THE NATURAL VEGETATION OF ARIZONA

By A. A. Nichol
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*On leave—with Resettlement Administration.
†† In co-operation with United States Department of Agriculture, Bureau of Plant Industry.
††† In co-operation with United States Department of Agriculture, Bureau of Agricultural Engineering.
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INTRODUCTION

There are 113,810 square miles in the state of Arizona. In the extreme southwestern corner where the Colorado River crosses the international boundary is the state's lowest point, an elevation of 137 feet above sea level, while almost due northeast 275 miles Agassiz Peak in the San Francisco Mountains tops out in volcanic rock at 12,610 feet. The many topographic types which are found through this wide range in altitude produce a wide diversity in the number, intensity, and the combining percentages of the factors which in turn develop the different kinds of natural vegetation. Consequently, the state has a great variety of plant cover types. The composition and density of each of these types are determined by the interoperative factors of temperature, rainfall, wind, sunshine, soil, and the like. While the sum total result of these factors then is the production of any given type of vegetation, the percentage importance of any one factor is determined by minor or major changes in the topography, by altitude, latitude, exposure, and by the proximity of large bodies of water. Each factor, however, has critical limits beyond which there is no tolerance for any given plant regardless of the optimum influence of all the other factors. For example, areas of chamiso and creosote bush on good agricultural land in the Salt River Valley were quickly replaced by dondia and chico, alkali-tolerant plants, when water from shallow wells high in salt content was used for irrigation. The chamiso and creosote bush will not return to the area. There still exist for them optimum conditions in all the other factors, but a change in the soil chemistry beyond the tolerance of the original cover has produced a distinct change in the vegetation now occupying the area.

Another illustration of the manner in which the critical limits of one or more factors operate to control the type of natural vegetation may be seen in a comparison of the plant cover found on any one of the many low desert ranges in western Arizona and the high, forested White Mountains near the eastern boundary of the state. Practically barren, the desert mountains carry only a scattering number of palo verde, cacti, and scraggy thornbush. The White Mountains are covered with a dense forest of spruce, fir, and pine. One may readily judge that this great contrast is brought about by wide differences in the moisture supply and the temperature. The lower temperatures and increased rainfall on the higher mountains are principal factors in the development of the fir-pine forests, while the sparse cover of the desert range
is a result of very low precipitation and very high temperatures. Should the desert range retain its high temperatures but receive a greatly increased annual rainfall, a forest type could eventually develop on them. If so, it would rarely be a coniferous forest, but rather a broad-leaved evergreen type, semitropical or tropical in nature, depending on the amount of rain, its time of occurrence, and on the range and height of temperature. Mean growing season temperatures from 50 to 60 degrees F. with an annual rainfall from 25 to 35 inches are ranges of the temperature and moisture factors conducive to the development of a coniferous cover. And while this same annual moisture may permit a forest type, the temperature factor may largely determine what kind of forest type will be developed.

It is economical, and should be essential, that in all land-use programs the degree and limitation of each environmental factor should be found (insofar as possible) before elaborate and expensive projects are attempted. A certain land development project had excellent soil, plentiful sunlight, frost-free temperatures, good water—all factors conducive to producing premium quality citrus and grapes. The influence of air movement, however, was overlooked. In this particular locality the wind blows persistently. The temperate climate grapes had no mechanism by which they could withstand the high evaporative strain caused by the wind, and they could not move water to their leaf surfaces rapidly enough to keep them protectively moist. While the citrus leaves are structurally better adapted to resist the factor of high transpiration, the continued mechanical fretting of the leaves and fruit prevented profitable development. Hope, labor, and money were lost and the area is now abandoned. Since the rice paddies of China and the wheat fields of the Nile, man has circumvented to a fair degree the all important factor of moisture when its original maxima were less than his economic needs. The permanence and success of these projects, however, does not depend upon the moisture factor alone. In the modern irrigation developments in the United States, for example, if costs are equalized it would appear that the profitableness of a given project is in more or less direct ratio to the height of temperature. Which is, in turn, a coefficient expression between our consumption of tropical commodities and the amount of acreage suitable for their production.

Temperature is manipulated within very narrow limits by the use of windbreaks and smudge pots. The factors pertaining to the soil can be altered to a high degree; in actual practice the limitations are economic rather than physical.

A second important phase present in the problem of modifying the natural environmental factors lies in the closeness to the critical limits with which the operation is carried on. Windbreaks and smudge pots are only needless expense if the cycle of killing frosts is as short or shorter than the maturity length of the trees. Homesteaders in the Sulphur Springs and Sonoita Valleys broke
### VEGETATION OF ARIZONA

#### Figure 1

Percentage representation of the different cover types in Arizona, with elevation ranges, annual precipitation, and significant temperatures. Alpine meadow is not included because of its negligible extent. N. B.—In Figure 1 and the color map the older classifications for the grassland types have been used.

Up excellent grazing sod in an attempt to produce field crops. They were gambling on crops whose moisture requirements approached the rainfall maxima for these valleys. When the average and minimum years occurred they were below the toler-

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**Figure 1:** Percentage representation of the different cover types in Arizona, with elevation ranges, annual precipitation, and significant temperatures. Alpine meadow is not included because of its negligible extent. N. B.—In Figure 1 and the color map the older classifications for the grassland types have been used.
ant limits for these crops and many farms failed. The native sod had been turned under and after years unpalatable grasses have come to occupy these abandoned fields, while the native grasses, with their moisture requirements less than the field crops, continued to grow to the old fence lines and each year produce their quota of marketable beef.

The short-time view of any land-use problem is its economic feasibility in the immediate future. Too often only two or three crops are depended upon to insure success; whereas intelligent plotting of the economics against the limitations of all the environmental factors would either prove the proposed project untenable or would add to the list of usable crops and give the undertaking increased insurance. The natural vegetation of the state is an end result of the direct development of all the environmental factors acting together, and the least risk comes in those industries which demand the smallest alteration in these factors and also operate well within the optimum range of the most critical single factor. The following descriptions of the various vegetation types in the state are generalized statements of the composition, use, and the apparent controlling factors that have determined their development and present types.

The three great natural divisions of the plant cover in the United States are forest, grassland, and desert shrub. These are further divided into twenty-two main types, of which ten found in Arizona are described in this paper. The forest is divided into three types: (1) the Douglas fir-ponderosa (yellow) pine, which includes all species of fir, spruce, and pine, with the exception of the piñon; (2) the piñon-juniper; and (3) the chaparral. The grassland is likewise divided into three types: (1) the highland grass (short grass), (2) desert land grass (mesquite grass), and (3) the mountain meadow (alpine grassland). The desert shrub is divided into four types: (1) sagebrush (northern desert), (2) palo verde-cacti (southern desert), (3) creosote bush—Atriplex (southern desert), and (4) mesquite bosques (southern desert).

**FOREST**

**DOUGLAS FIR-PONDEROSA PINE**

The forests proper in Arizona are in high mountain areas, usually above 6,000 feet elevation. In places where the surrounding region or base level is high, and warm ascending currents of air from the heated desert do not occur, and where cool air drainage collects, particularly on north slopes, these forests "move down" below the average elevation. This is observed in the

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3. When compared with the total area of the state, the mountain meadow is such a small fraction it is omitted from the grassland figures and from the map.
Prescott region of the Bradshaw Mountains where ponderosa pine is found as low as 5,000 feet. Conversely, isolated mountains set on the desert and warmed by the heated and rising air have the forest line well moved up above the mean. Navajo Mountain, on the Arizona-Utah line, is a striking example. It is a desert island, a compact isolated peak upthrust some 10,000 feet from out the northern sagebrush desert of the Navajo Indian Reservation. Here the ponderosa or western yellow pine is rarely found below 7,000 feet and is not abundant until 8,000.

Plate I.—Aspen grove. Kaibab National Forest. Elevation 8,500 feet. These dense stands are interspersed in the larger Douglas fir and spruce forests where increased moisture with low temperatures is found. These thickets are produced by the prolific suckering characteristic of aspen. Reproduction by seed is rare except following burns. The shrubs in the right foreground are the low, spreading mountain juniper commonly found as a fringe around the aspen where the groves appear on the edges of the mountain meadows.

The spruces and firs occupy the coldest, wettest, and highest areas of the forest type designated as the Douglas fir-ponderosa pine. In places on the Mogollon Mesa, the White Mountains (particularly the Blue Ridge), and on the Kaibab Plateau, Engelmann’s spruce (Picea engelmannii) and cork-bark fir (Abies arizonica) are found. The first tends to make dense, pure stands, while the latter is more often found in mixed forests. There is little or no herbaceous ground cover under these trees, because

the shade is dense and competition is vigorous between the trees themselves. Beautiful open mountain meadows, however, occur to break the forest stands. These meadows are often ringed with the white-barked quaking aspen [Populus aurea (tremuloides)], and occasionally prostrate juniper (Juniperus sibirica) fringes the edges of the aspen or the spruce and fir. Dense stands of mixed grasses and herbs make a heavy sod in these meadows. On the Kaibab they are dry except for occasional sinklike pools which have developed in the relatively soft limestone formation which caps this plateau. In the White Mountains small streams drain these meadows. These streams originally contained beaver and native trout. Sheep and cattle now graze these parks in summer. On the Kaibab they furnish midsummer feeding areas for deer, and in the White Mountains elk are gradually working them from the Mogollon Mesa.

