distance. It occurs usually on a soil from which the run-off is comparatively great and which accordingly supplies only a small amount of water for plant growth. The moisture conditions are even more extreme than on shadscale land. Soil moisture is confined to within a few inches of the surface, and only a relatively small total moisture supply is available for plant growth. Plant growth occurs largely in early spring, and the plants pass most of the summer season in a rest condition. This type is found usually in regions having less than 10 inches of rainfall and a high evaporation rate. The soil usually contains harmful amounts of alkali to the very surface. Land under this type of vegetation is not adapted to dry farming, but when the proper system of irrigation is applied it may be leached so as to become good agricultural or orchard land.

White sage.—Land similar to that occupied by salt sage is sometimes dominated by white sage (*Kochia americana vestita*). These areas are found in portions of Utah and Nevada, and are not extensive. In appearance they can be distinguished with difficulty from winter-fat areas. The two species are of about equal height as a rule, but the white sage is not as white as is the winter fat. White sage spreads by underground rootstocks, the plants are evenly distributed, the spaces between the plants being either bare or occupied usually by a small grass (*Poa sandbergii*). As a rule the surface of the soil is very light in color and a decidedly heavy loam in character. Alkali, while not noticeable at the surface, is abundant at a depth of 10 inches or 1 foot, and during most of the year the soil at a depth of 1 foot is moist, owing to the high alkali content, which inhibits the production of plant roots in this zone. Because of its compact character and high alkali content, land characterized by this plant is unsuited for irrigation agriculture, unless the alkali can be leached to some extent. During years of unusually well distributed rainfall land of this type will produce crops under dry-land culture, but it should not be regarded as productive dry-farm land. White sage is only grazed to a small extent, and the grazing value of this land is due to the associated grasses.

CREOSOTE BUSH (SOUTHERN DESERT SHRUB).

This type presents a much more varied appearance than the sagebrush desert. (Figs. 51 to 56.) The most important plants, creosote bush and mesquite, are shrubby, or sometimes the latter is treelike and continues growing through long periods of drought, having a much longer growing period than sagebrush. Yuccas, cacti, and spiny desert shrubs are prominent in many parts of this desert.

This desert occupies a comparatively narrow belt across the southern portion of the United States from the Pacific Ocean to the Gulf of Mexico. It does not occur to any extent north of the thirty-seventh parallel. Along the Virgin River in southern Utah this type reaches its most northerly limit. It is confined almost entirely to the Mohave Desert, the valleys of the Colorado, the Gila, the Rio Grande, and the Pecos. A small area of inland valley land in southern California, west of the main range, has also been included. The climatic conditions in this desert are more extreme than in any other portion of the country. The rainfall varies from about 2 to 20 inches, and the greater portion of the area receives less than 15 inches of rain. Over most of the area west of the Colorado River no rain falls during the hot summer months, the great portion occurring during the winter months. In other sections, on the contrary, especially those lying in Texas and New Mexico and the southeastern portion of Arizona, the rainfall during the summer is greater than that during the winter. Here grasses become relatively abundant. The temperature over all this area is high, often reaching 100° to 125° F. Over much of the area it rarely falls below 20° to 25° F., and the frost-free period usually ranges from 180 to 270 days. Because of the intense heat and the very rapid evaporation the conditions in portions of this area are more extreme for plant growth than in the northern desert shrub, although in many parts the wide spacing of the plants and the pervious nature of the soil combine to supply a quantity of available moisture sufficient to enable the desert shrubs to continue growing through extremely long periods of drought, in some cases lasting a year or more.

This desert is not sharply separated from the chaparral zone, into which it merges. On both the coast and the desert side of the mountains of California the great Adenostoma area of the chaparral zone lies just above areas of wild buckwheat or Encelia and California sagebrush, and these types, here classified with the southern desert, could with reason be placed with the chaparral. In the Mohave basin and in other portions of the southern desert the yucca-cactus type merges into the juniper. Shadscale pushes down into this desert from the north, and chamiso is common to both deserts, but is best developed in the southern desert. The line of demarcation between the southern desert shrub and the desert grassland is even more difficult to draw. Over great stretches of grassland are scattered shrubs or other large southern desert plants. On the map, areas dominated by shrubs have been placed in the southern desert, while areas which show only scattered shrubs over the grass cover have been mapped as desert grassland.

This shrub desert lies for the most part in a relatively frost-free area, and wherever water is available

Figure 51.—A dense, even stand of desert saltbush with plants about 4 feet high. (Creosote bush.) The uniform gray stretches of this plant resemble somewhat the sagebrush areas, and the plant is often called desert sage. Where the soil is poor or the moisture-supply deficient the plants are widely spaced. The type is limited largely to the bottom of valleys, but does not grow on soil which is subirrigated. A dense stand is characteristic of good agricultural land, of a soil of fine texture and containing a relatively slight amount of soluble salt. Indio, Calif.

