This article tells how native plants can be used under some conditions as a guide to the nature of the soil; describes the plant and soil correlations throughout the United States; and lists plants that indicate soil moisture conditions, good agricultural or grazing land, and (in the West) land that is good, medium, or poor for small grains, forage, and grazing.

Plants as Soil Indicators

By H. L. Shantz

The plant cover, if properly interpreted, can be used as an indicator of the climatic conditions under which it was produced, of the soils on which it grew, and of the practices of grazing or other use to which it has been subjected. It is of value in the rapid classification of land as to climatic conditions, soil types, soil texture, soil chemical composition, the value of soil for crop production under natural rainfall or under irrigation, the value of the land for grazing with domestic stock or wild animals, and the value for wildlife food production. It may also indicate the amount of overuse to which vegetation has been subjected, the kind of animal responsible for this overuse, and the degree of destruction of the soil profile on which the vegetation is growing.

Plant cover has been used by primitive man as a guide to the choice of the most productive land for crop production, by early settlers in the choice of the best croplands and grazing lands, and, in reconnaissance soil surveys, to note boundaries where soils change from one type to another (figs. 1 and 2). It was used as a rapid means of land classification in classifying lands under the 640-acre homestead law. Observations on crop production or methods of culture at any experiment station can be applied beyond the point at which they have been worked out if the natural vegetation is exactly similar in the new location.

Close Relationship Between Plants and Soils

As a result of rainfall on the land surface of the earth, a plant cover has developed in physiological and ecological balance with the climatic conditions and the substratum. The interaction of climate and

1 H. L. Shantz is Chief of the Division of Wildlife Management, Forest Service.
FIGURE 1.—The value of vegetation in indicating alkali in the soil. The vegetation at the left is white sage on soil strongly impregnated with salt, that on the right, sagebrush on good land free of harmful amounts of alkali.

vegetation cover modified the surface earth materials, and this surface developed a structure and composition which has been recognized in soil science as the soil profile. Like the great belts of soil series, the great world-wide plant communities are distributed in large zones. Since soil series are the result of interaction of climate and vegetation, plant communities are often closely correlated with the developed soil and often quite independent of the parent material from which the soil was originally formed.

The vegetation cover of the earth's surface made possible a varied animal population, adapted in every particular to this basic food supply. Man has depended in large part on the natural plant cover to furnish his food, building materials, and clothing, and to supply feed for game animals, fish, and flocks of domestic animals. Even today the grasslands and forests, little modified, furnish man a great proportion of his timber, wool, and meat, as well as hides and skins. This natural land use is being increasingly recognized as an important part of any land-use program from the standpoint of a long-time security.

In the classification of soils, only soil characteristics should be considered, and in the classification of vegetation, only characteristics strictly limited to vegetation. These independent groupings can then
Plants as Soil Indicators

FIGURE 2.—The effect of plowing and a disturbed surface of soil on plant cover.
At the right, typical short grass (blue grama and buffalo grass).
At the left, wire grass (red three-awn), which has come in as a result of breaking about 10 years before.

be compared. Plant communities can be correlated with soil series, climatic provinces, and agricultural regions.

Ecology studies the relation of a plant to its environment, as well as the morphology and physiology of the plant, but it is also interested in mass vegetation or, in other words, in plants grouped together into communities. These plant communities have been studied and classified into a more or less elaborate system. The groups are designated as formations, associations, societies, etc. It is necessary to recognize in vegetation the essential features that define a plant association or a plant formation, just as it is necessary in soils to recognize the properties that define a soil type or a soil series.

The great plant communities (formations and associations) are relatively independent of such factors as physical composition of the soil, while the smaller or minor communities are often directly affected by such factors. Soil provinces are relatively independent of such factors as physical composition of the parent material, but the soil types are often affected by this factor. In other words, soil units are closely associated with small vegetation communities (societies) and soil provinces with great communities (formations or associations).

While the correlation of plant communities and soil series or types may be relatively exact, there are basic differences between soil de-
Development and plant successions. Climate does not affect any two plants in exactly the same way, nor does it affect sand and clay in exactly the same degree. The plants are adjusted rather exactly to temperature, moisture, and even light conditions. The same is true, but in a somewhat different sense, of soils. Examples of a few of these differences will explain the lack of exact overlapping of plant communities and soil provinces or soil series.

In general, sandy soils more rapidly develop into a mature soil than loams and clays, since leaching is more easily effected. With plant communities, however, the sands are usually occupied with the earlier or less fully developed stages of plant succession. Sand is also an equalizer when the physiological conditions of soil moisture that affect the plant are considered. In a region of heavy rainfall, drainage in sand is so rapid that the plant is left in a moist soil with plenty of aeration. In regions of little rainfall the scant moisture supply passes rapidly into the soil which, because of low water-holding capacity, allows it to penetrate much deeper than in a heavier soil, and this moisture is protected from evaporation loss by the sand layer above. The soil moisture under both conditions is almost identical. Therefore, eastern (humid) species push far into the semidesert country on sandy lands, and the semidesert types far into the humid country on sand. The effect of the climatic conditions on soil development in the two areas is distinctly different, however, since leaching is proportionate to rainfall, and in addition, in the semidesert country, sand shifts about because it is less securely held in place by a plant cover.

Another factor, rainfall, translated into soil moisture, affects soils and vegetation in a somewhat different way. In North Dakota a ton of alfalfa can be produced with 500 tons of water, while on the Panhandle of Texas 1,000 tons would be required. Small grains generally require twice as much water in Texas to produce a ton of dry matter as in North Dakota. From the standpoint of soil development, however, the higher temperature in Texas, which is partly the cause of higher water use by plants, increases the solvent action of water, which tends to produce a greater reaction on the soil and thus hastens profile development. In Texas, conditions of soil moisture equal to those in Dakota from the standpoint of plant growth should have nearly twice the effectiveness in leaching the soil and increasing the depth to the carbonate layer. The observed correlation of vegetative communities on the High Plains is explained by these considerations. The Chernozem belt lies more wholly within the tallgrass and wire-grass belts in Nebraska and Kansas, but swings west in Texas until more than half its width is in short-grass vegetation. Soil provinces swing farther to the west or drier side in the South while plants swing farther to the west or dry side in the North. This lack of an exact correlation is inherent and affords a very interesting and valuable point of attack on both soil and vegetation problems.

If the map of the vegetation (fig. 3) and the soil map at the end of the Yearbook are compared, it is evident that, although the maps were drawn independently with no attempt to reconcile boundaries, there is a striking similarity.
On a broad basis the deciduous and coniferous forests and the prairie grasslands occur on soils of the Pedalfer group (354). Here water passes continually through the soil to the water table, the soils are moist during most of the year, and the subsoil is permanently moist. The true prairie, the Plains and desert grasslands, and the northern and southern shrub deserts are limited to the Pedocals. Here the rainfall is not sufficient to furnish the surface soils with

\[ \text{Italic numbers in parentheses refer to Literature Cited, p. 1181.} \]
more moisture than is utilized by the vegetation. The subsoils are permanently dry and mineral matter is not lost beyond the reach of the roots as is the case in the Pedalfers. Drought is always a factor and the growing season is usually shortened materially by lack of available soil water. These soils are rich in mineral matter. Where a water table comes near enough to the soil surface to enable water to rise to the surface by capillarity, salts are left behind by the evaporation of water, and the area is changed into a salt desert. Black alkali (carbonate of soda) and white alkali (sodium and magnesium sulphates and chlorides) are characteristic of the moist soils of the greasewood or salt-desert shrub areas of the West.

**VEGETATION TYPES AS INDICATORS OF SOIL SERIES**

**Spruce-Fir (Northern Coniferous Forest)**

This forest is found in the East in northern New England, New York, the higher portion of the Alleghenies, and the northern portion of the Lakes States, and in the West in the higher Cascades, Sierras, and northern and southern Rockies. In the West and on the Alleghenies it is found at high elevations, but in New England and the Lakes States it is characteristic of low, flat, acid lands. The eastern forest is chiefly red and black spruce, balsam fir, tamarack, and white cedar. There is often too little light at the forest floor for a ground cover to develop, but when it does it is usually of ericaceous and other plants which thrive in an acid, raw, humous soil. The biological characteristics of the various spruce-fir areas are similar.

Such observations as have been made in the West and studies in the East indicate a Podzol soil or raw material that is gradually being developed into a Podzol profile under the spruce-fir forest. Characteristic soils include Hermon, areas of peat and muck, Beltrami, Ontonagon, Dekalb, and Summersville. (For descriptions of the soil series, see Soils of the United States, p. 1019.)

**White, Red, and Jack Pines (Northeastern Pine Forest)**

This forest is confined largely to the Lakes States. White pine is scattered with hardwoods in New England and in New York, and white pine and eastern hemlock in the Alleghenies. The most extensive forest of white pine was on the sandy soils of Michigan. Jack pine is confined to the poorer sandy soils. Red pine occurred for the most part on light soils, while white pine occupied the better, or relatively heavier soils, or was mixed with the hardwoods.

Except for a few areas of good soils, this forest occupies land that has failed for agricultural use. It lies in the hay and dairying agricultural region (27), but the areas formerly occupied by the forest are marked out as nonproductive even on maps showing hay production. These areas were, however, of great value for forest production. Bad management has resulted in loss of the original stands and, with repeated fires, all or nearly all of the surface humus. To bring about a return to productivity may take many years.