Plate II.—High mountain parks in the spruce and fir belts. On the road from Springerville to McNary. Elevation approximately 8,000 feet. The forest background is mainly Douglas fir with a few aspen and occasional white fir and spruce. Sheep fescue, love grass (Eragrostis), some hairy dropseed (Blepharoneuron), and dry-land sedges make up most of the sod cover.

Slightly lower in elevation than the spruce and cork-bark fir and just above the yellow pine, the Douglas fir belt occurs. While this is the most important forest tree in Washington and Oregon, its smaller size, inaccessibility, and small acreage make it rela-
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Lively unimportant to the lumber industry in Arizona. The Douglas fir develops pure, dense stands with no under cover. Where light permits, the trees carry low spreading branches that lie on the ground, and only a litter of needles and cones is found under the trees. The high, open meadows described above are also characteristic feature in the Douglas fir belt. Shrubs are practically absent, although on breaks and ledges where there is sufficient sunlight, snowberry (Symphoricarpus sp.) and buckbrush (Ceanothus mogollonicus) may develop a very local shrub cover.

Below the fir and developing into pure stands at 7,500 feet and continuing to 6,000 feet, occurs the ponderosa pine (Pinus ponderosa). This makes the largest and most important economic forest type in Arizona. It is this species which furnishes practically all the saw timber. In the southern part of the state, the ponderosa pine areas dot each isolated desert range that rises above 7,000 feet. In central and northern Arizona it forms more or less of a continuous belt running northwesterly from the New Mexico border and the White Mountains across the north sloping incline of the Mogollon Mesa, past Williams and Flagstaff, and terminates in the Kaibab National Forest north of the Grand Canyon of the Colorado. This forest on the famous Kaibab Plateau of the Buckskin Mountains is one of the most magnificent and homogenous forests in the United States. Northeastward, capping Navajo Mountain, the Carrizos and the Lukachukais are additional small areas. In western Arizona scattering groves of pine are found on the Virgin Mountains that lie near the Nevada state line. These groves are small and are dropped just below the crests on the cooler north slopes. Similar groves are found in the Cerbat Mountains north of Kingman, while southeast the Hualpais Mountains have small but splendid stands. From the Hualpais the ponderosa pine areas swing sharply to the east into the Santa Teresa Mountains, the Bradshaws, Pinals, Pinalenos, Santa Catalinas and terminate their extreme southwestern distribution in the state atop the Baboquivari Mountains in south central Pima County.

In the smaller areas where abrupt changes produce many variations in temperature, moisture, and terrain, the small stands may appear as a mixed forest. In most areas, however, even on the desert mountains, ponderosa pine gives the clean, open appearance free from understory which is characteristic of this species. In the larger areas of the north central belt it is possible to travel for miles through pure and continuous stands of this fine tree.

As contrasted to the spruce and fir forests, the ponderosa canopy is quite open, and sunlight reaches the ground. Shrubs are practically absent, and the ground cover is composed of grass and herbs. Most important of the grasses are Arizona fescue (Festuca arizonica) and mountain muhly (Muhlenbergia montana), a bunch grass. The first comes in on the more open areas which intersperse the forest, while the latter makes a valuable grazing cover in the higher and denser parts of the forest.
Plate III.—Ponderosa pine (western yellow pine) forest, open type. Pine Flat, southwest of Williams, Arizona. Elevation 6,500 feet. These open parks are characteristic of the yellow pine belt. The ground cover is mainly little dropseed with lesser amounts of prostrate grama. At the base of the large tree on the left a scraggy alligator bark juniper is struggling for moisture.

Gambel's oak (Quercus gambeli) and Mexican locust (Robinia neomexicana) establish themselves in the occasional breaks in the forest to produce small but compact thickets. In the densest stands of pine the ground floor may be almost bare of vegetation by reason of high soil acidity and moisture competition, and only a litter of cones and needles are present. Where the stands are less canopied, grasses and herbs cover the ground. In addition to the fescue and mountain muhly, blue grama (Bouteloua gracilis) and the little dropseed (Sporobolus confusus) may frequently make an extensive cover. The grama species is normally limited to the lower parts of the timber belt and more open parks. Areas of mountain muhly which have been seriously overgrazed, however, give way to weak sods of the blue grama. Among the herbs, the early blooming lupine (Lupinus sp.), the midsummer phlox (Phlox longifolia), the fall larkspur (Delphinium sp.), and various Senecios and asters make islands of blue and yellow color throughout the growing season.

Outcropping ridges of rock and abrupt ledges (usually limestone or malpais) form in many places stringers through the forest. These are concentration areas of more varied local flora and
greatly raise the number of species found in the ponderosa pine association. Among the shrubs, cliff rose or quinine bush (*Cowania stanburiana*) is one of the most prominent, with the occasional occurrence of buckbrush and service berry (*Amelanchier utahensis*), although the last two are normally found lower down. All are good browse plants, as is mountain mahogany (*Cercocarpus montanus*) which may in certain areas extend its highest ranging plants into the pine belt to occupy these open ledges and ridges. The herbaceous plants appear so scarce in this type that there is a tendency to overlook them. This should not be done as investigation has shown that they make in the aggregate and through seasonal appearance an extremely important contribution to the support of domestic stock and the native wild life. The most important ground cover in this forest is the dense growth of seedling pine which is produced periodically.

The yearly rainfall for the Douglas fir-ponderosa pine division runs from 20 to more than 30 inches; the ponderosa pine type is established in the lower, drier part of this range (from 20 to 25 inches); the Douglas fir intermediate; and the spruce and cork-bark fir in the maximum annual precipitation belt, much of which is received in the form of snow. Mean growing season temperatures range from 50 to 60 degrees F. In the ponderosa pine areas summer maxima of 100 degrees are not uncommon, while winter minima have been recorded as low as 30 degrees below zero. There are two distinct precipitation periods: midsummer rains which are common any time after the first of July and continue intermittently for six or eight weeks, and winter snows which fall through the three winter months and extend well into March. The ponderosa pine forest was originally poorly watered as it occurs mainly on porous limestone and volcanic rock formations. It is good grazing country, and the construction of dams, represos, and small lakes permitted it to be used for summer range for sheep and cattle. Increased distribution of water has also increased the amount and distribution of native animal life. Bear, deer, turkey, elk, antelope (in the more open parks), lion, lobo, fox, bobcat, porcupine, and beaver were all found in this type and today are present in proportion to the press of grazing and the degree of hunting. The herbivorous animals found abundant food in the oak mast, palatable shrubs, grass, mushrooms, and annual weeds.

**PINON-JUNIPER**

Despite the fact the piñon-juniper type is one of the most distinctly marked, a description of its limits is difficult to make since long and narrow tongues of forest will extend away from the main body to follow stringers of favorable soil and areas of favorable temperature and moisture conditions. Also, scattered through the light background of the sagebrush and the highland grass areas, black islands of juniper and piñon cover the knolls and eminences that break the plateau topography.
Plate IV.—Piñon-juniper forest. Black Mesa. Elevation 5,500 feet. This is a relatively young forest, the original seed trees were largely confined to the knolls and ridges. Blue stem, tobosa, and blue grama grass make up the greater part of the ground cover. The dark strip in the foreground is a mixture of Russian thistle and poisonous whorled milkweed.

Next lower in elevation than the ponderosa pine, the piñon-juniper forest occupies an area north of the main ponderosa belt that is comparable in position to that occupied by the chaparral forest to the south of the pine. Roughly, the piñon-juniper is moved upward 1,000 feet higher than the chaparral. In other words, on the south boundaries of the pine forest the chaparral, or brush thicket, rises for 500 to 1,000 feet higher, to meet the timber trees, than the piñon-juniper does on the colder, drier slopes where the forest finds tolerant temperatures at lower elevations.

Often the piñon-juniper forest occurs in dense stands to the visual exclusion of other plants. In other places the type is more open and a sod of good grazing grasses such as bluestem (Agropyron smithii), blue grama (probably the most outstanding single species of the forage grasses), galleta (Hilaria jamesii), and other less prominent grasses grow between the trees. If the terrain is rough and rocky, shrubs such as cliff rose, mountain mahogany, scrub oak (Quercus turbinella), spirea (Chamaebatiaria millefolium), mimosa (Mimosa biuncifera), algerita or barberry (Berberis fremontii), skakweed (Gutierrezia tenuis), rabbit brush (Chrysothamnus spp.), and many others occur.
The stringybark or Utah juniper (*Juniperus utahensis*) is the most abundant species in the northern piñon-juniper type. This much branched, stiffly upright tree is resistant to decay and is in demand for fence posts. It is also an excellent firewood but does not produce the heat nor burn as quietly as the alligator bark (*Juniperus pachyphloea*) species. The latter tree is rarely found making a dense forest stand but occurs in small limited groves and isolated specimens. It attains much greater size than the Utah juniper, with a single, short but massive trunk carrying a dense and spreading canopy of deep green foliage. On mature trees the bark on the trunk becomes deeply checkered, from which characteristic appearance it derives the common name “alligator bark.” This species occurs also on the higher ridges of the southern mountains growing on the warmest and driest exposures next to the ponderosa pine. The Utah juniper does not come into the southern mountains. Its place is taken by the single-seeded juniper (*Juniperus monosperma*), also a stringybark type. It is with difficulty separated from the northern species but is generally smaller, more scraggy, and has blue-colored fruit, instead of the brown of the Utah tree. The single-seeded juniper is usually found somewhat lower in elevation than the alligator bark.