Figure 52.—Creosote bush with a sparse growth of annuals. (Creosote bush.) The widely spaced plants are about 5 feet high. The thin, dark-green, lacquered foliage contrasts sharply with the light-gray color of the desert plantain, which forms an even cover following the winter rains. During the flowering period the bushes are covered with yellow flowers, which are soon replaced by conspicuous hairy fruits. Creosote bush usually draws its moisture supply from the deeper soil layers, and is therefore not dependent on an even distribution of rainfall. It is confined to soil relatively free from alkali. Near Indian Wells, Calif.

a highly specialized type of agriculture is developed. Production ranges widely from alfalfa and small-grain crops, produced as hay, to truck crops, citrus fruits, cotton, and dates. Cotton production in the West is confined largely to this desert, since both the long season and the warm climate are favorable. In the lower parts of the valleys, especially in Arizona and California, are grown the only dates produced in the United States, largely on land of the desert saltbush type.

Although most interesting from a botanical point of view, the southern desert shrub has not been studied in a sufficiently comprehensive way to enable one to present clearly the different types composing it. Over much of the area these types are recognized with difficulty, since there is often a great mixture of species. Viewed as a whole, the area is most often characterized by pure stands. Although it presents great diversity, it may be reduced to the following five main associations, with each of which a number of minor associations or associes may be correlated:

Desert saltbush (*Atriplex polycarpa*).
- Narrow leaf saltbush (*Atriplex linearis*).
- Desert saltbush–mesquite (*Atriplex polycarpa–Prosopis juliflora*).
- Chamiso (*Atriplex canescens*).

Creosote bush (*Covillea tridentata*).
- Creosote bush–bur sage (*Covillea tridentata–Franseria dumosa*).
- Black brush (*Flourensia cernua*).

Yucca-cactus.
- Yucca–cholla (*Yucca mohavensis–Opuntia bigelovii*).
- Joshua tree–wild buckwheat (*Clistoyucca brevifolia–Eriogonum fasciculatum*).
- Cactus–palo verde (*Carnegiea gigantea–Cercidium torreyanum*).
- Lechuguilla–sotol (*Agave lechuguilla–Dasylirion texanum*).

California sagebrush.
- California sagebrush–encelia (*Artemisia californica–Encelia farinosa*).
- Wild buckwheat (*Eriogonum fasciculatum*).

Mesquite (*Prosopis juliflora*).
- Cat's claw (*Acacia gregii*).
- Mesquite–chamiso (*Prosopis juliflora–Atriplex canescens*).
- Mesquite–rayless goldenrod (*Prosopis juliflora–Isocoma coronopifolia*).

Desert saltbush (fig. 51).—The desert saltbush type covers extensive areas in California, Nevada, and Arizona, where often it is referred to as desert sage. The uniform gray stretches of this plant (*Atriplex polycarpa*) somewhat resemble the sagebrush areas of the northern desert shrub. For the most part the plants occur in dense thickets from 3 to 4 feet high on fine loam soils well supplied with moisture, which is largely derived from drainage. On the poorer land, and on land from which there is a run-off or which receives only the normal rainfall, the moisture supply is insufficient to produce a dense stand, and scattered plants 2 or 3 feet high and widely spaced are characteristic. This type is limited largely to the valleys, where it occurs just above the salt desert shrub, on fine loam soils impregnated with a moderate amount of salt or alkali. The desert saltbush does not occupy land which is subirrigated. The agricultural value of land characterized by desert saltbush is probably greater than that occupied by any other type in the southern desert region, and much of the land now under irrigation was formerly thus characterized. A good growth of desert saltbush indicates a good deep soil of fine texture with a considerable amount of alkali. Under a system of careful irrigation this land is very productive.

Narrow-leaf saltbush.—Where conditions are relatively less favorable for plant growth, due to more compact subsoil with high salt content, the narrow-leaf saltbush (*Atriplex linearis*) is found. It occurs in southern Arizona below the desert saltbush and above the seepweed of the salt desert shrub.

Desert saltbush–mesquite (fig. 53).—If ground water or subsoil conditions are favorable for the growth of mesquite, scattered trees occur in the even cover of desert saltbush. This type is usually confined to the lower part of the desert-saltbush land in Arizona, Nevada, and California, and indicates conditions favorable for crop production under irrigation. Here the mesquite trees are often large, ranging from 15 to 30 feet in height. Sand ridges in the desert-saltbush area are often covered with chamiso (*Atriplex canescens*).

Figure 53.—An open stand of desert saltbush with scattered mesquite trees. (Creosote bush.) The wide spacing of the desert saltbush indicates a relatively deficient soil moisture supply, but the presence of the mesquite trees indicates water available in the subsoil due probably to a water table within reach of the roots. Las Vegas, Nev.

Creosote bush (fig. 52).—This type of vegetation is more extensive in the southern desert than any other type, and occupies the region lying between the desert saltbush and the yucca-cactus zone above. It is abundant in southeastern California, southern Nevada, western and southern Arizona, southern New Mexico, and extreme western Texas. The plants (*Covillea tridentata*) vary from a foot or two to 10 or 15 feet in height, depending on the unfavorable or favorable moisture supply, and are usually very widely spaced, the intervals varying from a few feet to 100 feet or more. In Arizona and California, following the winter rains, the spaces between the plants are covered with a rather dense growth of annuals, of which desert plantain (*Plantago erecta*) is one of the most frequent (fig. 54). The appearance of the whole is that of a widely spaced orchard of small trees or bushes. The plants consist of branches which radiate from near the ground and form a very open shrub. The shrub appears very dark green, almost black, as compared with the light desert soil and the silvery Plantago. In the western part of its range it usually indicates several feet of very permeable light soil, well drained, with low run-off, and with a relatively abundant supply of available moisture in the surface 3 to 6 feet of soil after the rainy period, which comes in winter in the Colorado Desert and both in winter and summer east of this region. In the early spring in the Colorado Desert the plants are covered with bright yellow flowers. During summer and autumn the plants retain their leaves but present a brownish appearance and remain in a condition of drought dormancy. This type indicates a relatively alkali-free soil. In respect to soil and alkali conditions it is similar to the sagebrush of the north desert shrub, and like the sagebrush reaches its best development on the alluvial fans which are often composed of coarse sand and gravel. In the eastern part of its range, under much heavier rainfall, it often indicates a very shallow soil and caliche.

