

Saguaro Cactus

Overview

The saguaro cactus (*Carnegiea gigantea* [Engelm.]), often reaching a height of 12 meters (m; 39.4 feet [ft]), is the largest cactus in the United States. This slow-growing, columnar cactus is found only in the Sonoran Desert of the U.S. and Mexico. Within the U.S., it occurs in southern Arizona and extreme southeastern California. Freezing temperatures and altitude limit its range. Ecologically, the saguaro is a highly important species. Large and small bird species build nests on its arms or within excavated cavities. A variety of animals, including species of birds, bats, mammals, reptiles, and insects, benefit from its flowers, fruit, and flesh for nectar, food, and moisture. In addition to providing food and shelter for numerous desert animals, the saguaro plays a vital role in the culture of the Tohono O'odham people. The saguaro cactus is near the northeastern limit of its range in the 1,119-acre Tonto National Monument (NM). The cactus grows on steep hillsides in the monument, which probably provide a favorable, relatively warm microenvironment (Bennett and Kunzmann 1991).

Distribution

Throughout its range (Figure 1), the saguaro cactus grows on rocky hillsides and outwash slopes (Turner et al. 1995). It tends to be more abundant on south-facing slopes than north-facing

OVERVIEW

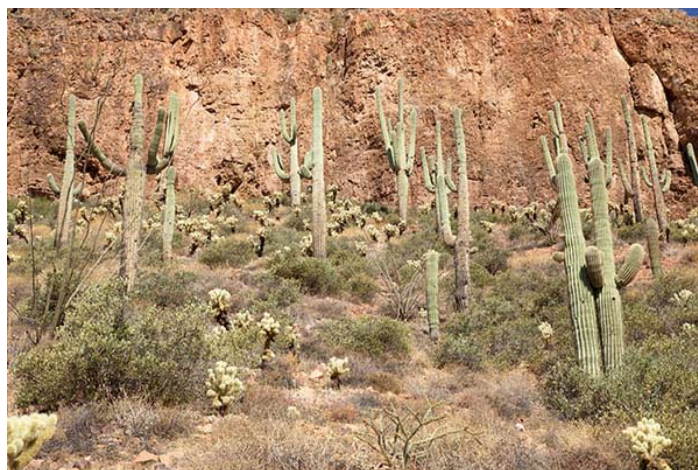


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Saguaro cacti at Tonto National Monument (NM)

slopes, especially near its northern limit. This plant grows in most areas of the Sonoran Desert that receive substantial summer rainfall, except for Baja California Sur and eastern Sonora. The densest stands of saguaro cactus are found in Arizona, approximately east of 112.8 degrees W. The plant's northwestern limit is approximately the Colorado River. Its distribution to the west of the Colorado River is limited by insufficient summer rainfall. Along the northern and northeastern area of its range, as well as its upper elevational limits, the saguaro's distribution is limited by low temperatures. The factors that limit its distribution in eastern Sonora have not been determined. At the southern portion of its range, it is limited by competition with more mesic tropical vegetation and is restricted to lower elevations.

In Arizona, the saguaro cactus occurs as far north as Kingman in western Arizona, and somewhat farther north than the monument on the eastern side of its range. The primary saguaro cactus stand at Tonto NM occupies the steep slope between the Visitor center and the Lower Cliff Dwellings. The saguaro cactus has inhabited Arizona for more than 10,000 years (Turner et al. 1995). It has existed longer, for instance, than another well-known columnar cactus—the organ pipe cactus (*Stenocereus thurberi*), which has occurred in southern Arizona for about 3,500 years (Yetman 2006).

Physical Description

The saguaro is a columnar cactus that grows to 12 m (39.4 ft) or more in height (Turner et al. 1995). Older plants often have one to several branches about 2-3 m (6.6-9.8 ft) above



Figure 1. Sonoran Desert (brown), with an overlay of the range of the saguaro cactus (green).



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Saguaro cactus flowers

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Saguaro cactus fruits

the plant's base. The plant's main stem is up to 40 centimeters (cm; 15.7 inches [in]) in diameter (although this can vary seasonally depending on the amount of moisture) and typically has 12-25 vertical ribs. Clusters of spines occur on the ribs about 2-3 cm (0.8-1.2 in) apart. Each cluster contains 15-30 spines that measure up to 3.8 cm (1.5 in) in length.

The saguaro cactus has white flowers that are about 5-6 cm (2.0-2.4 in) in diameter (Turner et al. 1995). Saguaros flower primarily in May and June (Evans 1993). Their large, waxy flowers form at the tips of stems and arms. An individual plant blooms for about one month, with flowers opening a few at a time. Individual flowers bloom for only one night, from after sunset until mid-morning or afternoon the next day. The fruits produced by the saguaro are 6-10 cm (2.4-3.9 in) long and contain about 2,000 tiny black seeds. The fleshy fruits turn purple or red when mature and split open to reveal the seeds.