The piñon pine (*Pinus edulis*) closely associated with the junipers, particularly in this type, is a true pine as can be determined by finding the leaves grouped into clusters in a common papery basal sheath. The tree rarely grows over 40 feet in height in Arizona and is commonly shorter. The wood is soft and not durable but in certain areas is used for firewood. It does produce a very valuable and desirable seed—the piñon nut. Many tons of these are gathered in early winter, mainly by the Indians for their own food supply. A fraction of the crop reaches the market either fresh or roasted. The nut is high in fats and sugars and has a pleasant flavor.

The more open juniper forests are good grazing lands for sheep and cattle. Every evidence points to the fact that many areas that were at one time mainly grassland, with a scattering of juniper and piñon trees, now have rather dense stands of juniper reproduction brought about by the grazing influences of domestic stock. According to C. K. Cooperrider of the Southwestern Forest and Range Experiment Station, co-operating with the University of Arizona, these new juniper forests have been brought about by a sequence of three causes: first, the greatly increased amount of seed that is capable of germinating. Juniper seed does not germinate readily unless it has passed through the alimentary tract of some bird or animal. The second influence is the wide dissemination given these seeds by livestock, particularly driven bands of sheep. The third is the removal by this livestock of the competing grasses that originally occupied the area. He further states there is good evidence to believe that the juniper would be replaced by the original grass cover if the strain of severe grazing was removed from these areas. These new forests can be found several places in the state. Probably one of the largest areas gone
over from the grassland to the piñon-juniper type is the Black Mesa above Chino Valley. Smaller, but plainly distinguished, are many similar areas over on the mesa lands lying west and above the Blue in eastern Arizona.

This type is yet more sparsely watered than the yellow pine forest, the mean annual rainfall varying from 12 to 15 inches. The mean growing season temperatures range from 60 to 70 degrees with minima as low as 10 degrees above zero.

The native wild life was correspondingly scarce but has increased somewhat with the development of water. Antelope, preyed upon by wolves and coyotes, was the most abundant large mammal, with occasional herds of mule deer. In winter, elk and additional herds of mule deer wintered in this forest finding excellent protection and less severe temperatures. Wild turkey migrated to the upper fringes to feed on the juniper fruits and pinon nuts. Other birds were and still are scarce, the piñon jay being the most common.

CHAPARRAL

Approximately 8 per cent of the state’s area is covered with brush thicket or chaparral. The most extensive and continuous forests of this type occur on the southern side of the main ponderosa pine body where the mountain slopes drop away to lower elevations and higher temperatures. Smaller bodies of typical chaparral growth are found throughout southern and eastern Arizona on the slopes of the isolated mountain ranges, occurring above the grass and below the ponderosa pine. In the United States this type of vegetation is largely limited to southern Arizona and southern California, although small amounts of it are found in the south central Rocky Mountain states. It is characterized by shrubs and stunted trees, much of the cover being so dense it is impenetrable to man or horse. Differences in soils, elevations, and exposures produce differences in the floral structure and dominance. Many areas can only be described as a heterogeneous assoication. More often one or two species dominate the type to give it a specific character. A much observed and accessible illustration of the first is the lower few miles of the White Spar road where it leaves Kirkland Valley to cross the mountains to Prescott. The elevations of the chaparral cover here run from 4,000 to 4,500 feet. Some of the shrub and tree species that compose this particular type are: mountain laurel (*Rhus ovata*), lemon bush (*Rhus trilobata*), turbinella oak (*Quercus turbinella*), Fendler oak (*Quercus fendlera*), algerita (*Berberis fremontii*), manzanita (*Arctostaphylos pungens*), madrona (*Arbutus arizonica*), cliff rose (*Cowania stansburiana*), buckbrush (*Ceonothus greggii*), mountain mahogany (*Cercocarpus breviflorus*), Apache plume (*Fallugia paradoxa*), brickellia (*Brickellia californica*), buckthorn (*Rhamnus spp.*), sensitive plant or cat’s-claw (*Mimosa biuncifera*), silk-tassel (*Garrya*), service berry (*Amelanchier mormonica*). In other areas the cover will be made up mainly of one or two species. Well known
Plate V.—Chaparral. Kirkland Valley. Elevation 5,000 feet. The shrub species in this area are mainly scrub oak, barberry (algerita), sumac, and buckthorn. Along the washes Apache plume is prominent, and slightly higher, manzanita, mountain mahogany, and mountain laurel occur.

to stockmen who work cattle in the southern Arizona ranges are the dense thickets of manzanita which cover the high, south-exposed shoulders of these desert mountains. The manzanita may appear in almost pure stands on the southern exposures, but where this type follows around to north slopes one or two species of scrub oaks will often make up an equal part of the flora. Much of the extensive brush thicket of the Tonto Basin is characterized by the dominance of several species of these scrub oaks. Roughly speaking, the higher levels of the chaparral belt show ceanothus and oak as the outstanding species, while on the lowest, driest level adjoining the desert will be found the thickets of jojoba or coffeeberry (Simmondsia californica), with the sumacs, barberry, and buckbrushes in between.

At the present time unless much broken by sod patches of considerable extent the type as a whole is poor range land. Originally, however, the chaparral areas were good grazing lands. The change has been largely brought about by too heavy grazing which has removed the grass cover, permitted soil erosion, and an increased density and distribution of the deeper rooted shrubs. The topography is rough, the soil poor, it is difficult to work cattle
in the thicketts, and now with the absence of grass to supplement a browse diet it is less desirable than either of the two preceding types for range use. The sod areas in the openings are meeting places of the desert land and highland grasses and arc figurative herbariums of gramas, *Hilarias*, and others.

Plate VI.—More open type than that shown in Plate V. Kirkland Valley. Elevation 4,700 feet. In the heavier soils of the grass areas tobosa is the principal sod. This is the transition zone for highland short grasses and desert grasses. Northern cat’s-claw (*Mimosa biuncifera*) is the most common shrub on the grassy volcanic hills in the background.

In the enumerated list of plants above, the most important from the forage standpoint are the oaks, cliff rose, mountain mahogany, silk-tassel, and probably cat’s-claw and service berry.

The climatic conditions vary little from the ranges found in the piñon-juniper belt. Although subject to much qualification the generalization may be made that the chaparral and piñon-juniper types have been differentiated on the factors of soil, slope, and exposure.

Native animal life is largely small rodents and birds which, in the abundant mast and bush fruits produced, largely circumvent the lack of water while finding a plentiful and varied food supply. Coyotes, bobcats, badgers, and foxes follow the rodent food supply. Skunks are omnipresent in this type. White-tailed deer are also partial to the higher regions, where if adjacent to water the excellent cover and the varied diet of browse, nuts, and fruits
meet every demand of this animal. No economic use is made of the plants or their fruits of this group except for minute amounts of the barberry and manzanita fruits gathered by Indians and Mexicans for conserves. Fractional amounts of jojoba, the nut which contains a liquid wax, are used in cosmetics. The root of mountain mahogany is an ingredient of one of the red dyes used by the Indians.

GRASSLAND

The grasslands of Arizona cover approximately one fourth the area of the state. High plateaus on both sides of the Colorado River west of the Grand Canyon carry extensive areas of grass. Otherwise, the grass cover is found mainly in the eastern two-thirds portion of the state. These grasslands may best be defined as a semidesert type. The kinds of grasses occurring on the high, cool uplifts north of the mountainous, forested district in central Arizona differ markedly from those found in the low, plainlike valleys in the south. Island areas of the one, however, may occur in the other. The differences which are found between the northern grass regions of the higher elevations and the southern, lower areas are correlated rather closely with differences in elevation which permit this type to be divided into highland and desert land subtypes. The highland subtype approximates in character more of the plains grass type; the desert land is the mesquite or desert grass of earlier descriptions.

HIGHLAND GRASS

Blue grama (*Bouteloua gracilis*) and galleta (*Hilaria jamesii*) are the two most important species in the highland subtype. Both may be found in pure stands, the galleta, however, making an open sod cover. They are excellent forage grasses; blue grama may be said to be established through custom as the standard of comparison. Some muhlys, needle grasses, and *Aristidas* are also found in this type in a greater or lesser degree. They are less palatable and may increase on the galleta and grama areas when this choice pair are suffering from too heavy grazing. These highland grass species usually start their growth as the temperatures become warm enough in the spring, as contrasted to the desert grasses which green up only after the midsummer rains. The growing season is approximately 100 days, but they retain their palatability and a high per cent of their nutritive value long after ripening.

One other grass and two shrubs can best be located as members of the highland grass region. Blue stem, mentioned as a grass of the pinon-juniper belt, is in certain areas a prominent plant in the heavy gumbo soils, or on rocky, malpais formations which carry innumerable pockets of light volcanic soil between outcropping "nigger heads." The first of the two shrubs, the silvery-white winter fat (*Eurotia lanata*), is one of the outstanding browse shrubs of the state. This attractive plant at one time oc-
Plate VII.—Highland grass. Mogollon Mesa, Chavez Pass in background. Elevation 6,300 feet. Bluestem makes an early spring growth. The prominent heavy crowned trees are alligator bark juniper. In the background is a strip of yellow pine established in the cold drainage area of the draw.

curred locally in almost pure stands on the areas of the heavier, alkaline-free soils in the lower levels of the highland grass type. Its high palatability has resulted in its virtual extermination over much of the grazing range except where conservative use has aided it to survive. The second browse shrub is chamiso (*Atriplex canescens*), one of the saltbushes. It also prefers the heavy type soils (although occasionally selecting sandy soils) and tolerates alkali conditions better than the winter fat. This member of a valuable browse tribe, has a wide altitudinal range, first appearing in the desert shrub at 500 feet elevation and continuing upward to 6,000.

