CALIFORNIA NATURAL HISTORY GUIDES

INTRODUCTION TO CALIFORNIA DESERT WILDFLOWERS

Revised Edition

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INTRODUCTION

The California Deserts

The California deserts comprise a considerable area if we include the region below the yellow pine belt *(Pinus ponderosa),* beginning in the north with the lower slopes of the Sierra Nevada and a large part of the Inyo and White Mountains and their environs and ending in the south with the Imperial Valley and the arid mountains to the west and the sandy region toward the Colorado River. Roughly, and for practical purposes, we can think of our desert as consisting of (1) the more northern Mojave Desert reaching as far south as the Little San Bernardino and Eagle Mountains and the ranges to the east and (2) the more southern Colorado Desert. Being quite different from each other, these two deserts are worth short separate discussions.

In the first place, the Mojave Desert, except for the Death Valley region and the area about Needles, lies mostly above

2,000 feet. Hence, it has more rainfall and colder winters. It opens out largely toward the northeast and in many ways is an arm of the Great Basin of Utah and Nevada, and its plant affinities often lie in that direction. The Colorado Desert, on the other hand, consists largely of the Salton Basin, much of it near or below sea level. It opens toward the southeast, and its affinity floristically is with Sonora, and it is often placed as part of the Sonoran Desert. Not surprisingly, then, many species of the Mojave Desert extend into Nevada and southwestern Utah, whereas many of the Colorado Desert range into Sonora and western Texas. There are of course many patterns of more limited distribution, such as along the mountains bordering the western edge of the Colorado Desert from Palm Springs into northern Baja California or around the western edge of the Mojave Desert from the base of the San Bernardino Mountains to the Tehachapi region.

The climatic conditions in the desert and the situation for plant growth are severe. Plants have had to resort to interesting devices to exist at all. In the first place, seeds of many desert plants have so-called inhibitors that prevent germination unless the inhibiting chemicals are thoroughly leached out by more than a passing shower. This means that for many of them it takes a good soaking rain to get started, one that wets the ground sufficiently for the seedling to send a root down below the very surface. A second characteristic of many of the annuals is that if the season is rather dry, they can form a few flowers even in a most depauperate condition and ripen a few seeds under quite trying circumstances. Thirdly, many of those plants that do live over from year to year cut down evaporation by compactness (small fleshy leaves and reduced surface area as in cacti), by coverings of hair or whitish materials that may reflect light and hence avoid heat, and by resinous or mucilaginous sap that does not give up its water content easily, as exemplified by creosote bush *(Larrea tridentata)* and cacti.

A widespread popular fallacy should be mentioned. We read of the great depth to which desert plants can send their roots in order to tap deep underground sources of moisture. This situation is true along washes, watercourses, and basins, where mesquite *(Prosopis glandulosa* var. *torreyana)* and palo verde (*Cercidium* spp.), for example, send roots down immense distances, but in the open desert an annual rainfall of six or eight inches distributed over some months may moisten only the upper layers of soil. Therefore, shrubs such as creosote bush and plants such as cacti tend to have very superficial wide-spreading roots that can gather in what moisture becomes available.

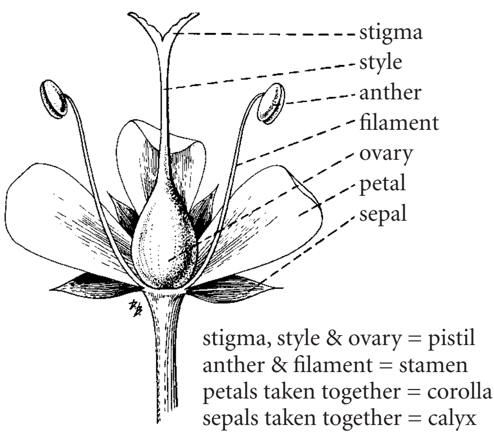
Something should also be said about summer rains. On the coastal slopes at elevations below the pine belt, we are accustomed to summer months practically without rain. But in Arizona and the region to the east of us, there are two definite rainy seasons: one producing a spring flora and another producing a late summer and early fall crop. For the most part the annuals that come into bloom in these two distinct seasons are quite different. Many summers, the Arizona rains reach into the desert areas of California and sometimes produce veritable cloudbursts of water. At such times thunderheads appear over the adjacent mountains such as the San Bernardino, San Jacinto, and San Gabriel Mountains, and the neighboring coastal valleys are much more humid and uncomfortable than when the desert is dry. After these summer rains some of the perennials may exhibit new growth and flowering, and a new crop of annuals may appear, such as chinchweed *(Pectis papposa* var. *papposa)* and California kallstroemia *(Kallstroemia californica).* In the southern Mojave Desert west of Baker and Cronise Valley, I have seen the desert floor green for miles with California kallstroemia in early September.