In places this pine forest marks a true Podzol such as the Hermon, but more often it is not fully developed. Even as far south as New Jersey the sands occupied by pitch and shortleaf pine are Podzolic in structure. Hermon, Dekalb, and Beltrami, especially the lighter, more nearly Podzol types, are indicated by the northeastern pine forests. In the Alleghenies of Pennsylvania, great forests of white pine and hemlock also occurred on Podzolic soils of Dekalb-Lectonia and similar types.

**Birch, Beech, Maple, or Hemlock (Northeastern Hardwoods)**

This forest varies considerably in composition. Great hardwoods such as sugar maple, beech, and yellow birch, with a forest floor of dogwood, blueberry, and ericaceous plants, ferns, and mosses, beech forests, and beech-maple forests have
largely disappeared to make room for the hay and dairying region of the United States. This forest is typical of the Lakes States, New England, and New York, and is also found in favorable locations in the Alleghenies as far south as Georgia. The soils under the forest are podzolic, including the less fully developed, such as Caribou and Dekalb, and the Gray-Brown Podzolic soils, such as Gloucester, Lordstown, Volusia, Muskingum, and Superior.

**Oak (Southern Hardwood Forest)**

The larger part of the eastern deciduous forest is characterized by oak, of which there are many species. This forest differs from the beech, birch, and maple in that it is less likely to be characterized by an creaceous ground cover and is not as a rule so cool and dark. For the most part, the area corresponds to that of the Gray-Brown Podzolic soils. In the Southeast, if the oak-pine type is excluded, the forest and soil province boundaries are fairly close. The oak forest may be divided into three large subdivisions.

**Chestnut, Chestnut Oak, and Yellow Poplar**

This forest, one of the most extensive and especially interesting, has lost its principal member, the chestnut, as a result of disease and would now be more properly known as the chestnut-oak and yellow poplar forest. It extends from southern New England, New York, and Pennsylvania south on both sides of the Alleghenies across North Carolina and Tennessee and into northern Mississippi, Alabama, and Georgia. It includes a greater number of important species than are found in any other American forest.

This forest has given way to farm land over large areas and its soils have been mapped and studied to a greater degree than the northern coniferous and hard-wood forest lands. It lies largely in the Gray-Brown Podzolic soil region and includes the northern part of the Red and Yellow Podzolic soils. A large number of soils are included, but all are similar in character. Among the more important are the Chester soils of the Piedmont of Virginia, Maryland, Pennsylvania, and New Jersey; the Gloucester farther north; the Hagerstown and Frederickburg of southeastern Pennsylvania, Maryland, Virginia, Kentucky, Tennessee, and southern Indiana; the Muskingum southwest to Alabama; the Ontario-Honeoye of New York; the Upshur-Muskingum of eastern Ohio and western Pennsylvania; the Westmoreland of western Pennsylvania; and the Welston, Zanesville, Lowell, Dickson, and Baxter of Kentucky.

This forest area, once important as a source of timber and forest products, has given way in large part to a dense agricultural population.

**Oak-Hickory**

This was the western extension of the oak forest, the type that pushed up along the flood plains of the rivers draining the Great Plains and the great prairies and out onto the level lands, where possible in the face of competition by grass and fire. The chestnut oak, chestnut, and yellow poplar give way to oaks, hickories, ash, elm, walnut, and boxelder. If a detailed map could be drawn, it would show great diversity in Michigan, Ohio, and Indiana, and there is a great difference between the southern oak-hickory and the most northern extension of the type in northern Minnesota. This forest area dovetails into the prairie, from which it differs, not in environmental conditions, but in original vegetation and consequent soil. The soils developed under the two covers are distinct except where recent recessions have established grasslands on the Gray-Brown Podzolic soils, which are light in color as compared with the soils of the northern and southern prairie, or where trees have recently pushed out onto the dark Prairie soils.

In this forest area the typical Gray-Brown Podzolic profile is shown in the Miami-Kewaunee soils of Ohio, Indiana, southern Michigan, and southeastern Wisconsin; the Baxter on the more level areas over limestone in the Ozarks of Missouri; the Clinton and Lindley soils along the rivers of Missouri, Illinois, Iowa, and adjacent States. The forest area abuts closely on the prairie. The Cross Timbers of Texas are found on Windthorst-Nimrod Red and Yellow Podzolic soils. The oak-hickory in its northern extension has developed into parts of the
hay and dairy region; in the central section in Ohio and Indiana into the Corn Belt; in southern Illinois and Missouri into the Corn and Winter Wheat Belts; and in the extreme south into the Cotton Belt.

Oak-Pine

This forest is probably not a true climax forest. Grouped with the oak forests by Shantz and Zon, the soils on which it occurs have been mapped by Marbut as Red and Yellow Podzolic soils, which are characteristic of land occupied by the southeastern pine forests. The original forest was largely cleared for farm lands. Shortleaf is the principal pine, although scrub pine is prominent in parts of Virginia and North Carolina, especially on poorer soils and old fields, indicating that it occupies a prominent place in the earlier stages which lead to a climax forest. Better soils are occupied by loblolly. In the North, red, yellow, and chestnut oaks are prominent, while the pines, hickory, and oak are more prominent in the South. West of the Mississippi, shortleaf pine, yellow oak, bitternut and pignut hickories, blackjack oak, and mockernut hickory were prominent in the original forest. Much of this oak-pine forest is reestablishing itself on abandoned farm lands and now presents many earlier successional stages in progressing toward the climax forest.

Soils of importance are the Sassafras soils in the North, which belong to the Gray-Brown Podzolic group; the Cecil and the associated Appling, Georgeville, Alamance, Iredell, and Louisa, Red and Yellow Podzolic soils of the Piedmont, from Virginia to Georgia and Alabama; the Susquahanna and Hanceville-Conway of Arkansas and the Ozark Plateau, and the Norfolk-Ruston, in Texas. Except for the northern portion, which lies in the Corn and Winter Wheat Belts, the oak-pine forest has become part of the Cotton Belt, occupied by farms throughout. The number of farms is large and they are relatively small in size with a relatively dense white farm population.

Cypress, Tupelo Gum, and Red Gum (River-Bottom Forests)

This is a mixed forest varying in character with the amount of standing water on the soil or the nearness of the water table to the surface of the soil. Cypress and tupelo gum are swamp trees occupying the sloughs and swamps, which are under water most of the year. The overflowed glades contain, besides cypress and tupelo gum, water ash, cottonwood, and sweet and red bays, and the ridges produce oaks, hickories, gum, ash, and red maple.

The soils are composed of materials flooded in from the highland near the headwaters and are grouped as alluvial soils of the southern United States. Along the river bottom east of the Mississippi, the Ochlockonee in Mississippi and western Alabama and the Congaree farther east were occupied by this type of forest. The great Mississippi flood plain is mostly Sharkey, Sarpy, and Yazoo soils, and the Arkansas and Red River bottoms are soils of the Miller series.

This forest area lies in the humid high-temperature region. The northern part is an area of large cotton acreage and concentrated colored tenant farmers and croppers.

Longleaf, Loblolly, and Slash Pine (Southern Pine Forest)

This pine forest area extends in a broad belt from 1 to nearly 300 miles wide along the Atlantic Ocean and the Gulf of Mexico from North Carolina to eastern Texas, including practically all of Florida except the marsh, prairie, and river-bottom areas. About 10 species of pine are important, with longleaf most prominent on the better drained lands and loblolly on the lower lands. There are great open stands of pine which because of the long, favorable growing season produce timber more rapidly than any other forest in the United States.

The older part of the Cotton Belt lies mostly in this forest. The chief soils are of the Norfolk series. Others are the Orangeburg, Coxville, and Leon; the Tifton in Georgia; and the Ruston and Susquehanna in Alabama, Mississippi, Louisiana, Texas, and Arkansas. These are almost entirely Red and Yellow Podzolic soils.

A great deal of this pine forest is in a raw-land state, in process of reestablishing the original timber type. The best lands are still held in cultivation, principally of cotton. As a general rule these pinelands are not highly productive.
Plants as Soil Indicators

Tall Grass (Prairie Grassland)

The western portion of the oak forest gives way to a tall-grass region, generally called a prairie. Here, owing to fire and, at times, a high water table, trees have been unable to establish themselves, although the conditions of soil and climate would favor their growth. A constantly maintained coarse grass and herb vegetation burned off each year, or at irregular intervals, has developed a soil out of keeping with the Gray-Brown Podzolic soils of the oak forests, or the Red and Yellow soils of the southern extension. Here are grasslands similar to those found on the Chernozems, but the lime layer is not present because of high rainfall. From the standpoint of plant geography and soil geography it is exceptional, and no similar extensive areas are found on other continents.