In portions of Arizona, New Mexico, and Texas creosote bush forms a scattered growth over a relatively pure grassland sod. Such areas constitute a transition from the southern desert shrub to the mesquite grass or desert grassland.

Creosote bush–bur sage.—Above the areas of pure creosote bush in the Colorado Desert there may be distinguished a zone of varying width characterized by a mixture of the dark lacquer-leaved creosote bush and the low, light-gray bur sage (*Franseria dumosa* or *F. deltoides*). This type is not sharply differentiated from the yucca-cactus type.

Black brush.—In portions of Arizona, New Mexico, and Texas black brush (*Flourensia cernua*) constitutes the chief component of the vegetation. It lies either above or below the grassland, and occurs only on the better, deeper soils in the creosote-bush areas.

Yucca–cactus.—Lying above the creosote-bush zone there may be distinguished a broad zone made up largely of yuccas, century plants, cacti, palo verde, and related plants. It is varied in appearance and in botanical composition, and is characterized almost throughout its range by a greater mixture of species than is either the desert saltbush or creosote bush. For the most part it is found on the relatively rapidly eroding hills and ridges, the rough slopes, and low mountains of the southern desert region. Only rarely does it push down over the level stretches of the valleys, but reaches its lowest extension along the washes. Although the botanical composition varies considerably, this zone is set off sharply from all the other desert areas by the abundance of the yucca-like plants and cacti which here become prominent features of the vegetation. Very little of the land occupied by this type of vegetation is suitable for agriculture, and the grazing value of the natural vegetation is slight, although during periods of extreme drought cattle are able to subsist upon the relatively unedible plants which characterize this vegetation unit.

Yucca–cholla.—At higher elevations on the west and north side of the Colorado Desert, Mohave yucca (*Yucca mohavensis*) and cacti (*Ferocactus acanthoides*, *Opuntia bigelovii*, and *Opuntia acanthocarpa*), together with shrubs of bur sage (*Franseria dumosa*) and encelia (*Encelia farinosa*) constitute the major portion of the plant cover.

Figure 54.—Joshua trees and wild buckwheat. (Creosote bush.) The trees are about 25 feet high and present a unique appearance. The soil is loose and sandy and free from injurious amounts of alkali. Dry farming is seldom successful. Under irrigation the land is largely devoted to orchards. Hesperion, Calif.

Figure 55.—Giant cactus, cholla, visnaga, palo verde, ocotillo, and other plants. (Creosote bush.) A luxuriant phase of cactus-yucca vegetation found on rough or rocky land at the upper edge of the desert valleys. This vegetation presents a striking appearance due to the unusual character of the dominant plants. The land is not usually of agricultural value, due to its rough and uneven character. Chandler, Ariz.

Joshua tree–wild buckwheat (fig. 54).—In the Mohave Desert region the Joshua tree (*Clistoyucca brevifolia*) is one of the most picturesque plants. It forms trees of from 15 to 30 feet in height, spaced from 15 to 100 yards apart. Much of the ground is covered by wild buckwheat (*Eriogonum fasiculatum*) and similar low-growing shrubs. Juniper often pushes down into the area from the forest above, and creosote bush up into the area from the desert below. The moisture conditions under this type are relatively favorable, and the soil is light and pervious and free from harmful amounts of salt.

Cactus–palo verde (fig. 55).—The flora and appearance of the vegetation in central and southern Arizona is different from that in the Colorado and Mohave deserts. The vegetation in Arizona is largely palo verde (*Cercidium torreyanum*), cactus (*Carnegiea gigantea*, *Ferocactus wislizeni*, *Opuntia fulgida*, *O. mamillata*, *O. spinosior*, *O. echinocarpa*, and *O. acanthocarpa*), and ocotillo (*Fouquieria splendens*), with the smaller and less conspicuous bur sage (*Franseria dumosa* and *F. deltoides*). No portion of the southern desert is more varied or picturesque than this. The great columnar bodies of the giant cactus, the white, spiny, bushlike plants of the palo verde, the tall radiating stems of the ocotillo, and the annual flora following the rainy periods, combine to produce a vegetation of great variety and of unusual interest. The land is rough and the soil is rocky and consequently of little agricultural value.