As any desert habitué knows, plant life there is not uniform but varies with elevation, drainage, character of soil, and the like. One of the characteristic features is the presence of many undrained basins, known locally as "dry lakes," where water may gather in unusually wet years only to dry up more or less completely after a few weeks. Such a situation through the centuries brings about the accumulation of salts or alkali, making these areas too salty for any plant life, or at the fringes there may be an accumulation of species adapted to salty conditions, such as various members of the goosefoot family (Chenopodiaceae), including desert-holly *(Atriplex hymenelytra)* and iodine bush *(Allenrolfea occidentalis).* These basins are scattered over the Mojave Desert and form a series along the old channel of the Mojave River, which flows eventually into Death Valley, the largest of all. A similar situation exists in the area near the Salton Sea.

The great open plains and flats of much of the desert are covered with creosote bush (which is associated with burroweed *[Ambrosia dumosa]*), box thorn *(Lycium cooperi),* brittlebrush *(Encelia farinosa),* and many other species. Here the average rainfall is from two to eight inches, and summer temperatures may be very high. Some cacti grow in this region, which is mostly pretty well drained, but many are found on rocky canyon walls, in stony washes, and in other places also. In areas above the creosote bush in the Mojave Desert, say from 2,500 feet to 4,000 or higher, Joshua trees *(Yucca brevifolia)* tend to distribute themselves in a sort of open woodland with lower shrubs in between. Here the annual precipitation may be from six to 15 inches, and the vegetation is correspondingly richer. And then, along the western edge of the Colorado Desert and more particularly in the mountains bordering on and situated in the Mojave Desert, is a zone of pinyon and juniper, mostly at 5,000 to 8,000 feet. Here the annual precipitation runs about 12 to 20 inches a year, some of it as snow. This belt has some summer showers and some plants in bloom in summer and even fall, as well as in spring, which comes later than in the creosote bush zone. Particularly in the more northern parts of the desert, creosote bush gives way in the upper elevations to sagebrush (*Artemisia tridentata* and relatives), and large regions in Lassen, Mono, and northern Inyo Counties have a sagebrush desert like that of Nevada and Idaho. With so wide a diversity of conditions, then, it is not surprising to find quite different flowers at various altitudes and in various habitats.

How to Identify a Wildflower

It is impossible to talk about plants and their flowers without using some specialized terms to describe their parts. Some of the most necessary terms are explained here, and a more complete list is defined in the glossary. In the typical flower we begin at the outside with the sepals, which are usually green, although they may be colored. The sepals together constitute the calyx. Next comes the corolla, which is made up of separate petals, or the petals may grow together to form a tubular or bell-shaped corolla. Usually the corolla is the conspicuous part of the flower, but it may be reduced or lacking altogether (as in the grasses [Poaceae] and sedges [Cyperaceae]), and its function of attracting insects for pollination may be assumed by the calyx. The calyx and corolla together are sometimes called the perianth, particularly when they are more or less alike. Next, as we proceed inward in the flower, we usually find



The parts of a representative flower

the stamens, each consisting of an elongate filament and a terminal anther where the pollen is formed. At the center are one or more pistils, each with a basal ovary containing the ovules or immature seeds; a more or less elongate style; and a terminal stigma with a rough, sticky surface for catching pollen. In some species, stamens and pistils are borne in separate flowers or even on separate plants. In the long evolutionary process by which plants have developed into the many thousands of types of the present day and have adapted themselves to various pollinators, their flowers have undergone very great modifications, and so now we find more variation in them than in any other plant part. Our modern system of classification is largely dependent on the flower parts.