Something of the richness of the Chernozems combined with the adequate water supply indicated by the podzolic soils gives this area great significance as agricultural land. Grain crops can be grown year after year without fertilizer. It therefore constitutes one of the most valuable blocks of agricultural land found on any continent on the earth. The tall-grass area presents a phase that has developed along the eastern shelf of the Pedocals, where the vegetation is so nearly in balance with the total moisture supply that none of the soil water is lost to the subsoil, which is permanently dry. A layer of lime accumulation is deposited at or near the limit of depth of moisture and root penetration. Just east of this line the soils are Pedalfers, since here water passes below the reach of the grass roots and the subsoil is permanently moist. The grassland east of this dividing line is characterized by the bluestem-sod type of tall grass in the north and the bluestem-sod and the broomsedge-water grass type in the south.

The soils, like the vegetation, are different from those ordinarily characteristic of grasslands in Europe and Asia. The soils of this type in most continents are tree-covered, and forest plantings by Professor Burrell at the University of Illinois show that they quickly return to a forest soil profile here.

Although the soils must be classed as Pedalfers, they are not well developed, and they show characteristics usually associated with the Pedocals. The vegetation is a luxuriant grassland, but the conditions are favorable for the development of the western extension of the oak-hickory forests.

Bluejoint Sod (Northern Part)

This great grassland, known to the early explorers as the prairie, was made up for the most part of tall, coarse grasses such as bluejoint, little bluejoint, and Indian grass, with a rich admixture of flowering herbs and other grasses. A mass of flowers in the spring and summer, it changes to a rich reddish-brown color in the fall.

The plant cover of this bluejoint sod marks a soil type with characteristics of both the Podzol and the Chernozem great soil groups. It is correlated with the Carrington, Clarion, Tama, Marshall, Summit, and Cherokee soils. The Carrington and Clarion soils, important in the northern portion, with the northern portion of the Marshall, are considered typical Prairie soils. In eastern Kansas and western Missouri, Summit, Grundy, Shelby, Cherokee, Bates, Crawford, and Parsons are important. They are less typical prairie soils because of the nature of the shales and materials from which they were derived.

The northern part of the bluejoint-sod grassland lies in the Corn Belt and the southern part in the corn and winter wheat region.

Bluejoint Sod (Southern Part)

This grassland is characterized by the soils of the southern prairie. The vegetation is not decidedly different from that of the northern prairie except for a number of grasses, such as the broomsedges, from the south. The climatic conditions are less severe than in the northern prairie.

The Houston, Austin, and Wilson soils are associated with the Black Prairie of Texas, and the Sumter, Vaiden, and Wilson with the prairie region of Alabama and Mississippi. This grassland lies wholly in the Cotton Belt.
Broomsedge and Water Grass

A strip of prairie grassland lies along the Gulf of Mexico in Texas and Louisiana and constitutes small prairies in Florida. *Andropogon, Paspalum,* and other coarse grasses predominate. Because of the long growing season, parts of this belt resemble the Plains, and the short grasses push in in many places.

The soils are dark-colored because of the parent material and are classified as Lake Charles. This area lies wholly in the humid subtropical agricultural belt.

Porcupine Grass, Junegrass, and Slender Wheatgrass

This grassland, which occupies the Red River Valley of North Dakota and Minnesota, lies north of the bluejoint sod and east of the needle-and-thread, junegrass, and slender wheatgrass area. From the latter it differs chiefly in greater abundance of porcupine grass and a somewhat larger growth.

This plant community occupies the eastern edge of the spring wheat region and produces, also, a large amount of native hay. The soil occupies the eastern edge of the true Chernozems represented by the Fargo-Bearden soils.

Needle-and-Thread, Junegrass, and Slender Wheatgrass

This grassland extends from northern North Dakota south to southern Nebraska and lies wholly within the Chernozem soil province. It is characterized by the grasses named and a luxuriant mixture of other plants. It merges almost imperceptibly into the porcupine grass, junegrass, and slender wheatgrass on the east and the more luxuriant phase (called by Clements (69) the "midgrass") of the short grass or plains grassland on the west.

The subsoil is permanently dry or at least contains no water available to growing plants (452). The growth period is shortened by summer and autumn drought, although the frost-free period is from 100 to 170 days. The evaporation from a water surface amounts to 30 to 40 inches. Summer temperatures average 60° to 75° F., winter temperatures 5° to 30°. The temperature range is from —60° to 115°.

The plant community marks the eastern edge of the Pedocals in the north and falls near the midline of the true Chernozems or northern Chernozems. It is characterized in the Dakotas by the Barnes soils, and on somewhat more open or rocky soil by the Bearden. The correlation between these soils and the grassland community is almost exact. In Nebraska the vegetation is correlated with the Moody soils. This grassland marks out very sharply the spring wheat area in the north and the Corn Belt in the south, but also produces barley, rye, and flax.

Little Bluejoint-Bunchgrass {Bluestem-Bunchgrass}

This grassland (452) occupies a belt about 100 miles wide running from north to south across the middle of Kansas, swinging west to the eastern edge of the Panhandle of Texas, and extending across Oklahoma. One grass is dominant over much of the area. In the fall this stands as a dense, almost grainlike field of rich reddish-brown color. The grasses are closely placed bunches and have less of a sod character than they do farther east.

The northern portion of the bluestem-bunchgrass lies in the Corn Belt, the center in the Winter Wheat Belt, and the southern portion in the Cotton Belt. It is an area of high productive capacity.

The soils that characterize the bunchgrass vegetation are Chernozems such as the Holdredge, Hall, Crete, and Colby soils in Nebraska, the Hays and Crete soils in Kansas, and in southern Kansas and Oklahoma the Reddish Chestnut soils such as the Miles, Vernon, Greensburg, Pullman, and Richfield.

Sandgrass, Sand Sage, and Shinnery Oak

A mixture of bluejoint, Indian grass, switchgrass, sandgrass, and sand sage, and in the south the shinnery oak, marks areas of sand valuable only for moderate grazing and for the production of native hay. This type has been mapped in soil maps only as sand. It is never found on heavy land.
Plants as Soil Indicators • 845

Short Grass (Plains Grassland)

This great belt of grassland lies between the prairies of the Central States and the Rocky Mountains. Naturally the line of demarcation where there is no physiographic boundary is not distinct. The boundary which separates the Pedals from the Pedocals falls farther east at the eastern boundary of the needle-and-thread, junegrass, and slender wheatgrass, and the little bluejoint-bunchgrass associations. The western edge of the Chernozem belt falls within the boundary of the blue grama, junegrass, and needle-and-thread association in the north, and west of the wire-grass association in the middle Plains section. But the line drawn between the tall grass and the short grass represents a very marked change from a darker to a lighter Chernozem and is distinctly indicated in dot maps of crop production, land in farms, and size of farms.

These two eastern associations of the short-grass or Plains grasslands are often referred to as midgrasses (69) or as mixed prairie, and since many of the taller grasses continue across to the mountains, the whole area is referred to as the mixed prairie. During dry years the taller grasses are not in evidence, but during wet years they are much in evidence. There is a tendency for the tall grasses to push west on lighter soils and for the short grasses to push east on heavier ones.

The communities comprising the Plains grassland may be grouped into the following six associations:

Blue Grama, Junegrass, and Needle-and-Thread

This vegetation occupies most of western North Dakota and north-central South Dakota north of the areas of the Pierre shales and also some of the better soils of eastern Montana (fig. 4). It consists of a short cover of blue grama with

Figure 4.—Overgrazed short-grass land in Montana, showing pasture sagebrush replacing the grasses.
needle-and-thread and junegrass, and a scattering of many herbaceous plants such as silver *Psoralea* and purple coneflower.

This grassland occupies the northwestern part of the Chestnut soils in the belt of the Williams-Morton-Bainville series. The area lies in the spring wheat region.

**Wire Grass**

This is an intermediate type lying mostly between the little bluejoint-bunchgrass of the central High Plains and the grama-buffalo grass of the west-central High Plains. It consists of a ground cover of blue grama and buffalo grass and a scattered growth of red three-awn (wire grass) with coneflowers, *Psoralea*, and many other herbaceous plants.

The eastern portion of the northern extension of this association is correlated with Chestnut soils of the Rosebud, Bridgeport, and Keith series. The western edge covers northern Brown soils such as the Rosebud and the Daws, and the southern portion Reddish-Chestnut soils such as the Zita, Pullman, and Greensburg. The wire-grass vegetation marks the western part of the hard winter wheat region.

**Grama-Buffalo Grass**

The most typical part of the west-central High Plains is the short-grass cover on hard land. Beginning growth in the spring as soon as the temperature is favorable, the grasses fruit in 40 to 60 days but are often caught by drought before maturity of the seed crop. Before the flower spikes are pushed up, the appearance at a distance is that of a well-kept lawn. During periods of drought it forms a dry carpetlike mat of gray or lemon-yellow color. The grama heads, with a mixture of other taller plants such as *Psoralea* and other legumes and many showy flowering plants and taller grasses, give the area an appearance of a more varied composition. This is especially noticeable during wet years.

In the north, grama and buffalo grass (fig. 5) occur on Chestnut soils of the Rosebud series. On the western side they occupy the eastern extension of the Weld series of the Brown soils. In southeastern Colorado they occur on soils of the Baca and Prowers series. In the southern Plains they occupy the eastern part of the Springer series of the southern dark-brown soils and the western portion of the Amarillo, Zita, and Pullman soils.

This association marks the western edge of the hard winter wheat region.