Lechuguilla–sotol (fig. 56).—In New Mexico and the Big Bend country of western Texas the yuccalike plants and scattered shrubs constitute the dominant vegetation. Lechuguilla (*Agave lechuguilla*) is the most characteristic plant, but sotol (*Dasylirion texanum*) and other species and ocotillo (*Fouquieria splendens*) are also important. The soil is rocky for the most part and of little or no agricultural value. The value of this type for grazing depends largely upon the various grasses from the mesquite grasslands which occur scattered throughout this portion of the desert. During periods of drought the sotol is chopped open and cattle subsist on the thickened bases of the leaves, which are relatively high in sugar content and are considered exceptionally good emergency feed.

Figure 56.—Lechuguilla and sotol. (Creosote bush.) Many desert shrubs, a few cacti, and resurrection plants occur in this type. It is not agricultural land. Sanderson, Tex.

California sagebrush.—This type lies below the true chaparral zone and is limited in distribution. It is found in the dry interior valleys or slopes west of the Coast Range of southern California and extends over into the desert below the chaparral on the east side of the range and at higher elevations across southern Arizona. Much of the best irrigated orchard land of southern California was formerly covered with California sagebrush.

California sage–encelia.—On the drier slopes west of the mountains in California encelia (*Encelia farinosa*) forms dense thickets of gray broad-leaved shrubs from 2 to 4 feet high. On the more humid slopes this plant is replaced by California sagebrush (*Artemisia californica*) of about the same size, but with very fine foliage of darker color. During the winter rainy season and in early spring there are many showy flowering herbs. The soil is moistened during this period to a depth of 6 feet or more, and growth continues usually until about midsummer, when this stored moisture is exhausted.

Wild buckwheat.—On especially dry hills below the chaparral on the coast side of the mountains and above the creosote-bush zone on the desert side, pure stands of wild buckheat (*Eriogonum fasiculatum*) cover large areas.

Mesquite.—While mesquite is scattered throughout the southern desert from the Pacific coast to the Gulf of Mexico, it is relatively more important in the eastern portion than in the western. In New Mexico and Arizona the mesquite often constitutes the principal type in the subirrigated valleys. In the extreme western part of the Colorado Desert mesquite thickets occur only rarely and are relatively insignificant.

Cat's claw.—Extensive thickets of cat's claw, practically impenetrable because of the sharp, recurved spines, occur in Texas and portions of New Mexico.

Mesquite–chamiso.—In southern Arizona, New Mexico, and California isolated sandy ridges are usually covered by mesquite (*Prosopis juliflora*) and chamiso (*Atriplex canescens*). In the western part of the desert dunes are often built up around the mesquite trees, which become more and more submerged, only the tips of the branches protruding. On these new areas chamiso is the principal shrub.

Mesquite–rayless goldenrod.—In portions of Arizona, New Mexico, and California the vegetation consists of scattered low shrubs of rayless goldenrod (*Isocoma coronopifolia*) with small trees of mesquite. This type probably represents land on which the original shrub vegetation has been destroyed and replaced by rayless goldenrod.

GREASEWOOD (SALT DESERT SHRUB).

Within the Great Basin the drainage is often entirely hemmed in by mountain ranges and the salts leached from the soil accumulate in the lower valleys. This is especially true of areas which are characterized by ground or artesian water. The water rises to the surface and by evaporation deposits its load of soluble salts to form salt flats. Even beyond the Great Basin region, in arid sections salts accumulate along the drainage channels and in the bottom lands. Alkali areas are, as a rule, not very extensive, and their extent and distribution can only be indicated on the map. Almost every drainage channel in the arid portions of the United States is lined with a narrow strip of alkali vegetation, and similar vegetation is found on the small salt flats along the coasts. The soils occupied by this type of vegetation are usually moist, but excessively supplied with salts. These salts are usually referred to as alkali, of which there are two types—white alkali and black alkali. The principal salts of white alkali are common salt (sodium chloride), Glauber's salt (sulphate of soda), Epsom salts (sulphate of magnesium), and bittern (magnesium chloride). These salts crystallize on the surface to form a white deposit known as "white alkali." Black alkali is composed of sal soda (carbonate of soda), and known as "black alkali" because of its corrosive action on organic matter. Where it occurs the leachings are dark in color and the deposited salt contains enough organic matter to give it a dark color. Black alkali is much more harmful to vegetation than white alkali.

In appearance this desert shrub varies with the particular type of vegetation represented (figs. 57 to 60). It may present the uniform shrublike growth of pure greasewood, deep green during the growing period, but gray and monotonous during the drought or winter rest period; or a barren white salt surface with only here and there a dark green plant of samphire or pickleweed; or a grass cover with scattered tall plants of rabbit brush; or lawnlike areas of pure salt grass.

The salt desert shrub may be reduced to three main associations, with each of which may be grouped a number of minor associations or associes:

Greasewood (*Sarcobatus vermiculatus*).
- Greasewood-shadscale (*Sarcobatus vermiculatus–Atriplex confertifolia*).
- Seepweed (*Dondia torreyana*).

Pickleweed (*Allenrolfea occidentalis*).
- Samphire (*Salicornia authensis, S. rubra, S. ambigua*).

Saltgrass (*Distichlis spicata*):
- Tussock grass (*Sporobolus airoides*).
- Rabbit brush (*Chrysothamnus graveolens*).
- Alkali heath (*Frankenia grandiflora campestris*).