To help with the identification of a wildflower, either a color photograph or a drawing is given for every species discussed in detail, and the flowers are grouped by color. In attempting to arrange plants by flower color, however, it is sometimes difficult to place a given species to the satisfaction of everyone. The range of color may vary greatly, from deep red to purple, from white to whitish to pinkish or greenish, from blue to lavender, or through a wide range of yellows and oranges, so that it presents a challenge for the writer himself, let alone the readers, to determine whether one color group or another should be used. I have done my best to recognize the general impression given with regard to color and to categorize the plant accordingly, especially when flowers are very minute and the color effect may be caused by parts other than petals. My hope is that by comparing a given wildflower with the illustration it resembles within the color section that you think is most correct and then checking the facts given in the text, you may, in most cases, succeed in identifying the plant.

One of the chief difficulties in writing such a book is to find usable common names. I am not interested in taking those coined from the scientific name by a professional botanist who breaks down the genus name into its Greek roots and then adds the species name, such as, for example, the common name Mrs. Ferris's club flower for *Cordylanthus ferrisianus.* On the other hand, if the local inhabitants call this bird's beak, that is acceptable. For some plants, however, I may have been unable to ascertain a true folk name. In these cases it has seemed best to me to use the genus name, such as *Phacelia* or *Oxytheca,* as a common name too. Many desert plants are not very conspicuous and just do not have good, widely used names, so we have to resort to this scientific appellation.

Another problem I confronted is which plants to present. I have tried for the most part not to include those already shown in *California Spring Wildflowers,* so that anyone having both books has that many more species shown. I have chosen plants that I feel are interesting, but not all are necessarily showy or common. I have attempted not to present the various closely related forms of a complex group but have taken one as an example and often added a word about additional forms closely resembling the first. I have tried, too, to include species from the different parts of the desert so that the book is useful for more than just the Palm Springs region, for example, or just Death Valley, to name two of the commonly visited areas.

I cannot help but register a plea that residents of the desert and visitors thereto exercise discretion in picking, transplanting, and otherwise interfering with normal development and reproduction of desert plants. The thousands of people who live in or visit the desert nowadays are bound to inflict hardship on the vegetative covering. With the scant rainfall, desert plants grow slowly, and a branch broken off a pinyon tree for a campfire may have taken many years to produce. Certainly those who have known the desert over a period of years cannot help but be appalled by the magnitude of the recent destruction.

Philip A. Munz
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INTRODUCTION TO THE PLANT COMMUNITIES OF CALIFORNIA'S DESERTS

Robert Ornduff

The word "desert" brings to mind dry, hot, harsh landscapes that scarcely support living beings. By definition, deserts are harsh environments, but California deserts support a surprisingly rich diversity of plants and animals. Three major deserts occur in the state: the Mojave Desert, the Colorado Desert, and the Great Basin Desert. The wildflowers described in this book grow in the first two deserts. Plants of the Great Basin Desert, found east of the Sierra Nevada and Cascade Range crests, are not included. Philip Munz's introduction to the first edition of this book, which is reproduced here, describes the location of the Mojave and Colorado Deserts in California, gives a brief account of their climates, and presents a synopsis of representative adaptations of the plants that live in these extreme environments.

The term "desert" has no precise definition; a desert is simply an area with low average annual precipitation. Deserts may occur along coastlines, in interior regions, at the poles, or on mountaintops. They may be very local, lying in the rainshadows of mountains; they may occupy the uppermost peaks of mountains; or they may extend over many thousands of square miles, as does the Colorado Desert, which is a northwestern extension of the vast Sonoran Desert. Portions of the Mojave and Colorado Deserts receive an annual average precipitation of four inches or less. In places, some years pass with no measurable precipitation. In parts of our deserts, rainfall is mostly limited to winter months, but in other areas there are two peaks of rainfall—one in winter and another in summer. The Mojave and Colorado Deserts have high numbers of sunny days during the year—commonly more than 300 days per year are cloudless or nearly so. Summers are hot, with 150 days or more having maximum temperatures exceeding 90 degrees F. Death Valley may be the hottest place on earth—a maximum temperature of 134 degrees F has been recorded there. Winters in our deserts generally are mild. The Mojave Desert is wetter and cooler than the Colorado Desert because it occupies higher elevations. It may even experience frosts or light snowfall during winter. The Mojave Desert occupies about two times more area in California than does the Colorado Desert.