---

**Figure 5.—The vegetation under like climatic conditions indicates the soil texture:**  
*A*, A loam soil under blue grama and buffalo grass;  
*B*, a sandy soil under wire grass;  
*C*, little bluejoint on sand.
Blue Grama, Buffalo Grass, and Bluestem

On heavy soils derived from the Pierre shales the bluestem (western wheatgrass) forms an even stand on a blue grama and buffalo grass sod. During dry years the cover is similar to the grama-buffalo grass association, but when moisture is available the appearance is almost like a field of small grain.

Although bluestem is found scattered through much of the short-grass area, in no case does it become as prominent as in this association. Here it is correlated closely with the Chestnut soils of the Pierre series (fig. 6, A).

This association lies in the southwestern part of the spring wheat region.

**Figure 6.**—A, Blue grama, buffalo grass, and bluestem on good Pierre soils; B, bluestem alone on undeveloped soils with enough alkali to shut out the short grasses.

Bluestem (Alone or With Sagebrush or Salt Sage)

This association (fig. 6, B) is found in the badlands areas and on heavy soils along the rivers of Montana, Wyoming, and South Dakota. The plant cover is rather open and varied and distinguished by the absence of short grass. Bluestem may occur as widely spaced plants or with poor sagebrush, and on saline soil with salt sage.

The association occurs on heavy, impervious, saline soils of little value except as grazing land of low carrying capacity. For the most part these are undeveloped Brown and Chestnut soils such as the Pierre and Bainville, and badlands types.

Blue Grama Grass

This area is occupied by blue grama in combination with "niggerwool," junegrass, selaginella, pasture sagebrush, and sagebrush. Each of these combinations indicates a different type of soil and also varying conditions favorable for grazing or crop production. The group covers most of the northwestern part of the Plains grassland.

Blue Grama and Niggerwool

This grassland is a little drier and covers the soil less completely than the blue grama, junegrass, and needle-and-thread. It is characteristic of much of the better soil of the northern and western portion of the Great Plains. In the south it extends to about central Colorado. Semidesert in character, it forms an open cover and is characterized by a large number of other grasses and herbaceous plants.

In the north this association occupies Chestnut soils such as the Williams, Scoby, and Morton. Further south in Colorado it is found on Brown soils such as the Joplin and the Weld. In New Mexico and Arizona it occurs on Brown soils.
of the Capulin and Tucumcari series. It also occurs in some of the parks of the intermountain country and over the higher grasslands of New Mexico and Arizona as blue grama and galletta on the Otero soils.

Blue Grama, Junegrass, and Selaginella

An area sharply marked out in northern Montana is covered with short grass with a good deal of selaginella, phlox, and other small xerophytic species. This type is scattered throughout the range of the blue grama and niggerwool association, but is not easily segregated on a map. Conditions are rather extreme, but the change in vegetation is marked more by amount of growth than by change of botanical composition. As grazing land it will carry from 15 to 20 head of stock per square mile.

This area is correlated with Brown soils of the Joplin series, surrounded on all sides by Chestnut soils.

Blue Grama and Pasture Sagebrush

This name is an inadequate description of that portion of the Plains grassland which on the west meets the Pacific bunchgrass with its attendant Balsamorhiza, and the bunchgrass-wheatgrass and the extensions of pine forests. Naturally, with an increase of rainfall, the vegetation becomes denser and taller. More of the herbaceous plants such as goldenrods, asters, legumes, lilies, as well as needle-and-thread and other grasses, enter. The soils are darker and deeper. The vegetation type is an extension from the north characteristic of the mountain front. It is also found on certain open sandy and rocky soils in North Dakota. In places the land has been cultivated, but as a rule it is pasture varying in carrying capacity from 20 to 30 head per section. Not much of the area has received detailed attention in soil surveys, but its characteristic soils are of the northern dark-brown or the Chernozem groups.

Blue Grama and Ring Muhly

This combination occupies the driest and hottest portion of the Plains grasslands. It is characterized either by the "fairy ring" growth of the Muhlenbergia, which has led to a proposed common name "ring muhly," or this plant may occur in almost equally distributed tufts. This plant, seldom seen north of central Colorado, is mixed with blue grama, and often cane cactus grows as scattered bushes over the grass cover. As a rule the soils are heavy and the vegetation for the most part occupies the low and level lands.

In Colorado and New Mexico this association occurs on Brown soils of Capulin and Tucumcari type. The value of this land is chiefly for light grazing. Care should be exercised, since erosion is likely to start if the vegetation cover is disturbed.

Mesquite-Desert Grass Savanna (Desert Savanna)

A scattered growth of mesquite over a desert-grass cover occupies a curved belt of land across Texas from the Red River on the north to the Gulf of Mexico. It is interrupted slightly by the Edwards Plateau. The vegetation differs from that of the Plains grassland in that trees are scattered over a short-grass cover. The growing season is not determined by suitable temperature but almost entirely by the time when moisture is available in the soil. Growth starts following spring or summer rains.

This desert savanna is divided into two major associations.

Thornbush and Mesquite Grass

Mesquite and other thornbushes and cacti are scattered over a desert grass cover consisting of curly-mesquite, buffalo grass, and three-awn grasses. This plant association occurs on Reddish Chestnut soils of the Miles, Vernon St. Paul, Abilene, Valera, Ector, Duval, Victoria, and Webb series.
Plants as Soil Indicators

Mesquite and Mesquite Grass

A thin belt of curly-mesquite and buffalo grass with a scattered growth of mesquite extends from south of the Panhandle of Texas in a narrow curved belt to the Gulf of Mexico. It lies just west of the thornbush and mesquite grass association. In its northern extension, it occupies Reddish Chestnut soils, but the southern and western portions pass over onto southern Brown soils.

Climatic conditions are a little more arid than in the thornbush and mesquite grass association. In the north it occupies soils such as the Vernon and Amarillo. At about 32° N. latitude this vegetation occupies Reddish Chestnut and Reddish Brown soils such as Springer, Reagan, and, farther south, Maverick, Duval, and Victoria.

Mesquite Grass (Desert Grassland)

This grassland resembles the short-grass areas of the High Plains, especially where curly mesquite is relatively dominant. The vegetation is distinct from the short grasses in habitat and physiological adjustment. Growth starts as soon as rain falls. This vegetation occurs in Texas, New Mexico, and Arizona on Reddish Brown soils such as the Whitehouse, Tumacacori, and Coronado. It is fairly good grazing land, supporting 20 to 30 head of cattle per section. Curly-mesquite, with black, Rothrock, and sprucetop gramas, are probably most important on the uplands and constitute most of the desert grasslands in southern Arizona (280), southern New Mexico, and western Texas.

Bunchgrass (Pacific Grassland)

This grassland occurred in California, Oregon, and Washington and in the mountains of Idaho, Nevada, and Montana. It has been divided into three associations.

Wheatgrass Sod

This grassland of bluebunch wheatgrass, Idaho fescue, and an admixture of balsamroot is limited largely to the Palouse section of Washington and adjacent portions of Idaho and Oregon. Both the soils and the vegetation are similar to those of the northern Great Plains. The soil is classified as Palouse. This vegetation unit marks the best wheat lands of the Northwest.

Wheatgrass Bunch

This open grassland made up of distinct bunches of bluebunch wheatgrass and a rich admixture of other plants occurs where moisture is not as abundant as on the sod and where the soils are not so good. It is found in eastern Washington and Oregon and in Idaho, Montana, and northern Nevada, where it occupies the zone above the sagebrush desert. The topography is hilly and not favorable to cultivation, but much of the area is farmed to wheat. The community characterizes the Brown Ritzville and the Chestnut Walla Walla soils.

Stipa-Poa Bunchgrass

The original vegetation has largely disappeared from the California grasslands. This was a luxuriant bunchgrass land of pine bluegrass and California needlegrass, probably as rich a mixture as found on the bunchgrass land of the north. The former grasslands were usually noncalcic Brown soils such as the Placentia and Ramona, which lie on the benches at the side of the valleys; the Yolo alluvial soils; and in places, the San Joaquin and the Fresno, the latter sometimes passing over to salt-desert shrub. This Stipa-Poa bunchgrass has given way to a weed grass cover of wild oats, bromes, and tarweeds. Under cultivation it is productive of cereals grown for grain and hay, and under irrigation for subtropical fruits and vegetables.

50183—38—55
Sagebrush (Northern Desert Shrub)

Sagebrush is the most prominent plant of this association and has been used to designate the whole area. The plants are usually 3 or more feet apart and from 2 to 7 feet high. At times they present the appearance of a miniature forest. The soil surface, originally partially covered with grasses and native herbaceous plants, is now often covered after rains with bromes, filaree, and Russian-thistle. The area occupies the Great Basin, the Harney Plateau, the valley of the Snake River, central Washington, western Colorado, and Utah.

The soils are largely alluvial materials deposited as alluvial fans. This results in soils in all stages of development on each fan and also all stages of vegetation development. The association occupies the Gray Desert soils typical of Nevada, southeastern Oregon, Washington, southern Idaho, Wyoming, and Colorado of which the Portneuf, Sagemoor, and Navajo-Chipeta soils are types.

The northern desert shrub can be broken into many types, each definitely correlated with soil conditions. The principal plant communities and what they indicate as to soil conditions are as follows.