Greasewood (fig. 57).—Greasewood plants (*Sarcobatus vermiculatus*) are evenly spaced, from 4 to 7 feet apart, and range from 2 to 5 feet in height. The plants are green in color, due to the succulent leaves, and when in full leaf present a relatively luxuriant appearance, contrasting sharply with the gray of the shadscale or sagebrush. The soil between the plants is often covered with little or no perennial growth. Greasewood is widely distributed, ranging throughout the northern and much of the southern desert. The most extensive areas are usually only a few miles across and lie near the bottom of the valleys or along drainage channels. Land of this type contains harmful amounts of salt and is usually supplied with ground water during a part of the year. It has been successfully irrigated, and much of the best agricultural land of the lower portions of the Great Basin previously bore this type of vegetation.

Greasewood–shadscale.—Between the northern desert shrub and the salt desert shrub in the Great Basin

Figure 57.—Greasewood in a semidormant condition. (Greasewood.) Characteristic of moist, moderately saline soils. It is gray and sagelike in winter and bright green during the growth period. The luxuriant growth is deceptive, since the soluble salt-content of the soil is so high that only with leaching and careful irrigation can the land be made productive. It is characteristic of the bottom of the valleys, where for the most part ground water furnishes part of the moisture supply. The transition from this type to the shadscale is usually very gradual. Lund, Utah.

Figure 58.—A pure stand of seepweed, characteristic of moist, strongly saline soils, where the ground water rises to or near the surface. (Greasewood.) Plants are about 3 feet high, and commonly purple in color, especially late in the season. The amount of salt in the soil is usually greater than in soils growing greasewood, and the land is of doubtful agricultural value. Thermal, Calif.

region, greasewood (*Sarcobatus vermiculatus*) is often scattered through an even stand of shadscale (*Atriplex confertifolia*). The appearance is varied, since the shadscale plants are ashen in color and the greasewood plants bright green. The condition indicated is intermediate between pure shadscale and pure greasewood, namely, a soil containing alkali in the second or third foot but with ground water limited to the deeper soil, not available to the shadscale but available at least during a part of the year to the deep-rooted greasewood.

Figure 59.—A salt flat with scattered hummocks of pickleweed. (Greasewood.) Green plants contrast sharply with salt-covered soil. Soil contains 2 or more per cent of soluble salts. Lower Death Valley, California.

Seepweed (fig. 58).—Throughout the entire range of the salt desert shrub, seepweed (*Dondia torreyana*) occupies land nearer the local water level and a little higher in salt content than that occupied by greasewood. The plants range in height from 1 to 4 feet, are very finely branched, and often purple or dark in color, especially in the latter part of the growing season.

Pickleweed (fig. 59).—On the great salt-flats hummocks of pickleweed (*Allenrolfea occidentalis*) occur, while on soil more favorable for plant growth the plants may have an even distribution and form a relatively close cover. In the southern desert region the plants are often 3 or 4 feet high, but as a rule are much smaller in the northern desert region. They are of dark-green color and very succulent. This type occurs at a lower level than the greasewood and on soil which contains more moisture and is more strongly impregnated with salts. The conditions, therefore, are much more extreme than those indicated either by greasewood or seepweed. Over much of the surface salt incrustations give the soil an almost snowlike appearance. Large areas occur near Salt Lake, and on the alkali flats in Nevada, Arizona, southeastern California, and in the San Joaquin Valley.

Samphire (fig. 60).—Conditions very similar to those indicated by pickleweed are found where the samphire grows. The soil contains as a rule about 2.5 per cent of soluble salt and usually is supplied with ground water at a relatively short distance below the soil surface. The conditions are the most extreme encountered under any type of vegetation in the salt desert shrub. In the region about Great Salt Lake, where it is widely distributed, it is composed of the perennial Utah samphire (*Salicornia utahensis*) and the annual red samphire (*Salicornia rubra*). The annual form is greatly favored by precipitation which leaches slightly the surface soils, and germination is usually best along the drainage channels. The perennial form occurs on scattered hummocks or may form a practically pure even stand. The appearance of the two species is very different, since the annual is a bushlike plant 2 to 6 inches high, which turns very red toward the end of the growing season, while the perennial pushes up almost unbranched stems and does not take on an autumn coloration. Along the coast the salt marshes are similar to the inland areas, but are usually inundated at high tide by ocean water, and are dominated by a different species (*Salicornia ambigua*). These areas are too limited to be shown on the map.

Salt grass.—Alkali flats, especially those over which during flood time a supply of fresh water flows, usually develop a salt-grass cover. Salt grass (*Distichlis spicata*) is a low-growing grass and forms either an open cover with occasional plants from underground runners showing at the surface, or under more favorable conditions a uniform dense sod, in which few other species are prominent. Salt-grass pastures miles in extent occur along many of the watercourses in the Great Basin, the Colorado and Rio Grande deserts, east of the mountains on the Great Plains, in the San Joaquin Valley, and along the coasts. The appearance of this type of vegetation is not markedly different from that of a closely grazed meadow, or of the plains or desert grassland. The principal value of land of this type is for grazing. Only with careful management and some leaching does it produce crops under irrigation. The salt content is generally high (about 1 per cent). The soil moisture is supplied from ground water as well as by flood water and precipitation.