Another characteristic plant of the grass regions in northern Arizona is the silver spined cholla (*Opuntia whipplei*). It is rarely abundant except on the western margins of its range, which corresponds closely to the grass range, and is sparsely but uniformly distributed throughout the sod cover. Snakeweed, or matchweed (*Gutierrezia tenuis*), and rabbit brush (*Chrysothamnus* spp.) were once undoubtedly minor species in this highland grass association but now in many places due to excessive grazing are the dominating plants. Soapweeds or Spanish bayonets
(Yucca baileyi) and (Y. angustissima) are often visually prominent members of this type, and one of the prostrate, narrow-leaved pentstemons is a desired forage plant. Many annual weeds, fleabanes, parsley, partridge peas, dandelions, and others grow and mature rapidly following sufficient moisture and temperature. While many of them increase the seasonal grazing use they are uncertain and quick ripening and do not characterize the permanent cover.

The environmental factors responsible for the development of a grassland type of vegetation may be so divergent that accurate plant and soil knowledge must be applied through an intensive study to determine the major factor or factors controlling this development. Rainfall, occurring mainly in spring or summer, shallow penetration of the moisture (which involves soil character), excessive winds, intense cold, short growing periods, soils poorly aerated, and repeated fires are factors any one of which may play the major part in determining the existence of a grass type of vegetation. The highland grass cover in central and northern Arizona has an annual average rainfall less than the average of the forest types, ranging from 10 inches or less to a maximum of 14. While this maximum is capable of producing a forest type of juniper or chaparral from the standpoint of moisture requirements alone, it does not because in most cases the soil is too heavy to permit sufficient water penetration or too shallow to support the deeper rooted plants. Temperature may also be a main factor. Growing season mean temperatures run through a wide range, as would be expected with a vegetation type having as many phases and subtypes as does the grass cover. This range for the highland areas in Arizona may be reasonably included between 55 and 75 degrees F. Mean minimum temperatures will reach freezing or slightly below, mean maxima will reach 95 degrees.

The original native animal life of the northern highland regions in this state was not diversified, but antelope made up in numbers what the open plateaus and mesas lacked in variety. Wolves and coyotes naturally followed the antelope. Prairie dogs and the northern plains jack rabbit were abundant. Eagles were also common as predators of the antelope kids and the larger rodents. Lieutenant Beale, who had charge of the army transport of camels across northern Arizona just previous to the Civil War, records in his diary that when they camped at the mouth of Cottonwood Wash a few miles east of the present site of Winslow they found elk, antelope, deer, beaver, and coyote there. Today much of this is drifting sand with sparsely scattered clumps of sacaton grass. The grass areas east of the Flagstaff divide have not withstood grazing as well as the regions lying on the western slopes. This appears to be largely a rainfall factor as the eastern side is more lightly watered. The average yearly precipitation for Winslow and Holbrook is 8.7 and 9.4 inches, respectively; while the mean annuals for Kingman and Seligman are 11.5 and 12.2 inches.
Plate VIII.—Highland grass near Pica. Elevation 5,500 feet. Aubrey Valley with Aubrey Cliffs in the background. The sod cover is mainly blue grama, side oats, aristidas, and tobosa. The dark shrubs are soapweed (Yucca glauca).

DESSERT LAND GRASS

The desert land grass cover is made up of a perplexing number of species, very many of which are excellent range grasses. Outstanding are the members of the grama tribe which in their southern range are more or less democratic and grow in mixed stands. Blue grama also may appear on the upper levels of the desert grass range as islandlike expressions of the highland subtype, but here it must compete with black (Bouteloua eriopoda), slender (B. filiformis), rothrock (B. rothrockii), hairy (B. hirsuta), spruce top (B. chondrosioides) gramas, and many others. Rothrock, or crowfoot, is one of the best known; it tolerates the lower ranges better and at one time made pure stands of grass in the upper borders of the cacti and desert shrub belts.

Almost equally desirable as forage grass is the curly mesquite (Hilaria berlangeri), a characteristic grass of the higher elevations, especially in the open emory-oak parks of the mountain foothills. Another member of the Hilaria genus, tobosa (Hilaria mutica), often referred to as galleta in southern Arizona, occupies the heavy alluvial soils, growing in dense heavy sods, with a characteristic matted twist to the dried stems. Tobosa is good forage when green, as it may be twice a year following either or both
the summer and winter rainy periods. Along the drainage areas the sacaton (*Sporobolus wrightii*) is a conspicuous grass because of its great size. In the accounts of early Arizona history which frequently mention the tall grass which came “above a mule’s back” undoubtedly had reference to the sacaton. This species is to the desert-land grass region what the bunch grass (*Sporobolus aroides*) is to the highland areas, although both are found interspersed on the ranges of the other. They are excellent forage grasses.

The desert grass belt is one of the most attractive types in Arizona. Roughly these areas follow between the 3,000- and 4,500-foot contours around the desert mountain ranges in the southern part of the state. The largest solid areas are found in Cochise County where the valley floors between the mountains are high and the cover is a rolling but unbroken sea of grass. This is some of the best cattle range country in the United States.

Arising from the lower levels narrow strips of mesquite (*Prosopis velutina*) follow up the drainage systems. Scattered over the mesa land and sometimes approaching the density of a forest the picturesque palmillo (*Yucca alata*) occurs with occasional cholla (*Opuntia spinosior*) and bisnaga (*Ferocactus wislizeni*). Along the upper edges of the belt the grass furnishes a sod cover for the upright, holly-leaved emory oak (*Quercus emoryi*). Cat's-claw
Plate X.—Desert land grass. Benson Pass, Whetstone Mountains in background. Elevation 4,300 feet. Summer aspect. Mostly gramas and aristidas. In the immediate foreground cotton top and finger grass grow along the ditch and in the depression. The shrub is a mesquite; the yucca is the abundant palmillo (Yucca elata).

(Acacia greggii), desert hackberry (Celtis pallida), lotebush (Zizyphus lycioides), desert willow (Chilopsis linearis), soapberry (Sapindus drummondii), and mesquite are prominent shrubs or trees in the drainage washes which serve this type. The cat’s-claw and mesquite are valuable as browse plants. The hackberry is very palatable but too thorny to be available.

This browse adds much to the value of the grazing ranges since the majority of the desert grasses have only a single, short growth period following the midsummer rains. Temperatures at this time are high—July, August, and September means ranging from 75 to 85 degrees F. Growth is consequently very rapid, with maturity depending on the spread and duration of the rainy period. The grasses, however, retain their high palatability and much of their nutritive value when dry. The average rainfall for the area is 14 to 18 inches per year with one half or more of this falling in July, August, and September. The precipitation factor is decidedly cyclic; several years may occur when the annual totals are far above the average, to be followed by drought years when the resulting cover is short and thin. The evaporative factor
plays an important part in this vegetation type. In the presence of sufficient soil moisture it aids in the production of a heavy forage crop in a relatively short time. With insufficient water present, however, the excessive evaporation may hurry the maturity to such a degree that the plants are not permitted to bridge the dry periods between the too frequently widespread rains.

This region supports an unusual abundance and variety of wild life: desert mule deer, antelope (now almost extinct), coyotes, foxes, bobcats, badgers, skunks, jack rabbits, cottontails, many species of rodents, valley and scaled quail, and a large number of mammals and birds. There is some form of succulent vegetation available throughout most of the year. The winter rains start many weed annuals in late January and February; the fruits of the bisnaga, rich in fats and sugars, are matured in late fall and are much liked by deer and rodents. Coyotes supplement their meat diet with prickly pear fruits and the sweet pods of the mesquite bean. Midsummer rains bring in addition to the green grasses, a new crop of palatable weeds such as the portulacas, Talinums, Amaranthus, buckwheats, nightshades with edible fruits, and many others. The thorny branches of the desert hackberry furnish excellent cover, and the sweet fruits supply good food for quail. On the more upland reaches of the range and on rockier soil, mesquitillo (Calliandra eriophylla), parosela (Paro-sela formosana), false mesquite (Eysenhardtia orthocarpa), and many species of mimosas, acacias, and other leguminous shrubs and herbs contribute in forage and fruit to the total food supply and variety.

MOUNTAIN MEADOW

In the highest parts of the White Mountains are found small but typical areas of alpine grassland. They are noted here simply in recognition of their occurrence and not because of economic importance. These scattered open areas in the dense forest are colorful because of the many bright flowers that occur with the varying greens of grasses and sedges. Here moisture is abundant, but temperatures are very low and the growing season short.

DESERT

The diversity of cover types which are found under this classification makes a general statement difficult or misleading. Temperature is not necessarily a factor in the production of a desert. High temperatures do, however, hurry the loss of water, as conversely, continued low temperatures that are below the physiological activity of the plants in reality amount to drought conditions for the plants affected. Moisture is the determining factor, and one of its significant phases is the time of year, or distribution, of this annual supply. In Arizona the nearest extreme desert condition is found along the lower Colorado River, a region which may get from 0 to 3 or more inches of rain per year. Even the 3
inches may fall all in one storm. Here much of the ground surface is covered, not by vegetation but by a finely laid mosaic of small stones, the handiwork of normal wind and water erosion, the result of which now successfully defies further influence from the very agencies which brought the present status about. Most plant growth is limited to the washes, arroyos, sand ridges, and mountains.