Sagebrush indicates a pervious soil moistened to a depth of several feet and free from alkali (fig. 7, A). This is good agricultural land under irrigation and is successfully dry-farmed during average or better-than-average years.

Small sage indicates a shallow and often impervious soil. Such land, although not high in alkali, is nonagricultural.

Scabland sage indicates the absence of sufficient soil to produce sagebrush. Little rabbitbrush grows in Utah and Nevada on soils similar to sagebrush lands but drier and less valuable for crop production. They are free from harmful amounts of salts and often mark areas where sagebrush has been driven out by drought or burning.

Bitterbrush is usually on sandy, volcanic, or rocky soil. Coleogyne, occurring at the southern boundary of the northern desert shrub and the northern boundary of the southern desert shrub, occupies soils that are loose, rocky, or sandy.

Chamiso generally indicates sandy land in both the northern and southern desert shrub.

Shadscale dominates the more level and mature soils of the whole sagebrush desert (fig. 7, B). Rainfall is less than on sagebrush land. The soils are of fine
Plants as Soil Indicators

Texture, with harmful amounts of alkali at a depth of 1 to 2 feet, and poorly supplied with water owing partly to poor penetration.

Salt sage, as a low mat cover with much of the surface bare, occupies soils that are heavy and highly saline even at the surface (fig. 7, C).

White sage, sometimes with accompanying Sandberg bluegrass, indicates a fine ashylike soil with alkali at a depth of 10 inches to 1 foot.

Winterfat as a rule marks land that is suited for crop production without irrigation. Soils vary considerably but are often of fine texture with alkali at a depth of 1 to 2 feet. The land is excellent for grazing.

Galleta occupies soils usually pervious and free of harmful amounts of alkali. Conditions are not unlike those under sagebrush but the soils are probably older and are generally light loam or sand loam in texture. This is good grazing land.

Giant wild-rye characterizes the richer, more moist alluvial bottoms in the sagebrush desert free from alkali. It indicates the best soils and the best conditions of soil moisture in the northern desert shrub.

Creosotebush (Southern Desert Shrub)

This desert is far more varied than the sagebrush desert. The latter as a rule has plants of about equal size and with deciduous silvery leaves. The creosotebush has shiny, lacquered, yellowish-green leaves, and the desert as a whole shows great variety, ranging from the silvery bur-sages, desert sages, and encelia to the green paloverde and mesquite and from thornbush to giant cactus. There are a great number of plants of great variety in habit of growth. The northern desert offers expanses of miles and miles of uniform color and shape, while the southern desert offers endless variety.

In many places the soils under the southern desert shrub form a desert pavement, from which the fine materials have blown away leaving small rock fragments accumulated on the surface. These are polished by wind action and by temperature changes and take on a "desert varnish." This pavement holds the fine material in place and prevents erosion loss by either wind or water. Characteristic of Red Desert soils of California, Nevada, Arizona, New Mexico, and Texas are the Mohave, Reeves, and Anthony.

The various types of southern desert shrub are correlated sharply within any area with the soil type (353).

Creosotebush occupies the alluvial fans and like the sagebrush indicates a deep pervious soil free of harmful amounts of alkali. A stony, shallow soil is shown by poor growth of the creosotebush.

Desert saltbush occurring in a dense stand indicates a soil of fine texture containing salt, but not enough to injure cultivated plants if irrigation is such as to prevent further concentration. The character of the soil and the amount of available water is indicated by the density of the stand. As one passes from the better lower lands toward the alluvial fans, the plants stand farther apart. Soon creosotebush or bur-sage plants appear. These mark a transition from a heavy rich loam soil to a pervious sandy or rocky soil. Soils of the Gila and Imperial series, the best agricultural lands of the southern desert, are characterized by desert saltbush.

Mesquite in solid stands indicates a good soil of considerable depth with plenty of available water, and probably a water table or a body of soil water moving slowly through the soil below the trees.

Narrowleaf saltbush indicates a heavy, compact subsoil with a surface layer of lighter soil 4 to 8 inches in depth, a small amount of available water, a small amount of salt in the surface soil, but over 0.5 percent of salt in the compact subsoil.

Giant cactus as a rule is found on soils sufficiently rocky to afford a safe anchorage for the superficial root system.

Chamiso clearly marks the sand ridges in the southern deserts which often lie above a heavy alkali soil.

Sacaton, a tall coarse bunch grass, occupies the best alluvial bottoms in the southwestern desert where, after rains, water floods slowly over the surface and moistens the soil to several feet in depth (fig. 8, A). Such land is free of harmful amounts of alkali. The plant indicates the best soil and natural moisture conditions in the southern desert shrub area, just as giant wild-rye does in the northern desert shrub area.
Greasewood (Salt-Desert Shrub)

In the desert areas of the West, restricted drainage causes salts to accumulate in the soils. In extreme cases these salts crystallize out to form a white deposit; or, where black alkali is present, to produce bare flats that are slick when wet and as hard as concrete when dry, with no plant growth of any kind. Salt-desert vegetation is found along almost every drainage channel in the West. Such plants clearly indicate the soil condition.

Greasewood indicates a subsoil well supplied with water, probably within a few feet of the water table. The soil contains more than 0.5 percent of salt and is not productive under cultivation without leaching.

Greasewood and shadscale indicate a soil with alkali within 1 or 2 feet of the surface. Usually this is a heavy soil and nonagricultural unless it is leached.

Seepweed indicates a water table near the surface or actual seepage of water from the soil on which it grows and a high alkali content often exceeding 2.5 percent in the surface soil.

Pickleweed indicates moisture throughout the growing season from a water table near the surface, and a salt content rarely less than 1 percent and often as high as 1.5 percent.

Saltgrass indicates moist alkali land.

Saltgrass indicates alkali, usually a little less than 1 percent, and a moist soil. Generally there is a drainage of fresh water onto these lands after rains. The land is valuable for grazing.

Alkali sacaton, one of the most edible grasses of the desert regions, grows in wet alkali bottoms, on heavy land, moist to the surface, and containing about 0.5 percent of alkali (fig. 8, B).

Western Forests

These forests lie for the most part on “rough and stony land” which has so far received comparatively little or no attention from soil scientists. The various forests can probably be more nearly correlated with climatic conditions than with soils. But the earth materials must likewise be affected by climate. Ultimately the soils may be known by the forests that grow on them, and which forests are climax forest stages and which forests still occupy young and immature soils may thus be determined. Only a relatively small area of forests in the West has given way to agriculture and it is these lands which have been studied by the Soil Survey Division.
**Spruce-fir (Northern Coniferous Forest)**

This forest is practically the same as the spruce-fir of the eastern United States, and evidence indicates that like the eastern forest it grows on a true Podzol, or on soil material that is developing in that direction.

This forest is made up of a very interesting series of trees. In the Cascades there are the noble fir and California red fir, and at higher elevations the alpine fir, Lyall larch, and mountain hemlock; in the Sierras, alpine fir and mountain hemlock, pure California red fir, California red fir and white fir, and lodgepole pine. The latter becomes an important tree at high elevations, which in no wise resemble typical lodgepole areas of the northern Rockies. In the northern Rockies, alpine fir and Engelmann spruce are important; in the central Rockies, Engelmann spruce and balsam fir; and in Arizona, Engelmann spruce and cork-bark fir.

This forest would be relatively unproductive for anything but timber, squirrels, grouse, martin, and fisher except that it is broken by great mountain meadows. This alternation should be especially interesting from a soils point of view since conditions in the meadows would develop a Podzol soil except for the grass cover.

**Cedar-Hemlock (Northwestern Coniferous Forest)**

This is the heaviest forest in the United States and probably in the world. It occupies the northern Rockies, extends from the west slopes of the Cascades to the Pacific in Washington and Oregon, and forms a strip along the coast of California reaching down almost to San Francisco Bay. It can be divided into three major divisions.

**Western Larch-Western White Pine**

Located in the northern Rockies in Montana, Idaho, and adjacent areas in Washington, this forest is first composed largely of western larch after burning, followed by western white pine, which in turn is followed by western red cedar and hemlock; this is the reason for its classification with cedar and hemlock forests rather than with the ponderosa pine and Douglas fir.

The nature of the soils under this forest can only be inferred. They appear to belong to the Gray-Brown Podzols represented by such soils as the Everett, Alderwood, and Helmer-Santa-Benewah. The soils named have been cleared for agriculture but were formerly heavily timbered.

**Douglas Fir**

The great trunks of the Douglas firs almost rival the redwoods in height and diameter. Douglas fir comes in first after fire and stands for about 2,000 years. Here as in the western larch and western white pine forest the western red cedar and hemlock come in as an understory and if the forest is left undisturbed will eventually replace the Douglas fir. Sitka spruce is an important tree in the coast valleys.

This forest covers western Washington and Oregon from the Cascades to the Pacific. It is one of the finest forest types in the world and has given way in Washington and Oregon to agricultural lands, chiefly in hay and pasture, supporting dairying and poultry raising.

Judging from the lands that have been cleared for farm use, the soils under the forest are Gray-Brown Podzolic, such as the Olympic, Melbourne, Everett, Alderwood, and the Willamette-Amity series. In the higher mountains this forest type probably occurs on raw land which is showing a tendency to become podzolic.