Plants that grow in deserts must be able to survive extended drought and low annual precipitation and must be able to survive relentless heat and intense sunlight. California deserts by no means offer a uniform environment. Soils vary from place to place, and there are local occurrences of gypsum, alluvial fans, dry washes, oases, and soils with various levels of salinity. As one ascends desert mountains or descends into desert valleys, climatic and soil conditions change in relation to elevation, and these changes are reflected by differences in vegetation types and plant communities. The higher elevations may support juniper and pinyon pine woodlands; the lowest elevations are often highly saline and support only a few plant species. In low areas where the soils are moderately saline, low shrubs with intriguing names such as winter fat *(Krascheninnikovia lanata),* burrobush *(Hymenoclea salsola),* and hop-sage *(Grayia spinosa)* predominate. In even lower, highly saline areas that are the dry beds of former Pleistocene lakes, alkali sink scrub predominates. Here one finds the odd succulent shrub called iodine bush *(Allenrolfea occidentalis)* (because its sap stains human skin brown) and the equally succulent pickleweed (*Salicornia* spp.). The prominent American botanist T.H. Kearney once wrote of these shrub-dominated communities that "no other vegetation…gives the impression of being so nearly conquered by the environment," and even Philip Munz, author of this book, admits that these shrublands cover "large monotonous areas." Yet many visitors to the desert find this so-called monotony appealing and come back every year to enjoy its peaceful visual simplicity.

Two woody plant species occur over large parts of the California deserts. The more widespread of these is creosote bush *(Larrea tridentata),* which grows over about 16 million acres of the Colorado Desert and the lower elevations of the Mojave Desert in California. Creosote bush is the most abundant and widely distributed woody plant in the warm deserts of North America; it ranges from the southwestern United States to Guatemala, and close relatives grow in the deserts of southern South America. Creosote bush, sometimes called greasewood, is a dense evergreen shrub with leaves and branches that have an odor reminiscent of creosote. It thrives in hot, dry areas from below sea level to about 4,000 feet; the species is intolerant of saline soils and is damaged or killed by prolonged subfreezing temperatures. Because it is so common, creosote bush is often considered an uninteresting plant, but its dark evergreen foliage, resinous fragrance, and small but copious yellow flowers that are followed by tiny fuzzy fruits all add to the olfactory and visual interest of this sturdy species. Creosote bush shrubs are seemingly almost immortal. As they grow in diameter through the centuries, the central portion of the shrub dies, leaving a ring of free-living shrubs around this central area. The shrubs in this ring are all members of a single clone. Based on estimates of clonal growth rates, one enormous creosote bush clone called the King Clone is believed to be about 12,000 years old.

The higher edges of the Mojave Desert are occupied by vast tracts of Joshua tree woodland. Joshua tree *(Yucca brevifolia)* may not be considered a typical tree by some because of its bizarre appearance, but it is tall and woody and usually has a single central trunk and aerial leafy branches. If that doesn't qualify this species as a tree, what should we call it? Joshua tree, like all yuccas, has an interesting relationship with a specialized pollinator, the so-called yucca moth. If you visit Joshua trees or other yuccas when they are in flower, you will notice very small, whitish, day-flying moths flitting around the large masses of white flowers. These are Joshua tree yucca moths, whose life cycle is tied intimately to that of the Joshua tree, and vice versa. The female moth collects pollen from the anthers of the flowers, rolls the pollen into a small ball, and carries it using specialized mouthparts. The female then lays eggs on the ovaries of the female yucca flowers and deposits the ball of pollen grains on the stigma at the tip of the style. The pollen grains germinate, and the ovules are fertilized, eventually developing into seeds. Meanwhile, the moth eggs have hatched, and the larvae have burrowed into the ovary, where they feed on developing seeds. The young do not devour the entire seed crop but only enough seeds to allow them to mature and provide the next generation of moths that emerge when the yuccas next come into flower. At the same time, the yucca flowers have been pollinated and produce sufficient seeds to maintain the yucca population over the decades.