On the other extreme, and still in the classification of desert, lie the dense sagebrush stands of the northern mesas along the upper Colorado River, and the thick desert scrub composed of thornbush, cacti, vines, and annual grasses which occur throughout the lower valleys and on the hot mesas at the foot of the southern and central mountain ranges. Unless irrigated, the desert can be roughly characterized as those areas which have so low an annual rainfall that they are regions of very low productivity for any economic use, such as grazing, lumbering, farming, manufacturing, and even the mining industry, where the lack of accessible water may seriously handicap development in this field.

Plate XI.—Sagebrush, northern desert. Wolfhole, Arizona. Elevation 4,600 feet. Winter aspect. These pure stands of sagebrush are most extensive in Arizona north of the Colorado River. The stunted appearance of the sagebrush is due to heavy grazing by livestock.
SAGEBRUSH

Typical sagebrush in Arizona is mainly confined to the area known as the Strip, the region north of the Colorado River. Scattered areas occur, however, throughout the Navajo Indian Reservation and westward to the Grand Wash Cliffs. In such areas sagebrush usually grows in almost pure shrub stands with an understory of grasses, most of which are the same as those of the highland grassland. There are several species of sagebrush but the species which makes the unbroken stands that are miles in extent is the purple sage (*Artemisia tridentata*) of Zane Grey fiction. This plant grows from 3 to 6 feet in height. Sheep utilize it heavily, particularly in winter, as do deer, for example, where sagebrush approaches the skirts of the Kaibab. These shrubs are also scattered through much of the piñon-juniper woodland.

![Photo of sagebrush](image)

Plate XII.—Sagebrush, northern desert. Southeast of Navajo Mountain. Elevation approximately 6,000 feet. Summer aspect. Soapweed, traces of grass, snakeweed, and Mormon tea are lightly interspersed here. Severe grazing by goats and sheep. In the background a strip of piñon-juniper follows a rocky ridge.

Another characteristic shrub of the northern desert, not so extensive in area, but like the sagebrush usually in pure stands, is the northern blackbush (*Coleogyne ramosissima*). This species occurs in smaller belts around the Vermillion and Echo cliffs, Navajo Mountain, and the Black and Virgin mountains in Mo-
have County. It is a low, compact, evenly spaced shrub, dark in aspect, and is grazed by goats and sheep when other feed is short.

Shad scale (*Atriplex confertifolia*) is a third prominent member of the northern desert occupying the alkali flats. The purple sage and blackbrush grow only in salt-free soil. There is very little shad scale in Arizona east of the Colorado River; its range really begins in the Strip and extends north and west into Utah and Nevada.

The sagebrush desert in Arizona receives much less rainfall than the cacti-palo verde type that forms the foothill cover in the central and southern parts of the state. The annual precipitation is usually less than 10 inches.

The native animal life of the sagebrush type is very scarce. This is due to lack of water and lack of plant variety to furnish an all-season utilization. Both blackbush and sagebrush drop their leaves during the colder part of the year and cover becomes scarce. Jack rabbits are the most common mammal in the type; cottontails occur where outcropping rocks and ridges furnish warrens and a more diverse food supply. In the more broken stands where grass patches are found prairie dog communities often exist. Antelope utilize the fringes, especially where the *Atriplex* areas occur.

**Palo Verde, Bur Sage, and Cacti**

The roughest terrain and the highest levels of the southern desert are occupied by the palo verde-cacti type of desert. Differences in soil, slope, elevation, rainfall, and temperature cause this general subtype to present many variations in floral structure. Usually it is bordered below by the creosote bush and *Atriplex* formation or occasionally by the plainly marked strips of mesquite bosques in the alluvial bottoms. Above, it is often met by the belt of desert land grass as in much of southern Pima County. Or it may be the chaparral belt, as near Clifton, Superior, Hot Springs, and many other areas. Less frequently it may contact directly the piñon-juniper forest as on the upper drainages of the Santa Maria River or occasionally may even lie next the highland grass as in places in the Cerbat, Hualpai, and Music mountains.

Palo verde (*Parkinsonia microphylla*) is the dominant tree in the desert shrub and often in the lower chaparral. From the lower San Pedro valley, this species extends westward in the foothill cover around the desert ranges, gradually becoming more sparse until in the vicinity of Ajo and Gila Bend the trees have become scattering outposts seeking water in the rough and steep drainages of these hot and dry mountains. In its northward distribution it is found on the lower Verde, Salt, Gila, and lower Hassayampa drainages. Locally the palo verde may lose its prominence to some other species of tree or shrub in this type. Dense stands of the giant cactus or saguaro (*Carnegia gigantea*) may dwarf the woody forest. Outstanding areas of this kind are
Plate XIII.—Southern desert, palo verde–bur sage–cacti type. Southern slopes of Santa Catalina Mountains. Elevation 3,000 feet. Great differences in soil, moisture, exposure, and temperature in rough topography such as this bring in a large series of species and minor association types. Palo verde (P. microphylla) is the main tree species on the slopes with the saguaro. The cholla is Opuntia bigelovii. Between the two left chollas is desert hackberry, on the rock Lippia wrightii, and in the foreground the abundant resin plant (Encelia farinosa).

found on the foothills of the Santa Catalina, the Tanque Verde, and the Tucson mountains, and in the ranges bordering the Santa Rosa Valley on the Papago Indian Reservation. Northwestward in the region of the Vulture, the Harquahala, and the Harcuvar mountains, canotia (Canotia holocantha) replaces the palo verde; this unique tree reaches its maximum development and abundance on the Burro Creek drainage of the Aquarius Cliffs east of the Big Sandy River. On the hot ramparts of the Weaver and Date Creek mountains acacias distinguish the type. As it is carried westward this type can be roughly stated as gradually moving up from the foothill mesas and benches until it is confined to the higher and steeper parts of the range. In this shift, where frost-free areas occur, ironwood or palo fero (Olneya tesota) is the dominant tree. A meandering line drawn through the Tucson mountains, the Tortolitas, San Tan, Salt River, White Tank, and Rawhide ranges will approximately mark the eastern limits where the palo verde type not only aprons the foothills but covers the
entire range. Changes in slope and soil make marked visual differences between the mesa and mountain but the essential characters are similar.

It is along this eastern division that the bur sage (*Franseria deltoides*), which joins in establishing the type, reaches its greatest abundance. Moving westward its place is gradually, then entirely, taken by the light colored species (*F. dumosa*).

The cactus elements which aid in the classification of the type are so many and so varied that lucid descriptions are difficult to give in brief summaries. Next to the massive saguaros the extensive forests of chollas give unique character to this desert shrub type. These heaviest stands are largely composed of one species, the jumping cholla (*Opuntia fulgida*), and its varietal form, *Mammillata*. This is a plant of the mesas and valleys. A more compact, yellower spined relative (*O. bigelovii*), occupies the hottest desert hillsides. In other areas prickly pears of several species may take over the dominance, as is frequently done by the large jointed *Opuntia engelmannii* in the higher elevations in this type. Other characteristic chollas
Plate XV.—Southern desert. Date Creek Mountains. Elevation 2,700 feet. *Acacia, Lycium, Gutierrezia, Condalia, Simmondsia,* and *Opuntia engelmannii* are the main species present. This type as it moves up the slopes to increased moisture and additional density merges into the chaparral type on the higher levels.

found throughout the palo verde belt are the varied-colored cholla (*O. versicolor*), the tassajo of Christmas cholla (*O. leptocaulis*), the arborescent pencil cholla (*O. arbuscula*), and the long-jointed *O. acanthocarpa*. In the prickly pear group the low, unattractive *O. phaeacantha* is the most widespread, followed by the large Engelmann pear. More restricted in distribution but more interesting and colorful are the mahogany-spined *O. macrocentra*, the brilliant red or purple santarita (*O. santarita*), and the drooping-spined pancake pear (*O. chlorotica*).

Some of the woody plants typical of the palo verde-cacti region, although also legitimate members of the low chaparral, are the squawberry shrubs (*Lycium*) of many species, the unique ocotillo (*Fouquieria splendens*), white-spined cat’s-claw (*Acacia constricta*), resin plant (*Encelia farinosa*), *Brickellia*, *Hibiscus*, sangre de drago (*Jatropha cardiophylla*), and many others.

Crowfoot grama originally was found in the upper levels of this desert shrub; but since it was at the limits of its range, grazing quickly forced it back to areas of more optimum soil and moisture (*B. aristidoides*) are two annuals which grow rapidly after the spring. Six weeks grama (*Bouteloua barbata*) and needle grama
summer rains. In the heavy soils where floodwaters collect to- 
bosa grass makes a snarled and dense sod.

The melon family is also well represented in this type, many of 
them growing from huge underground woody tubers or fleshy 
roots. Two of these, the soft gourd (Cucurbita foetidissima) and 
the calabasa (C. digitata) are widespread throughout all desert 
types and extend into the grasslands, chaparral, and piñon-jun-
iper. Other perennial vines are the low, red-leafed Janusia gracil-
alis, Cocculus, several morning glory representatives (Ipomoea 
spp.), virgin's bower (Clematis neomexicana), the leguminous 
Nissola, and many others.