Tussock grass.—Under conditions a little more favorable than those found on salt-grass land, tussock grass (*Sporobolus airoides*) forms either a relatively close sod or a hummocky open cover. This grass is usually closely grazed by rabbits

Figure 60.—Hummocks of Utah samphire on salt flat. (Greasewood.) Characteristic of continuously moist salt flats containing 2 or more per cent of soluble salt. Great Salt Lake, Utah.

and by cattle and horses and contributes materially to the forage production of the region. If not grazed closely this grass is marked by a feathery purple panicle during the flowering period.

Rabbit brush.—In many places rabbit brush (*Chrysothamnus graveolens*) is scattered over a tussock-grass sod, and often becomes so dense that only the brush is evident. The yellow-flowered shrubs stand from 2 to 5 feet high; they grow rapidly and are relatively short-lived.

Alkali heath.—In the San Joaquin Valley alkali heath (*Frankenia grandiflora campestris*), pure or mixed with greasewood or salt grass, is one of the most important salt desert plants.

THE COMMON NAMES OF PLANTS USED IN THIS SECTION OF THE ATLAS AND EQUIVALENT SCIENTIFIC NAMES.

Alkali heath	*Frankenia grandiflora campestris* Gray.
Alligator juniper	*Juniperus pachyphloea* Torr.
Alpine fescue	*Festuca brachyphylla* Schult.
Alpine fir	*Abies lasiocarpa* (Hook.) Nutt.
Alpine larch	*Larix lyallii* Parl.
Alpine nigger wool	*Carex elynoides* Holm.
Annual brome	*Bromus tectorum* L.
Annual fescue	*Festuca octoflora* Walt.
Arizona cypress	*Cupressus arizonica* Greene.
Aspen	*Populus tremuloides* Michx.
Balsam fir	*Abies balsamea* (L.) Mill.
Balsam-root	*Balsamorrhiza sagittata* (Pursh) Nutt.
Barrel cactus	*Ferocactus acanthoides* (Lemaire) Britton and Rose.
Basket oak	*Quercus prinus* L.
Bear grass	*Nolina microcarpa* S. Wats.
Beech	*Fagus grandifolia* Ehrh.
Beggar's tick	*Lappula occidentalis* (S. Wats.) Greene.
Big rabbit brush	*Chrysothamnus nauseosus* (Pursh) Britton.
Bitterbrush	*Purshia tridentata* (Pursh) DC.
Bitternut	*Hickoria cordiformis* (Wang.) Britton.
Black brush	*Flourensia cernua* DC.
Black cherry	*Prunus serotina* Ehrh.
Black grama	*Bouteloua eriopoda* (Torr.) Torr.
Black gum	*Nyssa sylvatica* Marsh.
Black jack oak	*Quercus marilandica* Muench.
Black spruce	*Picea mariana* (Mill.) B. S. P.
Black walnut	*Juglans nigra* L.
Blue joint grass	*Calamagrostis canadensis* (Michx.) Beauv.
Bluestem	*Andropogon furcatus* Muhl.
Box elder	*Acer negundo* L.
Bristle-cone pine	*Pinus aristata* Engelm.
Broom sedge	*Andropogon glomeratus* (Walt.) B. S. P.
Broom sedge	*Andropogon saccharoides* Swartz.
Bunch grass	*Andropogon scoparius* Michx.
Bud sage	*Artemisia spinescens* D. C. Eaton.
Buffalo grass	*Bulbilis dactyloides* (Nutt.) Raf.
Bur clover	*Medicago hispida* Gaertn.
Bur sage	*Franseria dumosa* A. Gray.
Bur sage	*Franseria deltoidea* Torr.
Bush morning-glory	*Ipomoca leptophylla* Torr.
California needle grass	*Stipa pulchra* Hitchc.
California poa	*Poa scabrella* (Thurb.) Benth.
California poppy	*Eschscholtzia california* Cham.
California sagebrush	*Artemisia californica* Less.
California scrub oak	*Quercus dumosa* Nutt.
Cane cactus	*Opuntia arborescens* Engelm.
Cat's claw	*Acacia greggii* A. Gray.
Cat tail	*Typha latifolia* L.
Chamiso	*Atriplex canescens* (Pursh) Nutt.
Chestnut	*Castanea dentata* (Marsh.) Borkh.
Chestnut oak	*Quercus montana* Willd.
Cholla	*Opuntia bigelovii* Engelm.
Cholla	*Opuntia echinocarpa* Engelm. & Bigel.
Cholla	*Opuntia acanthocarpa* Engelm. & Bigel.
Cholla	*Opuntia fulgida* Engelm.
Cholla	*Opuntia spinosior* (Engelm. and Bigel.) Toumey.
Coleogyne	*Colcogyne ramosissima* Torr.
Cork-bark fir	*Abies arizonica* Merriam.
Cottonwood	*Populus balsamifera* Linn.
Creosote bush	*Covillea tridentata* (Moc. & Sesse) Vail.
Crowfoot grama	*Bouteloua rothrockii* Vasey.