The low annual rainfall and high daytime temperatures that characterize California deserts provide inhospitable conditions for plants as well as animals. In his book *Travels with Charley,* John Steinbeck wrote, “I find most interesting the conspiracy of life in the desert to circumvent the death rays of the all-conquering sun.” Desert animals are motile and can rest in burrows, crevices, or the shade of desert shrubs during the day to avoid the heat. Some of these animals venture forth after sundown, when temperatures are low, to feed and sip dew. Some desert animals have very low water requirements or can obtain water from their food. Plants, on the other hand, cannot hide during the day to avoid heat and cannot move about in search of moisture. Plants use water to maintain turgor and thus their characteristic architecture (a wilted plant lacks turgor) and as a medium in which the chemical reactions of metabolism take place. They also use water to move dissolved minerals and foods throughout their tissues and as an essential component of the complex set of chemical reactions called photosynthesis.

Desert plants possess an impressively wide variety of mechanisms that enable them to make economical use of the extremely limited water supplies in desert environments. One of the most familiar mechanisms for economizing on water is that employed by succulent plants. These absorb water through their shallow root systems after a rain and store it in their stems, leaves, or both during the very long dry spells between rains. The most familiar succulents in California deserts are members of the cactus family such as fishhook cactus *(Mammillaria tetrancistra),* various species of cholla and prickly-pears (*Opuntia* spp.), and hedgehog cactus (*Echinocereus engelmannii*). As adult plants, these cacti lack leaves and store water in fleshy stems that are usually armed with spines. Most plants, even in deserts, have leaves and carry on photosynthesis in the leaves, but because cacti lack leaves, photosynthesis is carried on in the stems, which are green because of the chlorophyll contained in their surface cells. The stems of cacti can expand and contract like accordions as water is taken up and later gradually used by the plant. Under experimental conditions, some cacti have survived without being watered for several years. A 10-foot specimen of saguaro cactus *(Cereus giganteus)* in Arizona that was deprived of water for three years weighed 48 pounds at the end of that period. After three weeks of rain, the plant had taken in so much water that its weight nearly doubled to 86 pounds.

The ferocious spines that cover the surface of most of our cacti ward off thirsty herbivores (if you encounter a cholla, resist the temptation to touch it, even gently, or you will find your fingers full of tiny transparent needlelike spines that are difficult to see and to remove). Spines may also shade the plant surface, reduce air movement along the surface and thus reduce water loss, help drain away heat from the stems, and even direct drops of nighttime dew to the soil at the base of the plant where its roots can absorb it. Although cacti often show few signs of life during the year, their flowers are frequently very large and colorful. Century plant (*Agave* spp.) and live-forever (*Dudleya* spp.) are also succulents, but they are not cacti; they store water in their fleshy leaves rather than in their stems.

Cacti and other succulents may be locally abundant in California deserts, but there are relatively few species of these plants in our deserts, and they do not dominate vast tracts of land. As one goes eastward into Arizona or southward in Mexico, cacti and other succulents become a more conspicuous feature of desert landscapes. Far more numerous in California deserts are more conventional-looking nonsucculent shrubs and perennial herbs. They do not store water but have other ways of economizing on the scant water supply. Creosote bush and Joshua tree belong to this group, as do numerous perennial herbs such as locoweed (*Astragalus* spp.), scarlet gilia (*Ipomopsis arizonica*), verbena (*Verbena* spp.), and Panamint daisy (*Enceliopsis covillei*).