There are two distinct growth periods of the annuals: a winter 
or early spring growth that begins as soon as temperatures are 
high enough and a new and different growth with the summer 
rains. These earliest plants utilize the moisture that has accumu-
lated from the winter rains. Outstanding of the winter annuals 
are two of the earliest, alfilaria (Erodium cicutarium) and Indian 
wheat (Plantago argyrea). "Filarree" is an excellent forage plant, 
being particularly valuable because it provides green forage in 
February and March. Although now widely distributed in all 
the warmer regions in the state, it is not a native but was origi-

Plate XVI.—Southern desert. Santan Mountains. Elevation (foreground) 
1,300 feet. This volcanic formation is sparsely watered and is subjected 
to high temperatures. The trees are saguaro and palo verde. The very 
abundant cholla is O. bigelovii. As the slope flattens and the soil becomes 
less stony, creosote bush and bur sage become established, with an oc-
casional mesquite and saltbush.
nally brought in from southern California where it was introduced from the Mediterranean region. With sufficient and properly timed rains combined with growing temperatures the desert creates a mass of bloom in the early spring months. The weight of this color is made up of the yellow Mexican poppy (*Eschscholtzia neomexicana*), the pink pentstemon (*Pentstemon parryi*), the blue lupines (*Lupinus spp.*), and the low butter-colored bladder pod (*Lesquerella gordoni*). Variety and species are unlimited, however, and to these must be added the tiny, but extensive, blooming asters, the incomparable mariposa lily (*Calochortus aureus*), the phacelias, mustards, and untold others.

The climatic conditions in the desert region are extreme. High temperatures are combined with a relatively low annual rainfall. Stress is further put upon the vegetation by the fact that this moisture supply is not evenly distributed throughout the growing season but is concentrated mainly in the last two summer and the three winter months. Drought conditions generally exist twice yearly for the shallow-rooted plants through April, May, and June and again in late September, October, November, and early December. In addition droughts are periodic, and an expression of a yearly average rainfall is apt to hide the fact that there must be a physiological ability or structural equipment in nearly all desert plants to enable them to withstand prolonged periods of no available water. The mean annual rainfall for Tucson is 11.5 inches. In thirty consecutive years a minimum year of 5.1 inches and a maximum year of 24.1 inches were recorded. In that period nine years were recorded in which the rainfall was 25 per cent, or more, below the average and four years in which it was 25 per cent, or more, above the average. Following are the mean figures for the seasonal distribution from the University of Arizona station records from 1875 to 1927, inclusive:

<table>
<thead>
<tr>
<th>Month</th>
<th>Inches</th>
</tr>
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<tbody>
<tr>
<td>July</td>
<td>0.8</td>
</tr>
<tr>
<td>August</td>
<td>5.7</td>
</tr>
<tr>
<td>September</td>
<td>1.4</td>
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<td>October</td>
<td>1.5</td>
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<td>November</td>
<td>3.1</td>
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<td>December</td>
<td>3.6</td>
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<td>January</td>
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<tr>
<td>February</td>
<td>3.6</td>
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<tr>
<td>March</td>
<td>0.8</td>
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<tr>
<td>April</td>
<td>0.8</td>
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<tr>
<td>May</td>
<td>0.8</td>
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<tr>
<td>June</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Intense temperatures, frequently combined with high winds; a low annual rainfall, biennially interrupted by drought periods; and the entire moisture supply in itself roughly cyclic together produce a type of vegetation which as a whole is distinctive in character, although unlimited in the number of structural and physiological variations that have been acquired by the different species to meet the extreme environmental conditions. The climatic factors of the desert are expressed as extreme because they

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present the upper limits of temperature and the lower limits of moisture in which plants can grow.

The great difference between the density of the cover in the eastern and western regions of this type is brought about by the differences in the water supply. Yuma on the western boundary has an average rainfall of 3.4 inches, as compared with Tucson’s 11.5 inches.

CREOSOTE BUSH AND ATRIPLEX

Subject to the same set of climatic factors that operate upon the palo verde type, the occurrence of the creosote bush–Atriplex cover is largely controlled (within the range of the climatic factors conducive to desert growth) by the soil features—its texture, permeability, the presence of alkali, caliche, or other influences. The areas occupied by this type in the main division of the southern desert in Arizona are roughly the more level terrain, the shallow valleys, mesas, and the sandy soils between the desert mountain ranges. A clearer understanding of this division can be obtained by dividing it into five subtypes.

Creosote bush

In the western part of the state this plant (Larrea tridentata var. glutinosa) grows in the better drained and sandy soil where

Plate XVII.—Southern desert, creosote bush. East slope, Tucson Mountains. Elevation approximately 2,500 feet. On the mesa the creosote bush is spaced as the result of water competition. In the arroyo in the background cat’s-claw and canyon ragweed grow; on the foothill slopes saguaro, palo verde, and ocotillo occur.
the plant can utilize the moisture that comes from the winter rains. The rainfall is low, rarely above 3 or 4 inches per year, and this falls mainly in the late winter or very early spring. Shortly after, the plants become a shining laurel green, produce a cover of bright yellow flowers, and then as the soil moisture disappears the leaves become brown and the plant remains dormant until a new supply of water is available. In the eastern parts of its range where the rainfall is three or four times greater, the presence of pure stands of creosote bush most often indicate a very shallow soil underlaid by impervious caliche. The bushes grow from 3 or 4 feet to 10 or 12 feet, the largest plants developing on the deeper, more open soils. In distribution they are evenly spaced by the competition for water. Following the winter rains a solid mat of the silvery Indian wheat will cover the ground between the bushes. Where the soil is heavier this cover may be "filaree." Following the summer rains these spaces are taken by the annual six weeks and needle gramas.

**Atriplex**

The desert saltbush (*Atriplex polycarpa*) is often found in almost pure stands, making this subtype a distinct subdivision of

Plate XVIII.—Southern desert, creosote bush—*Atriplex*. Sacaton Mountains in background. Elevation 1,400 feet. Mainly saltbush (*Atriplex polycarpa*) and quelite salada (*Dondia moquini*). *Dondia* is an indicator of strongly alkaline soils.
the creosote bush- \textit{Atriplex} type. It is significant in that it marks the extent of deep, fine loam soils of excellent agricultural value. Since much of the moisture supply is derived from natural flooding, alkali may be present in considerable amounts, but under proper irrigation the land can be kept to a high productivity.

The shrub is a light-gray plant growing from 3 to 5 feet in height when on the deeper soils and making dense scraggy thickets with an occasional sprinkling of mesquite, cholla, or creosote bush. It is a fairly good forage, much utilized by sheep on their winter ranges. There is little ground cover following the rainy seasons as compared with the creosote bush areas. The denser canopy and salt soil are probably factors.

\textbf{Joshua tree}

Prominently marked by the presence of the striking Joshua tree (\textit{Clistoyucca brevifolia}), this subtype may be readily followed as it sweeps northward from the Harcuvar Mountains through the Bill Williams, Date Creek, Santa Maria, Hualpai, Sacramento and Detrital valleys to the Colorado River. The extreme northwestern corner of the state and the Grand Wash Valley have a Joshua tree-creosote bush cover. Soil types and textures are variable. The trees may be found on coarse sandy ridges with their

\textbf{Plate XIX.—Southern desert, creosote bush; Joshua tree subtype. Southwest Hualpai Mountains. Elevation 3,000 feet. Typically a creosote bush type, but the prominence of the Joshua tree tends to overshadow the lower cover. Also present is bur sage (\textit{Franseria dumosa}), ocotillo, squawberry, crowfoot grama, and tobosa grass with several species of arborescent chollas.}
roots fanning out over the hardpan of caliche 6 or 8 inches below the surface or on deep porous loam where the roots extend downward many feet. In size the plants are in proportion to the soil and water supply. In many extensive areas the forest is one of dwarfed, compact plants rarely over 5 or 6 feet high. With deep soil and more water (mostly derived from natural drainage) the trees become much branched and grow from 25 to 35 feet. An exceptionally fine forest exists on the granitic soil north of the Rawhide Mountains. From an elevation and a distance this growth gives the impression of looking out over the top of a yellow pine forest. The old trees develop a checkered, corky bark. In February each terminal branch bears a short dense cluster of creamy white blossoms. Many tons of the stalks are used each year in the manufacture of tree protectors and similar items.

There is much variety in the plant species associated with the Joshua tree and creosote bush. Tobosa is the most prominent grass found with the denser stands on the heavier soils. In its southern range the stiff leaved, low growing banana yucca (Yucca macrocarpa) occurs while in the northern range the taller, broad-leaved Mohave yucca (Y. mohavensis) may be found occupying the rockier ridges just above the Joshua trees. On the Big Sandy drainages and west of the Hualpai Mountains the arborvitaelike juniper (Juniperus utahensis var. californica) alternates with canotia to make a most unique appearing forest. To add to the botanical bewilderment there are areas on the Burro and Santa Maria watersheds where the large, ribbon-leafed bear grass (Nolina bigelovii) and saguaros share equal prominence with the other three species. In addition many kinds of chollas and prickly pears are found with squawberries, saltbushes, bur sage, sophora, zinnia, buckwheats, particularly Eriogonum fasiculatum, and the bladderstem (Eriogonum inflatum).