Curly mesquite	*Hilaria belangerii* Steud.
Desert plantain	*Plantago erecta* Morris.
Desert saltbush	*Atriplex polycarpa* S. Wats.
Douglas fir	*Pseudotsuga macronata* (Raf.) Sudw.
Emory oak	*Quercus emoryi* Torr.
Encelia	*Encelia farinosa* A. Gray.
Engelmann spruce	*Picea engelmann* Engelm.
False needle grass	*Scleropogon brevifolius* Phil.
Filaree	*Erodium cicutarium* (L.) L'Hér.
Foxtail	*Hordeum murinum* L.
Galleta grass	*Hilaria jamesii* (Torr.) Benth.
Giant cactus	*Carnegiea gigantea* (Engelm.) Britton and Rose.
Grama grass	*Bouteloua gracilis* (H. B. K.) Lag.
Greasewood	*Sarcobatus vermiculatus* (Hook.) Torr.
Ground daisy	*Townsendia exscapa* (Richards.) Porter.
Gum weed	*Grindelia squarrosa* (Pursh) Dunal.
Hemlock	*Tsuga canadensis* (L.) Carr.
Highland live oak	*Quercus wislizeni* A. DC.
Holly-leaf cherry	*Prunus ilicifolia* (Nutt.) Walp.
Honey locust	*Gleditsia triacanthos* L.
Hop sage	*Grayia spinosa* (Hook.) Moq.
Horseweed	*Erigeron canadense* L.
Incense cedar	*Libocedrus decurrens* Torr.
Indian grass	*Sorghastrum nutans* (L.) Nash.
Indian rice	*Zizania aquatica* L.
Indian rice	*Zizania palustris* L.
Jack pine	*Pinus banksiana* Lamb.
Jeffrey pine	*Pinus jeffreyi* "Oreg. Com."
Joshua tree	*Clistoyucca brevifolia* (Engelm.) Rydb.
June grass	*Koeleria cristata* (L.) Pers.
Lechuguilla	*Agave lechuguilla* Torr.
Live oak	*Quercus agrifolia* Née.
Little bunch grass	*Festuca idahoensis* Elmer.
Little rabbit brush	*Chrysothamnus stenophyllus* (A. Gray) Greene.
Loblolly pine	*Pinus taeda* L.
Lodgepole pine	*Pinus contorta* Loud.
Longleaf pine	*Pinus palustris* Mill.
Lowland white fir	*Abies grandis* Lindl.
Mangrove	*Rhizophora mangle* L.
Manzanita	*Arctostaphylos glauca* Lindl.
Marsh grass	*Spartina alterniflora glabra* (Muhl.) Fernald.
Marsh grass	*Spartina patens* (Ait.) Muhl.
Match weed	*Gutierrezia sarothrae* (Pursh) Britton & Rusby.
Mesquite	*Prosopis juliflora* (Swartz) DC.
Mexican piñon	*Pinus cembroides* Zucc.
Mockernut	*Hicoria alba* (L.) Britton.
Mohave yucca	*Yucca mohavensis* Sargent.
Mountain mahogany	*Cercocarpus parvifolius* Nutt.
Mountain sage	*Artemisia frigida* Willd.
Muhlenbergia	*Muhlenbergia gracillima* Torr.
Narrow-leaf saltbush	*Atriplex linearis* S. Wats.
Needle grass	*Stipa spartea* Trin.
Nigger wool	*Carex filifolia* Nutt.
Noble fir	*Abies nobilis* Lindl.
Northern white cedar	*Thuya assingialia* L.
Norway pine	*Pinus resinosa* Ait.
Ocotillo	*Fouquieria splendens* Engelm.
One-seeded juniper	*Juniperus monosperma* (Engelm.) Sarg.
Overcup oak	*Quercus lyrata* Walt.
Painted brush	*Castilleja occidentalis* Torr.
Palo verde	*Cercidium torreyanum* (S. Wats.) Sarg.
Paper birch	*Betula papyrifera* Marsh.
Pasque flower	*Pulsatilla hirsutissima* (Pursh) Britton.
Pennyroyal	*Hedeoma hispida* Pursh.
Phlox	*Phlox hoodii* Richards.
Pickleweed	*Allenrolfea occidentalis* (S. Wats.) Kuntze.
Pignut	*Hicoria glabra* (Mill.) Britton.
Piñon	*Pinus edulis* Engelm.
Pitch pine	*Pinus rigida* Mill.
Plains plantain	*Plantago purshii* Roem. & Schult.
Poa	*Poa sandbergii* Vasey.
Polygonum	*Polygonum bistortoides* Pursh.
Pond pine	*Pinus serotina* Michx.
Post oak	*Quercus stellata* Wangen.
Prickly pear	*Opuntia lindheimeri* Engelm.
Psoralea	*Psoralea tenuiflora* Pursh.
Purple cone-flower	*Echinacea angustifolia* DC.
Rabbit brush	*Chrysothamnus graveolens* (Nutt.) Greene.
Rayless goldenrod	*Isocoma coronopifolia* (A. Gray) Greene.
Red bay	*Persea borbonia* (L.) Spreng.
Red brome	*Bromus rubens* L.
Red fir	*Abies magnifica* Murr.
Red gum	*Liquidambar styraciflua* L.
Red maple	*Acer rubrum* L.
Red oak	*Quercus borealis maxima* (Marsh.) Ashe.
Red samphire	*Salicornia rubra* A. Nels.
Red spruce	*Picea rubens* Sarg.
Reed canary grass	*Phalaris arundinacea* L.
River birch	*Betula nigra* L.
Rock sedge	*Carex rupestris* All.
Rocky Mountain red cedar	*Juniperus scopulorum* Sarg.