The diversity of ways by which this group of perennial, nonsucculent plants cope with a scanty water supply is almost overwhelming. Many of these plants have waxy coatings on their leaves; this coating waterproofs the plants and reduces water loss from the leaves. Many species have dense hairs on the leaf surfaces, often to the extent that the foliage is gray or white. These mats of hairs reduce water loss by trapping moisture next to the leaves or by reducing the drying effects of desert breezes. Their light coloration also reflects some of the hot rays of the sun away from the leaf surface, which results in reduced water loss. Other species, such as Mormon tea (*Ephedra* spp.), have tiny leaves, and most of the photosynthesis is carried on in their green (but not succulent) stems. Some species, such as the evergreen shrub jojoba *(Simmondsia chinensis),* have leaves that are vertically oriented and present a minimal surface area to the direct rays of the sun. Other species, especially grasses, have the ability to roll up their leaves during a hot day, thus reducing surface area and forming a tube that helps reduce water loss. Some woody species such as ocotillo *(Fouquieria splendens* subsp. *splendens)* are drought deciduous, that is, when soil moisture levels fall below a critical level, the plant loses its leaves. When heavy rains fall, new leaves are produced and the plants may even flower. If watered continuously in the garden, ocotillos are evergreen, but under field conditions they are not. Blue palo verde *(Cercidium floridum* subsp. *floridum)* is also leafless during much of the year, but as its common name indicates, it has chlorophyllous bark and can carry on photosynthesis even when leafless.

In photosynthesis, carbon dioxide, water, and light combine to make energy-rich sugars. This process requires movement of water into the plant via the roots and its transport throughout the stems and leaves. In order for photosynthesis to occur, carbon dioxide gas must move from the atmosphere into the interior of the plant, and oxygen, one of the products of photosynthesis, must leave the plant's tissues into the surrounding air. Movement of these gases occurs through tiny apertures called stomates that perforate the surfaces of leaves and stems. They also allow precious water to be lost from the plant's tissues. Stomates are surrounded by cells that open and close them. Plants typically have open stomates during the day because that is when gas exchange associated with photosynthesis occurs, but open pores also result in water loss. Some desert species have the ability to close stomates during the day; these plants open their stomates at night when temperatures are cooler and humidity is higher so that water loss is reduced. The plant takes in carbon dioxide at night, which is then converted into organic acids that are stored in the plant tissues and gradually converted back to carbon dioxide, which is used in photosynthesis during the day when the stomates are closed. Plants with this unusual type of mechanism include cacti and other succulents and members of the spurge (Euphorbiaceae) and sunflower (Asteraceae) families.

Some desert plants carry on a version of photosynthesis in which there is enhanced efficiency in the use of carbon dioxide and water, thus reducing the need for water and the risk of water loss during daylight hours. These plants have high optimal temperatures for photosynthesis, up to 115 degrees F, a temperature that would disable conventional photosynthesis. Photosynthesis of these plants also has a high light saturation, light levels that likewise would disable conventional photosynthesis. This type of photosynthesis occurs in creosote bush, many desert perennials, summer annuals, and many members of the grass (Poaceae), goosefoot (Chenopodiaceae), and sunflower families.

Desert plants may have very shallow root systems that fan out from the plant body only a few inches below the soil surface. These roots take advantage of the moisture that accumulates in upper soil levels after rain. A few desert plants, especially the trees and shrubs that grow along desert washes, have deep root systems that penetrate up to 180 feet below the soil surface and tap underground water tables. An example of such a deep-rooted species is mesquite *(Prosopis glandulosa* var. *torreyana),* which does not look like a desert plant because its aboveground parts resemble those of species found in areas with high rainfall. These deep-rooted desert plants have no obvious adaptations to drought because they have access to a continuous supply of water deep in the ground. Unfortunately, in parts of the Colorado Desert where underground aquifers have been tapped for human use, mesquite trees have died because the water tables have dropped too low for their roots to reach. California fan palm *(Washingtonia filifera)* is a remnant of a tropical flora that once occurred in California but disappeared because of climatic changes. This impressive tree is limited to oases in the desert, where there are permanent springs.