**Redwood**

A great forest of old trees standing close and occupying a relatively narrow strip along the Pacific Ocean from the Oregon line to just above San Francisco Bay, with outstanding groves as far south as Santa Cruz. It is often associated with Douglas fir.

The soils are similar to those under Douglas fir and are Gray-Brown Podzolic.
**Ponderosa Pine and Douglas Fir (Western Pine Forests)**

This pine forest covers all of the mountains of the West, occupying rather large areas in every State west of the 103d meridian with the exception of Texas and Nevada, where there are relatively small forests of this type.

The forest can be divided as follows:

- Lodgepole pine of the Rockies in Colorado, Utah, Wyoming, Montana, and Idaho—also important in parts of Washington, Oregon, and California.
- Ponderosa pine and sugar pine, chiefly confined to the Coast Range and west slopes of the Sierras in southern Oregon and California. Incense cedar and white fir are important trees in this forest.
- Western larch and Douglas fir, in western Montana and Idaho, occupy a position intermediate between western white pine and ponderosa pine and Douglas fir.
- Rocky Mountain Douglas fir, usually located above and on better sites than the ponderosa pine, with which it mixes along a broad contact zone.
- Ponderosa pine is the most extensive and most important of the trees of the northwestern pine forests. West of the Sierras it occupies the drier slopes and flats. East of the Sierras, ponderosa and the closely related Jeffrey pine occupy the timbered slopes. Ponderosa pine is important in every Western State and pushes down over the short grass of the Plains across Montana and into the Dakotas and Nebraska, extending over so great an area that it is found at elevations ranging from 2,500 to about 9,000 feet. It lies within the transition zone of the biologists and indicates climatic and soil conditions that are relatively uniform throughout its range.

It is difficult to correlate the western pine forests with soils as described by the Soil Survey Division, since as a rule these soils lie above the agricultural valleys and have not yet received critical study. They are chiefly the arid, subhumid soils such as Underwood-Babb or, under the Pacific forests, the Red and Yellow Podzolic Aiken-Konotki-Sites soils. As a rule ponderosa pine does well on raw land but in great stands the soils are very moist in winter. They may therefore be waterlogged at the surface and become podzolic. At the same time there is a tendency on the drier side to push out on the dark-brown soils of the Pedocals. This is to a great extent indicated by accompanying vegetation. Arizona fescue forms a continuous grass cover in places over the floor of the ponderosa pine forest of the southern Rockies. Blue grama also pushes up into this forest in many places. Idaho fescue in the northern Rockies behaves much as does Arizona fescue in the southern Rockies. It is not surprising, therefore, to find both Pedocals and Pedalfers under the ponderosa pine forests. Accompanying vegetation rather than ponderosa pine should be the indicator.

**Juniper-Piñon (Southwestern Coniferous Woodland)**

A belt lying below the ponderosa pine forest is in many places occupied by juniper and piñon. It is replaced in southern Arizona and California and to some extent in portions of Utah and Colorado by a chaparral. The junipers are chiefly Rocky Mountain red cedar, Utah, one-seeded, and alligator junipers, and there are two piñons. Juniper has a tendency to predominate at lower levels. In the Great Basin and in the north, juniper gives way at lower elevations to sagebrush, while farther south it may be replaced by desert grassland. Often the trees are scattered and the woodland is very open. The soils are drier than those under ponderosa pine forests. In Oregon the soil under the juniper woodland is classified as arid, subhumid McCammon-Deschutes. In many places in the woodland the erosion loss is so great that there can be no developed soil.

**Chaparral**

This is a mixed association of small trees or shrubs. In Utah, Colorado, New Mexico, and Arizona it may consist for the most part of deciduous oaks. It is most typical of southern Arizona and southwestern California and varies from a dense low stand of evergreen shrubs to a scattered oak savanna. Probably much of the shrub area is the result of fire.

Much of the more favorably located land has been developed for subtropical agriculture with the help of irrigation. In southern California and in Arizona the soils are noncalic Browns such as the Vista-Holland-Sierra types. Much of the soil material under this association is young and undeveloped.
APPENDIX

Plant Communities as Indicators of Growth Conditions

Temperature Conditions

Cool climates:
- Northern coniferous forests.
- Northwestern coniferous forests.
- Western pine forests.
- Northeastern pine forests.
- Northeastern hardwoods.
- Northern desert shrub.
- Alpine meadow.

Warm climates:
- Southwestern coniferous woodland.
- Southwestern broad-leaved woodland.
- Southern desert shrub.
- Desert grassland.
- Desert savanna.
- Southeastern hardwoods.
- River-bottom forests.
- Southeastern pine forests.
- Subtropical forests.

Moisture Conditions

High rainfall:
- Northern coniferous forests.
- Northwestern coniferous forests.
- River-bottom forests.
- Southeastern pine forests.
- Southeastern hardwoods.
- Northeastern hardwoods.
- Northeastern pine forests.
- Prairie grassland.

Low rainfall:
- Southern desert shrub.
- Northern desert shrub.
- Desert grassland.
- Plains grassland.
- Desert grass savanna.
- Southeastern coniferous woodland.
- Southwestern broad-leaved woodland.

Drought

Drought enduring:
- Desert grassland.
- Desert grass savanna.
- Plains grassland.
- Southern desert shrub.
- Northern desert shrub.

Non-drought enduring:
- Northern hardwoods.
- Southern hardwoods.
- River-bottom forests.
- Northeastern pine forests.
- Southeastern pine forests.
- Northern coniferous forests.

Soil-Moisture Conditions

Permanently dry subsoil:
- Plains grassland.
- Desert grassland.
- Desert grass savanna.
- Northern desert shrub.
- Southern desert shrub.
- Pacific grassland.
- Southwestern coniferous woodland.
- Southwestern broad-leaved woodland.

Permanently moist subsoil—Contd.
- Northern coniferous forests.
- Northeastern pine forests.
- Northeastern hardwoods.
- Prairie grassland (greater portion).
- Northwestern coniferous forests.
- Western pine forests (greater portion).
- Alpine meadow.
- Flooded condition:
  - Parts of northern coniferous forests.
  - Marsh grassland.
  - River-bottom forests.
  - Mangrove.

Valuable for Agricultural Production

Prairie grassland.
River-bottom forests.
Southern hardwoods.
Southeastern pine forests.
Northeastern hardwoods.

Northwestern coniferous forests (parts only).
Pacific grassland (parts only).
Desert grass savanna (parts only).
Plains grassland (parts only).
Prairie grassland.
Plains grassland.
Pacific grassland.
Alpine meadow.
Western pine forests.

Desert grass savanna.
Desert grassland.
Northern desert shrub.
Southern desert shrub.

Vegetation Types Found on Western Raw Lands

These types are listed as indicators of the value of the land for the production of small grains, for forage crops, and for grazing.

On a long-time basis it is doubtful if any use can equal the forage value of the natural vegetation.

For the Production of Small Grains

Best types:
- Blue grama and valley sage.
- Blue grama, junegrass, and needle-and-thread.
- Needle-and-thread.
- Blue grama and pasture sagebrush.
- Blue grama and sagebrush.
- Blue grama and wild alfalfa.
- Mountain brushland.
- Sheep fescue.

Medium types:
- Arizona fescue.
- Blue blue joint.
- Dry meadow.
- Bitterbrush.
- Red three-awn.
- Blue grama and buffalo grass.

Poorest types:
- Sagebrush.
- Bluestem.
- Little rabbitbrush.
- Giant wild-rye.

For the Production of Forage

Best types:
- Little blue joint.
- Aspen.
- Mountain weed.
- Mixed mountain grassland.
- Blue grama, buffalo grass, and broom snakeweed.
- Blue grama, buffalo grass, and soapweed.
- Willows.
- Hairy grama, blue grama, and sand sage.
- Blue grama, buffalo grass, and mesquite.
- Mesquite and mesquite grass.
- Blue grama and broom snakeweed.

Medium types:
- Sand hills mixed.
- Black grama.
- Blue grama and fourwing saltbush.
- Rothrock grama.
- Southwestern mountain brush.
- Conifer timber.
- Woodland timber.