Blackbrush

In southeastern Arizona, blackbrush (Flourensia cernua) occurs in such nearly pure stands that the creosote bush is a minor element in this subtype. The western limits of this shrub are the southern foothills of the Whetstone Mountains. It is an angular branched shrub growing 4 or 5 feet high on fairly deep soils and receiving 15 to 20 inches of rainfall per year. Its appearance at all seasons gives it the common name, blackbrush. The ground cover of weeds and herbs following the rains is much the same as the surrounding grass areas. One of the cat's-claws, the long whip-branched Acacia, is often associated with it.

Yucca-bladder sage

Closely following the Joshua tree subtype where it is found north of Bill Williams River, but occupying the higher and rockier soils the Mohave yucca and bladder sage (Salazaria mexicana) constitute much of the ground cover. This yucca is a very robust, upright plant, often with a single unbranched stem crowned with broad but stiff daggerlike leaves. A thick spike
Plate XX—Southern desert, west side of Castle Dome Mountains. Elevation 1,200 feet. This is typical desert pave. Wind and water erosion is to a high degree prevented by the interlocking apron of volcanic rubble on the surface. In the small washes creosote bush, ocotillo, and bur sage grow scantly, while in the larger drainages (background) cat's-claw, ironwood (Olneya), smoke tree (Parosela), jojoba (Simmondsia), and many other shrubs are found.

of wax-white flowers bloom on a short central spike in February. Found with this plant and extending upward into the grass areas is the brittle, stemmy, and almost leafless bladder sage. In many areas this makes almost a pure stand. It is reported as good year-long forage for livestock. Tobosa grass occurs in the rock pockets, and there are occasional intrusions of the gramas from the northern highland grass areas directly above. Four common Opuntias are the grizzly bear (O. erinacea), the beavertail (O. basilaris), O. parishii, and O. ramosissima. Three bisnagas are common: nigger heads (Echinocactus polycephalus), barrel (Ferocactus acanthodes), and the small Ferocactus johnsonii.

MESQUITE BOSQUES*

Following the water courses that drain the southern desert, wherever deep alluvial soils have been built up and subterranean water is available, dense forests of mesquite will be found—rather, were found—since the tree was valuable in a nonforested land and most of this virgin “timber” has been removed. The

*Bosque is Spanish for “woods.”
Plate XXI.—Southern desert, mesquite bosque. McClellan flats near Casa Grande National Monument. Elevation 1,450 feet. In the virgin stands of mesquite in these alluvial bottoms the mesquite often canopied the ground to the exclusion of most other vegetation. Perennial vines of several species of the legume and melon families, many with underground tubers of enormous size, grow into this canopy. Squawberry (Lyctium) and saltbushes (Donidia and Atriplex) are found in the more open stands.

mesquite played a very important part in the early settlement of southern Arizona. It furnished dimension timbers for buildings and bridges, sturdy walls for corrals, posts for thousands of miles of fencing, and excellent fuel wood. The wood is very strong and durable but subject to insect attack.

Reaching its maximum growth in the abundantly watered deep river soils the species grew here to 30 or 40 feet in height and from 18 inches to 2 feet or more in diameter. The tree sheds its leaves when near-freezing temperatures are reached. Following the summer rains and floods many forests are almost tropical in aspect as innumerable vines increase the density of the canopy, and every little opening becomes a tangle of vines, careless weed, sacaton, dondia, and other plants.

Remnant areas of the original stands still exist along the San Pedro River, particularly between Reddington and Cascabel. In addition to the forests that followed the bottom lands of the San Pedro, Santa Cruz, lower Gila, and lower Colorado, scattering
groves, some of considerable extent, occurred in the playas of the Santa Rosa and Santa Cruz valleys.

In the higher, cooler valleys of the San Pedro and Santa Cruz, mountain hackberry (*Celtis reticulata*) is sparsely interspersed among the mesquite. It remains today extruding through the canopy of second- and third-growth forests. Hackberry wood is valueless for any purpose, since it will not burn and it rots quickly. The Indians, however, gather the sweet, orange-colored berries. Along the edges and in the openings of the forest in these two drainages the valuable sacaton (*Sporobolus wrightii*) would grow high enough when in flower to hide a cow pony. Commonly associated shrubs are the lotebush, squawberries, chamiso, desert saltbush, and the leafless, spiny crown of thorns (*Koeberlinia spinosa*).

Along the lower, warmer watercourses of the Gila and Colorado rivers the screwbean or tornillo (*Strombocarpa pubescens*) fringes the upper edges of the mesquite belt. The wood is hard and durable and is used for fuel and fence posts. Here chamiso is replaced in part by the brittle saltbush (*Atriplex breviflora*) and the succulent-leaved chico (*Allenrolfea occidentalis*). The exotic salt cedar (*Tamarix gallica*) has spread extensively into the alkali bottoms, competing with arrowwood (*Pluchea sericea*) and the broad-leaved broom (*Baccarhis glutinosa*). Along the lower Colorado, salt grass [*Distichlis texana (?)*] makes a thick, cushiony sod cover in the openings and under the trees. Between Topock and Yuma dense stands of willow [*Salix gooddingii (?)*] and open groves of cottonwood (*Populus macdougalii*) form interrupted fringes along the channel or on the most recent alluvial benches.

Where these bottoms are relatively free from alkali and not subject to inundating floods they are exceptionally productive agricultural soils. Where floodwaters are used for irrigation the deposit of silt on the fine river soil may cause trouble by sealing the ground against the needful water penetration. Aside from the prolific Yuma Valley, the areas used agriculturally in this type are very minute and mainly composed of small individual farms which have been established on the inside bends and oxbows along the rivers. Little is marketed from them and the life is largely on a subsistence status. In the pioneer days thousands of head of cattle grazed the Colorado River bottoms and furnished beef to the desert military posts.

Abundant native animal life exists throughout all the southern desert types. Its density and variety is in proportion to the density and variety of the vegetation cover. The amount of animal life present in the western part of the state, however, seems significantly greater than this barren appearing region would support. Bighorn sheep are present in many of the desert ranges and surrounding mesas, and originally were found in practically all ranges to and including the western slopes and canyons of the forested mountains that bound the desert on the east. The desert mule deer ranges widely through the palo verde-cacti belt and high into the mesquite grass areas. Along the Colorado River
Plate XXII.—Southern desert, mesquite and screwbean. Flood bottoms of the Colorado River south of Cibola, Arizona. Elevation 412 feet. Where this forest is interrupted salt grass (Distichlis) forms a tough, heavy sod. Saltbush, arrowweed, and burrowweed are found along the fringes.

and following upward a short distance on the Gila and Bill Williams drainages, and also on the lesser, temporary tributaries, the stocky burro deer finds cover and food in the mesquite, willow, cat’s-claw, saltbushes, and salt grass. Drifting bands of antelope work the southwestern valleys and mesas for the ephemeral weeds and most palatable browse. Mountain lion and coyotes follow these herbivores. In certain areas, notably along the Bill Williams River, herds of wild burro play an important part in the wild animal society. They cause serious damage to the vegetation, will not tolerate other large grazing mammals, and by furnishing a favorite food for mountain lions help keep this predator in numbers injurious for the surrounding game mammals. Closely associated with the hot, dry foothills and thickets of jojoba and prickly pear is the peccary or javelina, a native pig which forages in herds of a few individuals to forty or more, feeding omnivorously on insects, grubs, scrub-oak acorns, jojoba nuts, berries, roots, and native beans. Always interesting are the occasional visitors into this region from the south: jaguars, ocelots, and the chula, or coati. An unlimited variety of rodents and small mammals exists. The enormous eared antelope jack, the smaller black-tail, cottontails, badgers, foxes, several species of
skunks, kangaroo rats, ground squirrels, and scorpion mice are a very few of the inhabitants of this desert type. The birds are equally diversified. It is the summer breeding ground of some subtropical species and the winter residence of many northern nesting ones. As would be expected there are many species of hawks and owls living on the large rodent population. This must exclude the tiny elf owl that finds grasshoppers and other insects about the most formidable with which his sparrow size can cope.

Mopping up after the hunters, predators, and diseases are the vultures—turkey, black, and the caracara—with the ravens giving ready aid. Unique, yet most characteristic of the desert, is the road runner, a lonely member of the cuckoo family, living in an avian Elba by the sentence imposed by all the other birds.

USES OF NATIVE PLANTS BY THE INDIANS

A few notes have been selected from a very crowded notebook to illustrate the many ways in which the Indians in Arizona utilized the native plants they found in their immediate environment.

Probably no single plant was as important to the Indians or late prehistoric people as the agave or mescal. There are many species, ranging in size from the tiny mescalito, no larger than a Delicious apple, to the giant maguey of Mexico which may weigh a ton or more. It is the maguey which brought the name century plant into use for this group, an expressive term for the fact that the plant grows many years before it produces a flower stalk. This bloom is in nearly every case its last bloom, since it is typical for the agaves to die after flowering.

Food, drink, medicine, soap, wood, fiber, and even needles were obtained from this one plant. The plants most used in Arizona are *Agave palmeri* and *A. couesii*, the two largest species with the exception of *A. huachucensis*, a plant of very limited distribution in the United States.

Occasionally the more succulent leaves are eaten uncooked, but the customary way is to roast the leaf bases or the young flower stalk in preheated, stone-lined mescal pits. When cooked this way it is truly an acceptable vegetable. The jet-black seeds are pounded and ground into flour and often added to the pinole of mesquite. In some species, particularly the deep-flowered *A. huachucensis*, the nectar is gathered and used as a sirup.