Rocky Mountain scrub oak	*Quercus undulata* Torr.
Sacaton	*Sporobolus wrightii* Munro.
Sagebrush	*Artemisia tridentata* Nutt.
Salt grass	*Distichlis spicata* (L.) Greene.
Salt sage	*Atriplex corrugata* S. Wats.
Salt sage	*Atriplex nuttallii* S. Wats.
Samphire	*Salicornia ambigua* Michx.
Sand grass	*Calamovilfa longifolia* (Hook.) Hack.
Sand sage	*Artemisia filifolia* Torr.
Sand sporobolus	*Sporobolus cryptandrus* (Torr.) Gray.
Sawgrass	*Cladium jamaicense* Crantz.
Scabland sage	*Artemisia rigida* A. Gray.
Scrub or Gambel oak	*Quercus gambelii* Nutt.
Scrub piñe	*Pinus virginiana* Mill.
Seepweed	*Dondia torreyana* (S. Wats.) Standley.
Serviceberry	*Amelanchier alnifolia* Nutt.
Shadscale	*Atriplex confertifolia* (Torr.) D. Wats.
Shin oak	*Quercus havardii* Rydb.
Shortleaf pine	*Pinus echinata* Mill.
Silver fir	*Abies amabilis* (Loud.) Forb.
Silver maple	*Acer saccharinum* L.
Silvery psoralea	*Psoralea argophylla* Pursh.
Single-leaf piñon	*Pinus monophylla* Torr. & Frem.
Sitka spruce	*Picea sitchensis* (Bong.) Trautv. & Meyer.
Six-weeks grama	*Bouteloua aristidoides* (H. B. K.) Griseb.
Six-weeks needle grass	*Aristida adscensionis* L.
Slash pine	*Pinus caribaea* Morelet.
Slender wheat grass	*Agropyron tenerum* Vasey.
Slough grass	*Spartina michauxiana* Hitchc.
Small sage	*Artemisia nova* A. Nels.
Soapweed	*Yucca glauca* Nutt.
Soft chess	*Bromus hordeaceus* L.
Sotol	*Dasylirion texanum* Scheele.
Sugar maple	*Acer saccharum* Marsh.
Sugar pine	*Pinus lambertiana* Dougl.
Sumac	*Rhus laurina* Nutt.
Sycamore	*Platanus occidentalis* L.
Switch grass	*Panicum virgatum* L.
Tamarack	*Larix laricina* (Du Roi) Koch.
Tasajillo	*Opuntia leptocaulis* DC.
Tobosa grass	*Hilaria mutica* (Buckl.) Benth.
Tule	*Scirpus validus* Vahl.
Tupelo gum	*Nyssa aquatica* L.
Tussock grass	*Sporobolus airoides* Torr.
Utah juniper	*Juniperas utahensis* (Engelm.) Lemmon.
Utah samphire	*Salicornia utahensis* Tidestrom.
Valley oak	*Quercus lobata* Née.
Viznaga	*Ferocactus wislizeni* (Engelm.) Britton & Rose.
Water ash	*Fraxinus caroliniana* Mill.
Water grass	*Paspalum* sp.
Water oak	*Quercus nigra* L.
Western hemlock	*Tsuga heterophylla* (Raf.) Sarg.
Western larch	*Larix occidentalis* Nutt.
Western needle grass	*Stipa comata* Trin. & Rupr.
Western red cedar	*Thuja plicata* Don.
Western wheat grass	*Agropyron smithii* Rydb.
Western white pine	*Pinus monticola* Dougl.
Western yellow pine	*Pinus ponderosa* Laws.
Wheat grass	*Agropyron svicatum* (Pursh) Scribn. & Smith.
White-bark pine	*Pinus albicaulis* Engelm.
White bay	*Magnolia virginiana* L.
White elm	*Ulmus americana* L.
White fir	*Abies concolor* (Gord.) Parry.
White mountain lily	*Leucocrinum montanum* Nutt.
White pine	*Pinus strobus* L.
White sage	*Kochia americana vestita* S. Wats.
White spruce	*Picea glauca* (Moench) Voss.
Wild buckwheat	*Eriogonum fasciculatum* Benth.
Wild lilac	*Ceanothus hirsutus* Nutt.
Wild oat	*Avena barbata* Brot.
Wild oat	*Avena fatua* L.
Wild onion	*Allium textile* Nels. & Macbr.
Wild rye	*Elymus condensatus* Presl.
Winter fat	*Eurotia lanata* (Pursh) Moq.
Wire-grass	*Aristida longiseta* Steud.
Yarrow	*Achillea millefolium* L.
Yellow birch	*Betula lutea* Michx. f.
Yellow oak	*Quercus velutina* Lam.
Yellow poplar	*Liriodendron tulipifera* L.
Yucca	*Yucca elata* Engelm.

Common names have little more than local significance; the same plant may be known by many different names, and the same name applied to many different plants. We have attempted to use the names applied in the sections in which these plants occur. Other equally good names could have been used. The word "sage" is generally applied in the desert region to any plant with light-colored foliage. Sage and sagebrush are often used for plants which should more properly be called saltbush.

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