Poorest types:
- Shinnery oak.
- Black grama and tobosa.
- Tobosa.
- Black grama and three-awn.
- Black grama, “niggerwool,” and sagebrush.
- Niggerwool.
- Yucca desert grassland.
- Wedgeleaf ceanothus.
### Grazing Lands

<table>
<thead>
<tr>
<th>Best types:</th>
<th>Medium types—Continued.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet meadows</td>
<td>Greasewood—sheep</td>
</tr>
<tr>
<td>Salt grass</td>
<td>Big saltbush</td>
</tr>
<tr>
<td>Sacaton</td>
<td>Hop-sage—sheep-winter</td>
</tr>
<tr>
<td>Alkali sacaton</td>
<td></td>
</tr>
<tr>
<td>Galleta</td>
<td></td>
</tr>
<tr>
<td>Rabbitbrush and alkali sacaton</td>
<td></td>
</tr>
<tr>
<td>Mountain-mahogany</td>
<td></td>
</tr>
<tr>
<td>Greasewood and saltgrass</td>
<td>Creosotebush</td>
</tr>
<tr>
<td>Winterfat</td>
<td>Creosotebush—cacti</td>
</tr>
<tr>
<td>Medium types:</td>
<td>Creosotebush and bur-sage</td>
</tr>
<tr>
<td>Mesquite and fourwing saltbush</td>
<td>Blackbrush</td>
</tr>
<tr>
<td>Creosotebush—desert grass</td>
<td></td>
</tr>
<tr>
<td>Blackbrush—desert grass</td>
<td></td>
</tr>
<tr>
<td>California mixed brush</td>
<td>California mixed brush</td>
</tr>
<tr>
<td>Desert brush type</td>
<td></td>
</tr>
<tr>
<td>Big galleta</td>
<td></td>
</tr>
<tr>
<td>Mesquite</td>
<td></td>
</tr>
<tr>
<td>Shadscale</td>
<td>25-75</td>
</tr>
<tr>
<td>Salt sage</td>
<td></td>
</tr>
<tr>
<td>Greasewood—shadscale</td>
<td></td>
</tr>
<tr>
<td>Greasewood—salt sage</td>
<td>25-75</td>
</tr>
</tbody>
</table>

#### Common and Scientific Names of Plants Mentioned

<table>
<thead>
<tr>
<th>Plant Name</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkali sacaton (tussock grass)</td>
<td>Sporobolus airoides Torr.</td>
</tr>
<tr>
<td>Alligator juniper</td>
<td>Juniperus pachyphloea Torr.</td>
</tr>
<tr>
<td>Alpine fir</td>
<td>Abies lasiocarpa (Hook.) Nutt.</td>
</tr>
<tr>
<td>Arizona fescue</td>
<td>Festuca arizonica Vasey</td>
</tr>
<tr>
<td>Arrowweed</td>
<td>Pluchea sericea (Nutt.) Cov.</td>
</tr>
<tr>
<td>Ash</td>
<td>Frazinus spp.</td>
</tr>
<tr>
<td>Asters</td>
<td>Aster spp.</td>
</tr>
<tr>
<td>Balsam fir</td>
<td>Abies balsamea (L.) Mill.</td>
</tr>
<tr>
<td>Balsamroot</td>
<td>Balsamorhiza sagittata (Pursh) Nutt.</td>
</tr>
<tr>
<td>Beech</td>
<td>Fagus grandifolia Ehrh.</td>
</tr>
<tr>
<td>Big bluejoint</td>
<td>Andropogon furcatus Muhl.</td>
</tr>
<tr>
<td>Big galleta</td>
<td>Hilaria rigida (Thurb.) Benth.</td>
</tr>
<tr>
<td>Big saltbush</td>
<td>Atriplex lentiformis (Torr.) S. Wats.</td>
</tr>
<tr>
<td>Bitterbrush</td>
<td>Purshia tridentata (Pursh) DC.</td>
</tr>
<tr>
<td>Bitternut hickory</td>
<td>Hicoria cordiformis (Wang.) Britt.</td>
</tr>
<tr>
<td>Blackbrush</td>
<td>Coleogyne ramosissima Torr.</td>
</tr>
<tr>
<td>Black grama</td>
<td>Bouteloua eriopoda Torr.</td>
</tr>
<tr>
<td>Blackjack oak</td>
<td>Quercus marilandica Muench.</td>
</tr>
<tr>
<td>Black spruce</td>
<td>Picea mariana (Mill.) B. S. P.</td>
</tr>
<tr>
<td>Bluebunch wheatgrass</td>
<td>Vaccinium spp.</td>
</tr>
<tr>
<td>Blue grama</td>
<td>Agropyron spicatum (Pursh) Scribn. and Sm.</td>
</tr>
<tr>
<td>Bluejoint</td>
<td>Agropyron smithii Rydb.</td>
</tr>
<tr>
<td>Bluestem (western wheatgrass)</td>
<td>Acer negundo L.</td>
</tr>
<tr>
<td>Boxelder</td>
<td>Bromus spp.</td>
</tr>
<tr>
<td>Bromes</td>
<td>Andropogon glomeratus (Walt.) B. S. P.</td>
</tr>
<tr>
<td>Broomsedge</td>
<td>Gutierrezia sarothrae (Pursh) Britt. and Rusby</td>
</tr>
<tr>
<td>Brom shakeweed</td>
<td>Buchloe dactyloides (Nutt.) Engelm.</td>
</tr>
<tr>
<td>Buffalo grass</td>
<td>Franseria spp.</td>
</tr>
</tbody>
</table>