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7 In some of the smaller species, particularly *A. parvifolia*, *A. treleasei*, *A. townsendii*, and *A. schottii*, the plants survive the flowering phenomenon more often than do the larger species. Bloom of the following year can usually be predicted the fall before by the increased thickening of the leaf bases, and the wider angle of the terminal shoot. Where the plant is used for specimens of landscaping, cutting the flower stalk after it is well started will in most cases save the plant from dying. The flower stalk grows very rapidly; in its initial stages the larger species make almost a foot of growth every twenty-four hours under favorable conditions of temperature.

8 A sweet flour made from the beans and sugar pods of mesquite, or parched corn to which sugar has been added.
Pulque is a beerlike drink made from several plants but is used generally in the Southwest and northern Mexico to designate the natural fermented product of the agaves. For local needs the operation is simple. The center leaves are removed; the white heart, which is really young leaves, is then pounded to a pulp with the outer leaves forming a container to retain the fermenting juices. Natural fermentation is allowed to go on and in a day or two in warm weather the liquid is either cupped out or drunk through hollow stems. The drink is high in vitamins. Mescal is a distilled liquor made after the leaf bases have been roasted and permitted to ferment. It is a clear liquid, or slightly amber colored, very aromatic, and very potent. Redistillation of mescal gives its brandy, tequila, one of the best known of the liquors of Mexico. The different species produce distinctive flavors and bouquets in the mescals and tequilas made from them. Generally speaking, the thick-leaved plants are preferred for pulque, while the thinner, strap-leaved species are used in mescal manufacture.

The younger leaves are often chewed as a so-called tonic, which may be a simple method of replacing a vitamin lack. Compresses are also made out of the wet and macerated pulp and used on local infections or bound on the chest to relieve congestion. The efficacy of these last two is not definitely known, although there are certain species in the cactus family in which there is highly satisfactory evidence that subcutaneous infections are localized and pulmonary and bronchial congestion relieved by the proper use of similar compresses made from certain cactus species.

Several of the agaves, particularly A. schottii, have marked detergent properties in their roots and are used as soap. The pounded roots when moistened with water lather very freely, and this “plant soap” is unexcelled for use in washing fine fabrics or the hair.

The ripened flower stalks, although pithy, have fair strength and are used in the construction of summer quarters, light corrals, and many other uses. They are the favorite nesting place of large carpenter bees, and their use frequently entails annoying consequences when used in house walls.

The sisal plant from which the well-known fiber of the same name is derived is a Central American member of the Agave genus. In Arizona the leaves of Agave palmeri and A. couesii are long enough to yield a usable fiber for rough cordage, sandals, etc., although it is coarse and less preferred than some of the Yucca fibers. After retting, many of the fibers remain attached to the very sharp, horny spine on the leaf terminal. In some cases this is used as a needle or shuttle.

The list of native and uncultivated plants that furnished some item of food is very large. Some of the seeds that were pounded or ground into a coarse flour or meal were from several of the grasses: sacaton and other dropseed; the panic grasses; rice; finger grass; careless weed or amaranth; staghorn cholla (Opuntia versicolor); saguaro; canutillo or Mormon tea (Ephedra); all yuccas, including the Joshua tree; agaves; acorns, particularly
those of the emory oak or bayote; canaigre (Rumex); many of the
terrestrial legumes, such as mesquite, the palo verdes, screwbean,
and cat's-claws; gourds, chamiso (Atriplex); chico (Dondia);
Indian wheat or plantago; purslanes; lamb's-quarters; and many
others. In many species, such as the amaranths, lamb's-quarter,
chico, and purslanes, the seeds are extremely fine and the amount
of labor necessary for a minute harvest made them correspond-
ingly valuable. Amaranth seed is considered an especially fine
item, and on flavor and taste alone well deserves this recognition.

Plants, or parts of plants, eaten raw or as greens or salads are
almost as numerous. Many mustards are utilized, also the purs-
lanes, lamb's-quarter, and amaranth, species all of which are
recognized greens in many regions. Others are the saltbushes
(Atriplex); docks or sorrels; the fleshy yucca fruits, especially
the baccate type, tradescantias; wild buckweats (Eriogonum);
dandelions; monkey flowers (Mimulus); plantagos; thistles; many
of the Senecios and Chrysothamnus genera; the devil's-claw
(Martynia); and several of the parsnip family.

Eaten as fresh fruits are the elderberries; Lyciums (squaw-
berry); many cacti, particularly the organ pipe (Lematreocereus
thurberi), the saguaro, strawberry (Echinocereus fendleri), and
prickly pears (Opuntia engelmannii, O. polycantha, and O. versi-
color); buckthorns of the Ceanothus and Rhamnus genera, with
Zizyphus and Condalia being especially favored in southern Ari-
zona; buffalo berry (Leoprgyrea argentea); manzanita (Arbutus
arizonica); hackberries; barberry; juniper; grape; service berry;
currants; and gooseberries In addition to their use as fresh fruits
many of these were fermented for wines and liquors, of which
the cactus fruits were the most commonly used.

Roots and bulbs used either raw or cooked were bulbs of the
Mariposa lily (Calochortus), the desert lily (Hesperocallis), and
the covena (Allium). Much liked when roasted are the walnut-
shaped tubers of the low yellow-flowering legume, Hoffmanseggia.
These more or less took the place on the desert of the wild potato
tubers (Solanum) that were used by the Indian tribes occupying
the higher elevations. Tubers of the night-blooming cereus (Pen-
iocereus) and morning glory (Ipomea) are very large, sometimes
weighing 40 pounds or more. These were cut in thick slices and
roasted, or cut thin and fried in animal fat. Other roots generally
used were thistle, arrowweed, Tradescantia, Frasera, canaigre,
and several of the wild parsnips.

Among beverages commonly used and made from other than
fresh fruits are the well-known Mormon tea (Ephedra) with its
sennalike taste, cosshui (Krameria) a truly acceptable and in-
vigorating drink, eriogonums, and lemon sumac (Rhus tridentata).

Used for condiments or seasoning were the seeds of the wild
coriander and Cogswellia, many of the mints, and the young dried
fruit buds of several of the goldenrod and snakeweed (Senecio)
genera. The covena or wild onion (Allium) is used also for
flavoring meat dishes.
The list of medicinal plants is exceptionally large. Many of these have been definitely proved of value; others are unknown, while some appear to derive their greatest value from some folklore or superstitious origin rather than from any inherent properties that the plant may have itself. The desert plants are high in alkaloids, oils, gums, and resins. Using as a lead the contents of the medicine kits of the tribal doctors and following with patient research, it is entirely probable that an investigator could contribute to science a discovery that might rank with quinine, cocaine, or chaulmoogra oil.

Southern and western Arizona have many representatives of the spurge or genus *Euphorbia*. This group leads all others in the number of medicines it furnishes for internal use. Only one or two examples can be given here, although the list of uses runs the gamut from outright lethal poisons, through medicines to cure various social diseases, induce pregnancy in sterile women, coagulins, many remedies for digestive disturbances, tonics, callus removers, and even chewing gum.

From the macerated and cold-steeped roots of the *Jatropha* genus is derived a medicine which, when taken daily for at least a fortnight, is considered a specific cure for gonorrhea. There is considerable evidence that it is efficacious. From the leaves of another spurge* is expressed a liquid used for removing corns and calluses. This is very effective, but care must be exercised in limiting its application only to the callus, as it will painfully burn live tissue.

As mentioned before, cold or hot poultices made from the soft tissue of prickly pear pads are generally used for localizing subcutaneous infections. Generally speaking, they appear to be helpful. This is also used in a firmer, drier pack, for relieving congestions caused by colds. Fresh cut slices of the tuberous root of the night-blooming cereus is also used when available for the same purpose. There is excellent evidence that both have a legitimate value.

Several plants with narcotic or excitant properties are used, such as the young seed pods of certain *Jatrophas*, the roots of Jimson weed (*Datura*), the juice from certain cacti roots, the mescal bean (*Sophora*), roots and seeds from certain members of the parsnip family, and extracts from the roots of several shrubby and herbaceous nightshades.

Obviously in the construction of shelters, corrals, and so forth, the material procurable with the least effort that would meet the needs was naturally used. In the north juniper timbers with sheathing made of Baccarhis and desert willow (*Chilopsis linearis*) were common. In the south and west mesquite cottonwood, the true willows, and occasionally palo verde and screw-
bean are used for dimension timbers; saguaro ribs for wall and sheathing; and arrowweed, Baccarhis, ocotillo, and occasionally beargrass (Nolte microcarpa), yuccas, and sacaton grass for roofs, placed either on, under, or mixed in the adobe dirt.

Common dyes are made from walnut husks, mountain mahogany root, Senecios, barberry, Chrysothamnus, wild mulberry, the cochineal insect that lives on the prickly pear, and many others.

Desert willow and devil’s-claw is much used in basketmaking. Shellac for sealing liquid containers or otherwise making things impervious is gathered largely from the creosote bush or from Coursetta in the mountain canyons. Among the Papago Indians gum balls made from the exudations of mesquite trees were widely used in their favorite game of skill and endurance. What is seemingly a combined deodorant and insecticide is made from the dried and powdered young fruit buds of one of the Senecios.

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Any error of reason, fact, or theory in this paper is my own.

The data for the color map, done as a Range Ecology Department project, were mainly the personal labor of W. G. McGinnies, both in the field work and the compilation. The subtype boundaries of the desert are my own.