One interesting phenomenon that reduces competition among desert plants is called allelopathy (this has also been termed "chemical warfare" among plants, but that dramatic term does not describe how it works). Many desert shrubs such as creosote bush synthesize organic chemical molecules that are exuded from their tissues and permeate the surrounding soil. These compounds are toxic and prevent seedling establishment of potential competitors in the immediate vicinity of the plant that produces them. The result is that allelopathic plants often are widely spaced, looking as if humans have planted them in orchards. This wide spacing is an effect of allelopathy and gives allelopaths nearly exclusive access to soil moisture and nutrients in their immediate vicinity. In a spring following heavy winter rains the ground among allelopathic shrubs may be carpeted with annuals. The roots of these annuals are restricted to the upper soil layer from which the allelopathic chemicals have leached by the rains. Because they are annuals, however, they do not pose a long-term threat to the well-being of their allelopathic companions because they are present on the site only during a brief period of late winter and early spring.

In late winter every year I receive telephone calls from friends and colleagues around the country asking, "How will the desert be this spring?" What these callers want to know is how abundant and well-spaced winter rains were and if the deserts will burst into flower during spring break. My usual answer to these inquiries is that despite the nature of the winter rainfall, I cannot predict whether it will be a colorful spring until the plants themselves come into flower. These natural flower shows are produced by winter annuals, plants whose life span is counted in weeks and who spend most of the year as seeds rather than as living, growing, flowering adults. During a wet year these annuals provide dazzling mats of color in our deserts, beginning in the low, hot desert of the Anza-Borrego Desert State Park area east of San Diego and ending several weeks later in the higher cooler deserts of Joshua Tree National Monument.

Winter annuals germinate, grow, and reproduce when soil moisture levels are ample and when daytime temperatures are relatively cool. Once the soil dries out and temperatures begin to rise, the plants quickly produce seeds and die. During the hot, dry summer, these winter annuals are not in evidence but persist as seeds. Because these annuals that have average moisture and temperature requirements die with the onset of the hot, dry summers, they are called drought evaders. Some winter desert annuals are known to have special seed germination requirements. Their dormant seeds must be subjected to a minimum of half an inch of rain before they will germinate. Presumably thousands of years of desert life have genetically imprinted on these annuals that half an inch of rain offers reasonably good assurance that the rest of winter will be wet enough to allow them to flower and set seeds normally. Upon germination, the seedlings may produce two seed leaves and appear to cease growth, but during this period the young plants are establishing extensive root systems that enable them to capitalize on whatever scanty rainfall comes their way. Then the seedlings may produce a rosette of leaves that lie flat on the ground. This ground-hugging feature places the leaves in a position where they receive maximum daytime warmth on cool winter days and may also help in reducing water loss from the leaves. With the onset of spring and the prospect of declining rainfall, the rosettes of many species produce surprisingly large, brilliantly colored flowers. These provide the showy floral displays that attract so many visitors to California deserts in early spring. These showy winter annuals include lion-in-a-cage *(Oenothera deltoides),* whose large white flowers open in early evening and are visited by hawkmoths. After the plant dies, the stems curl inward to form an odd basketlike tumbleweed that detaches from the soil and rolls around the landscape scattering seeds. This explains the fanciful name for this unusual plant. Other evening-primrose species produce smaller white or yellow flowers, but en masse these can be showy. Monkeyflowers

(*Mimulus* spp.) come in shades of pink and purple. Desert sand-verbena *(Abronia villosa)* is deep rose. Tackstem *(Calycoseris wrightii)* bears a white daisy, coreopsis (*Coreopsis* spp.) and desert-dandelion (*Malacothrix glabrata*) bear yellow daisies, and tidy-tips *(Layia platyglossa)* produce bicolored yellow-and-white daisies. Some desert annuals attract attention not because of their showy flowers but because of their curious architecture. Desert trumpet *(Eriogonum inflatum)* is so named because its tall flowering stems are shaped like an upright trumpet. Desert candle *(Caulanthus inflatus)* is a curious plant with inflated erect stems.