3 Types probably more valuable as well-managed grazing lands than for any type of crop production.

4 Estimated number of cattle per square mile for an average year.
<table>
<thead>
<tr>
<th>California needlegrass</th>
<th>Stipa pulchra Hitchc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>California red fir</td>
<td>Abies magnifica Murr.</td>
</tr>
<tr>
<td>California sagebrush</td>
<td>Artemisia californica Less.</td>
</tr>
<tr>
<td>Cane cactus</td>
<td>Opuntia sp.</td>
</tr>
<tr>
<td>Chamiso</td>
<td>Atriplex canescens (Pursh) Nutt.</td>
</tr>
<tr>
<td>Chestnut</td>
<td>Castanea dentata (Marsh.) Borkh.</td>
</tr>
<tr>
<td>Chestnut oak</td>
<td>Quercus montana Willd.</td>
</tr>
<tr>
<td>Coleogyne (blackbrush)</td>
<td>Coleogyne ramosissima Torr.</td>
</tr>
<tr>
<td>Coneflower</td>
<td>Ratibida columnaris (Sims) D. Don</td>
</tr>
<tr>
<td>Corkbark fir</td>
<td>Abies arizonica Merriam</td>
</tr>
<tr>
<td>Cottonwood</td>
<td>Populus balsamifera L.</td>
</tr>
<tr>
<td>Creosotebush</td>
<td>Cevilla tridentata (DC.) Vail</td>
</tr>
<tr>
<td>Cryptanthus</td>
<td>Cryptanthus graminipilus (T. &amp; G.) Greene</td>
</tr>
<tr>
<td>Curly-mesquite</td>
<td>Hilaria belangeri (Steud.) Nash</td>
</tr>
<tr>
<td>Cypress</td>
<td>Taxodium distichum (L.) Rich.</td>
</tr>
<tr>
<td>Desert saltbush</td>
<td>Atriplex polycarpa S. Wats.</td>
</tr>
<tr>
<td>Dogwood</td>
<td>Cornus spp.</td>
</tr>
<tr>
<td>Douglas fir</td>
<td>Pseudotsuga mucronata (Raf.) Sudw.</td>
</tr>
<tr>
<td>Downy chess</td>
<td>Bromus tectorum L.</td>
</tr>
<tr>
<td>Elm</td>
<td>Ulmus americana L.</td>
</tr>
<tr>
<td>Encelia</td>
<td>Encelia sp.</td>
</tr>
<tr>
<td>Engelmann spruce</td>
<td>Picea engelmanni (Parry) Englem.</td>
</tr>
<tr>
<td>Filaree</td>
<td>Erodium spp.</td>
</tr>
<tr>
<td>Fourwing saltbush</td>
<td>Atriplex canescens (Pursh) Nutt.</td>
</tr>
<tr>
<td>Galleta</td>
<td>Hilaria jamesii (Torr.) Benth.</td>
</tr>
<tr>
<td>Giant cactus</td>
<td>Carnegiea gigantea (Engelm.) Britt. and Rose</td>
</tr>
<tr>
<td>Giant wild-rye</td>
<td>Elymus condensatus Presl</td>
</tr>
<tr>
<td>Goldenrods</td>
<td>Solidago spp.</td>
</tr>
<tr>
<td>Greasewood</td>
<td>Sarcobatus vermiculatus (Hook.) Torr.</td>
</tr>
<tr>
<td>Hairy grama</td>
<td>Bouteloua hirsuta Lag.</td>
</tr>
<tr>
<td>Hemlock</td>
<td>Tsuga canadensis (L.) Carr.</td>
</tr>
<tr>
<td>Hickory</td>
<td>Hicoria spp.</td>
</tr>
<tr>
<td>Hop-sage</td>
<td>Grayia spinosa (Hook.) Moq.</td>
</tr>
<tr>
<td>Idaho fescue</td>
<td>Festuca idahoensis Elmer</td>
</tr>
<tr>
<td>Incense cedar</td>
<td>Libocedrus decurrens Torr.</td>
</tr>
<tr>
<td>Indian grass</td>
<td>Sorghastrum nutans (L.) Nash</td>
</tr>
<tr>
<td>Jack pine</td>
<td>Pinus banksiana Lamb.</td>
</tr>
<tr>
<td>Jeffrey pine</td>
<td>Pinus jeffrey A. Murr.</td>
</tr>
<tr>
<td>Junegrass</td>
<td>Koeleria cristata (L.) Pers.</td>
</tr>
<tr>
<td>Lambquarters</td>
<td>Chenopodium album L.</td>
</tr>
<tr>
<td>Lilies</td>
<td>Lilium sp.</td>
</tr>
<tr>
<td>Little bluejoint</td>
<td>Andropogon scoparius Michx.</td>
</tr>
<tr>
<td>Little rabbitbrush</td>
<td>Chrysothamnus stenophyllus (A. Gray) Greene</td>
</tr>
<tr>
<td>Loblolly pine</td>
<td>Pinus taeda L.</td>
</tr>
<tr>
<td>Lodgepole pine</td>
<td>Pinus contorta Doug.</td>
</tr>
<tr>
<td>Longleaf pine</td>
<td>Pinus palustris Mill.</td>
</tr>
<tr>
<td>Lyall larch</td>
<td>Larix lyallii Parl.</td>
</tr>
<tr>
<td>Mesquites</td>
<td>Prosopis spp.</td>
</tr>
<tr>
<td>Mockernut hickory</td>
<td>Hicoria alba (L.) Britt.</td>
</tr>
<tr>
<td>Mountain hemlock</td>
<td>Tsuga mertensiana (Bong.) Carr.</td>
</tr>
<tr>
<td>Mountain-mahogany</td>
<td>Cercocarpus spp.</td>
</tr>
<tr>
<td>Narrowleaf saltbush</td>
<td>Atriplex linearis S. Wats.</td>
</tr>
<tr>
<td>Needle-and-thread</td>
<td>Stipa comata Trin.</td>
</tr>
<tr>
<td>Niggerwool</td>
<td>Carex filifolia Nutt.</td>
</tr>
<tr>
<td>Noble fir</td>
<td>Abies nobilis Lindl.</td>
</tr>
<tr>
<td>Plant Name</td>
<td>Scientific Name</td>
</tr>
<tr>
<td>----------------------------</td>
<td>------------------------------------------------------</td>
</tr>
<tr>
<td>Oaks</td>
<td>Quercus spp.</td>
</tr>
<tr>
<td>Ocotillo</td>
<td>Fouquieria splendens Engelm.</td>
</tr>
<tr>
<td>One-seeded juniper</td>
<td>Juniperus monosperma (Engelm.) Sarg.</td>
</tr>
<tr>
<td>Paloverde</td>
<td>Cercidium sp.</td>
</tr>
<tr>
<td>Pasture sagebrush</td>
<td>Artemisia frigida Willd.</td>
</tr>
<tr>
<td>Peppergrass</td>
<td>Lepidium ramosissimum A. Nels.</td>
</tr>
<tr>
<td>Pickleweed</td>
<td>Allenrollea occidentalis (S. Wats.) Kuntze</td>
</tr>
<tr>
<td>Pinyon pine</td>
<td>Pinus edulis Engelm.</td>
</tr>
<tr>
<td>Porcupine grass</td>
<td>Stipa spartea Trin.</td>
</tr>
<tr>
<td>Ponderosa pine</td>
<td>Pinus ponderosa Dougl.</td>
</tr>
<tr>
<td>Psoralea</td>
<td>Psoralea spp.</td>
</tr>
<tr>
<td>Purple coneflower</td>
<td>Echinacea sp.</td>
</tr>
<tr>
<td>Red bay</td>
<td>Persea borbonia (L.) Spreng.</td>
</tr>
<tr>
<td>Red gum</td>
<td>Liquidambar styraciflua L.</td>
</tr>
<tr>
<td>Red maple</td>
<td>Acer rubrum L.</td>
</tr>
<tr>
<td>Red oak</td>
<td>Quercus borealis maxima (Marsh.) Ashe</td>
</tr>
<tr>
<td>Red pine</td>
<td>Pinus resinosa Ait.</td>
</tr>
<tr>
<td>Red samphire</td>
<td>Salicornia rubra A. Nels.</td>
</tr>
<tr>
<td>Red sprucee</td>
<td>Picea rubens Sarg.</td>
</tr>
<tr>
<td>Red three-awn (wire grass)</td>
<td>Aristida longiseta Steud.</td>
</tr>
<tr>
<td>Redwood</td>
<td>Sequoia sempervirens (Lamb.) Endl.</td>
</tr>
<tr>
<td>Ring muhly</td>
<td>Muhlenbergia torreyi (Kunth) Hitch.</td>
</tr>
<tr>
<td>Rothrock grama</td>
<td>Bouteloua rothrockii Vasey</td>
</tr>
<tr>
<td>Rocky Mountain red cedar</td>
<td>Juniperus scopulorum Sarg.</td>
</tr>
<tr>
<td>Russian-thistle</td>
<td>Salsola pestifer A. Nels.</td>
</tr>
<tr>
<td>Sagebrush</td>
<td>Artemisia tridentata Nutt.</td>
</tr>
<tr>
<td>Saltbush</td>
<td>Atriplex nutallii S. Wats.</td>
</tr>
<tr>
<td>Saltgrass</td>
<td>Distichlis stricta (Torr.) Rydb.</td>
</tr>
<tr>
<td>Salt sage</td>
<td>See Fourwing saltbush.</td>
</tr>
<tr>
<td>Samphire</td>
<td>Salicornia sp.</td>
</tr>
<tr>
<td>Sandberg bluegrass</td>
<td>Poa secunda Presl</td>
</tr>
<tr>
<td>Sandgrass</td>
<td>Calamovilfa longifolia (Hook.) Scribn.</td>
</tr>
<tr>
<td>Sand sage</td>
<td>Artemisia filifolia Torr.</td>
</tr>
<tr>
<td>Seabank sage</td>
<td>Artemisia rigida A. Gray</td>
</tr>
<tr>
<td>Seab sagebrush</td>
<td>Artemisia sp.</td>
</tr>
<tr>
<td>Scrub pine</td>
<td>Pinus virginiana Mill</td>
</tr>
<tr>
<td>Selaginella</td>
<td>Selaginella sp.</td>
</tr>
<tr>
<td>Seepweed</td>
<td>Dondia torreyana (S. Wats.) Standley</td>
</tr>
<tr>
<td>Shadscale</td>
<td>Atriplex confertifolia (Torr.) S. Wats.</td>
</tr>
<tr>
<td>Sheep fescue</td>
<td>Festuca ovina L.</td>
</tr>
<tr>
<td>Shinnery oak</td>
<td>Quercus spp.</td>
</tr>
<tr>
<td>Shortleaf pine</td>
<td>Pinus echinata Mill</td>
</tr>
<tr>
<td>Shrub buckwheat</td>
<td>Eriogonum sp.</td>
</tr>
<tr>
<td>Sitka spruce</td>
<td>Picea sitchensis (Bong.) Carr.</td>
</tr>
<tr>
<td>Sixweeks fescue</td>
<td>Festuca octoflora Walt.</td>
</tr>
<tr>
<td>Slash pine</td>
<td>Pinus caribaea Morelet</td>
</tr>
<tr>
<td>Slender wheatgrass</td>
<td>Agropyron pauciflorum (Schwein.) Hitche.</td>
</tr>
<tr>
<td>Small sage</td>
<td>Artemisia nova A. Nels.</td>
</tr>
<tr>
<td>Snakeweed</td>
<td>Guterrezia sarothrae (Pushr.) Britt. and Rushy</td>
</tr>
<tr>
<td>Soapweed</td>
<td>Yucca elata Engelm.</td>
</tr>
<tr>
<td>Spruce top grama</td>
<td>Bouteloua chondrooides (H. B. K.) Benth.</td>
</tr>
<tr>
<td>Sugar maple</td>
<td>Acer saccharum Marsh.</td>
</tr>
<tr>
<td>Sugar pine</td>
<td>Pinus lambertiana Dougl.</td>
</tr>
<tr>
<td>Sweet bay</td>
<td>Magnolia virginiana L.</td>
</tr>
<tr>
<td>Switchgrass</td>
<td>Panicum virgatum L.</td>
</tr>
</tbody>
</table>
Tamarack  
Tarweeds  
Three-awn grasses  
Tobosa  
Tupelo gum  
Utah juniper  
Utah samphire  
Valley sage  
Walnut  
Water ash  
Water grass  
Wedgeleaf ceanothus  
Western larch  
Western stickseed  
Western red cedar  
Western white pine  
White cedar (southern)  
White fir  
White pine  
White sage  
Wild oaks  
Willows  
Winterfat  
Woolly Indianwheat  
Yellow birch  
Yellow poplar  
Yellow oak (black oak)  
Yucca  

Larix laricina (DuRoi) Koch  
Hemizonia spp.  
Aristida spp.  
Hilaria mutica (Buckl.) Benth.  
Nyssa aquatica L.  
Juniperus utahensis (Engelm.) Lemmon  
Salicornia utahensis Tidestrom  
Artemisia cana Pursh  
Juglans nigra L.  
Fraxinus caroliniana Mill.  
Paspalum dilatatum Poir.  
Ceanothus cuneatus (Hook.) Nutt.  
Larix occidentalis Nutt.  
Lappula occidentalis (S. Wats.) Greene  
Thuja plicata D. Don  
Pinus monticola Dougl.  
Chamaecyparis thyoides (L.) B. S. P.  
Abies concolor (Gord.) Parry  
Pinus strobus L.  
Kochia vestita (S. Wats.) Rydb.  
Avena fatua L.  
Salix spp.  
Eurotia lanata (Pursh) Moq.  
Plantago purshii Roem. and Schult.  
Betula lutea Michx. f.  
Liriodendron tulipifera L.  
Quercus velutina Lam.  
Yucca spp.