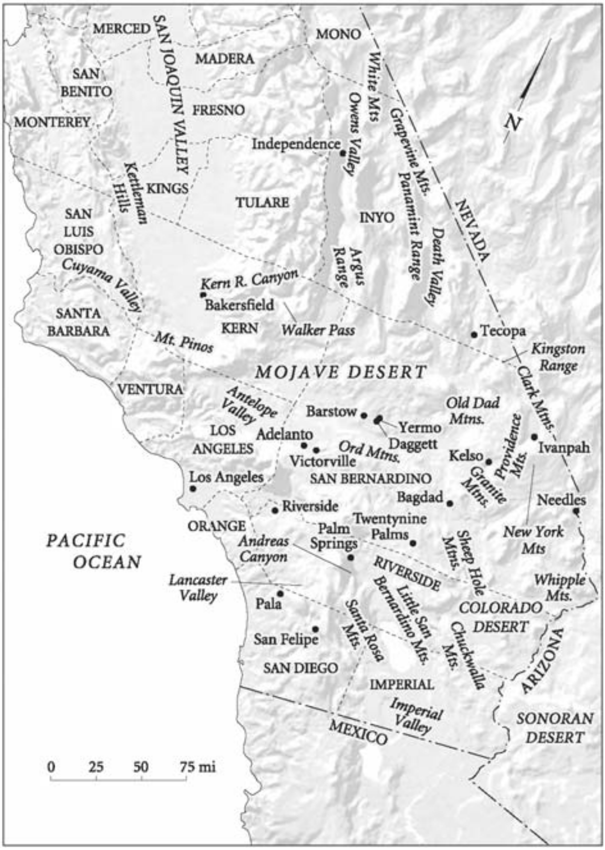
There is a small group of desert annuals whose seeds germinate after heavy summer thunderstorms when air and soil temperatures are high. For the most part these summer annuals have inconspicuous flowers and do not provide the massive shows of their winter counterparts. Because few human visitors venture into California deserts during summer, these summer annuals largely go unseen.

Other lifestyles are known in desert plants. A number of attractive shrubs and small trees occur along the beds of desert washes. These washes are dry during most of the year but become filled with torrents of fast-moving water after rainstorms. Once this surface water disappears, the subsurface soil holds moisture for long periods of time, hence the relative lushness of this riparian community. Many of the plants that grow in this habitat have seeds with very thick coats. When the watercourses are flooded, the tumbling of the rocks abrades the seed coats so that germination and seedling establishment can occur while the soil is still moist. A few desert species have deep underground bulbs and produce leaves and flowers only during a few weeks in spring and early summer. During the prolonged summer, the plant is represented only by a fleshy bulb that resides deep in the relatively cool soil. Desert plants with bulbs include desert lily *(Hesperocallis undulata)*, blue dicks *(Dichelostemma capitatum* subsp. *pauciflorum)*, and desert mariposa *(Calochortus kennedyi)*.

Some colonies of the latter species do not produce leaves or flowers during a dry year, and one instance is known of a population that did not produce any flowers or leaves for seven dry years in succession. Plant parasites are also found in the deserts. Mistletoes (*Phoradendron* spp.) grow on the branches of junipers and various shrubs. Paintbrushes (*Castilleja* spp.) obtain nutrients by attaching themselves to the roots of other plants, though they also carry out photosynthesis in their leaves. One of the most curious desert parasites is sand food *(Pholisma sonorae),* which resembles a fleshy toadstool but is a true flowering plant. Sand food grows in sand dunes.

Visitors to California deserts often express surprise to find ferns growing in these areas because normally ferns are associated with moist, cool, shaded habitats. Many desert ferns behave as so-called resurrection plants. During wet periods, the leaves are green and carry on photosynthesis. As the soil dries out, the leaves appear to die, but in reality they are merely curling up as they become desiccated and enter dormancy. When the next rain falls, these dry plants take up water and the leaves unfurl, turn green, and resume photosynthesis. Cloak fern *(Cheilanthes parryi),* lip fern *(Cheilanthes covillei),* and desert goldenback fern *(Pentagramma triangularis* var. *maxonii)* all behave this way, as do the related little club mosses *(Lycopodium clavatum).* These plants are not flowering plants but reproduce via minute spores.

Paradoxically, although our deserts are harsh environments, desert ecosystems are fragile ones. Various types of off-road recreational vehicles have done seemingly permanent damage in many areas of the desert. Mining, overgrazing by feral animals such as burros and horses, overgrazing by domestic animals, industrial and residential development, military activities, aggressive introduced weeds, and agriculture have all had their negative impacts. Fortunately, large tracts of our deserts now are protected as state and national parks or monuments.



Map of desert regions