Ecology

Habitat

The saguaro cactus grows only within portions of the Sonoran Desert. The Sonoran Desert, which receives rain in both

the summer and the winter, contains a diversity of plant life with more than 2,700 known species (Evans 1993). Although the saguaro is common on rocky hillsides and outwash slopes throughout its range, it may grow in dense stands on sandy flats or on fine alluvium (Turner et al. 1995). Warm-season rain is very important to this species, like other Sonoran Desert cacti. Across its range, the saguaro grows at elevations between sea level and 4,500 feet (13,716 m; Evans 1993). Minimum temperatures in its range usually do not remain below freezing for more than about 20 hours.

Dominant vegetation at Tonto NM consists of jojoba (*Simmondsia chinensis*), foothill paloverde (*Cercidium microphyllum*), velvet mesquite (*Prosopis velutina*), and brittlebush (*Encelia farinosa*) (Brian 1991), with other common plants including teddy-bear cholla (*Opuntia biglovii*), saguaro, sotol (*Dasyliiron wheeleri*), banana yucca (*Yucca bacata*), Century plant (*Agave chrysanthra*), ocotillo (*Fouqueiria splendens*), and native and non-native bunch grasses (Hiett and Halvorson 1999). The establishment of a saguaro seedling is improved by nurse plants or rocks, which protect the seedling from cold, heat, and herbivores (Turner et al. 1995). Different plants may serve as nurse plants in different areas. For example, velvet mesquite and foothill paloverde were more common as nurse plants than creosote bush (*Larrea tridentata*) at Organ Pipe Cactus NM.

Life History

The saguaro belongs to a large group of tropically-derived species of columnar cacti (Steenbergh and Lowe 1977). It occurs with four other related, ecologically similar species of columnar cacti in the Sonoran Desert (not all of which occur in the U.S.): the organ pipe cactus (*Stenocereus thurberi*), senita cactus (*Lophocoreus schottii*), hairbrush cactus or hecho (*Pachyereus pecten-aboriginum*), and Cardon or sahuaso (*Pachycereus pringlei*) (names follow Turner et al. 1995). The organ pipe and senita are the only cacti of the four that occur in the U.S., primarily within Organ Pipe Cactus NM. They do not grow with the saguaro at Tonto NM.



Young saguaros under nurse plant

PHOTO: NPS



PHOTO: NPS

Saguaro with branches

The period of growth for a saguaro cactus is mostly during rainy times in July-September (Turner et al. 1995). Flowering occurs from late April to early June. There is substantial variation among individual saguaros in terms of the number of flowers they produce (Schmidt and Buchmann 1986). In a study of 20 randomly selected mature

saguaros of all sizes at Saguaro NP, Schmidt and Buchmann (1986) determined that the plants produced an average of 295 (with a range of 82-980) flowers per plant per season. Pollination of the saguaro occurs primarily at night and in early morning hours. In order to produce fruit, flowers need to receive pollen from flowers on a different arm of the same plant or from another plant (Alcorn et al. 1959). Pollinators include birds, bees, and bats. Fruits ripen late May-mid July (Steenbergh and Lowe 1977), and seeds are released around the start of the summer rainy period. Seeds are dispersed by animals including coyotes, peccaries, and doves. Of the roughly 2,000 seeds produced per fruit, only a few will germinate, and only a small percentage of those will survive to become a mature cactus.

Because seeds need light, they will not germinate if buried more than a few millimeters (Turner et al. 1995). Saguaro establishment may be affected by climate, rodents, bacteria, livestock grazing, and insects, as well as the availability of nurse plants. Once a saguaro cactus is large enough to survive without the nurse plant, it may compete with the nurse plant for water.

A saguaro cactus attains sexual maturity at 30-35 years of age (Steenbergh and Lowe 1977), at which time only a few fruits are produced. The plant produces more fruit as it ages, with up to 100 fruits per year produced by age 50-70. A saguaro may produce its first branches by the same age, and within a few years the new branches may also produce flowers and fruits (Steenbergh and Lowe 1977).

The amount a plant grows in height each year depends upon the plant's size (Turner et al. 1995). Seedlings may grow as little as 1-2 millimeters (mm; 0.04-0.08 in) per year during their first few years of life. The growth rate then increases dramatically until the saguaro becomes 2-4 m (6.6-13.1 ft) tall. Once plants reach reproductive age, more energy is placed in flowering and fruiting than vegetative growth. Growth decreases each year until branches start to grow, then the rate levels off. Some individual saguaros live 200 years or more. A 12.2-m (40-ft) -tall individual is estimated to be about 150 years old. Causes of saguaro mortality, once a plant is established, include wind, lightning, fire, catastrophic freezes, and disease.

A saguaro's root system is wide-reaching and shallow, which allows for the quick absorption of moisture (Evans 1993). About 75-95% of a saguaro's mass is water. Its ribs expand and contract as it takes up moisture or goes through periods without moisture. Additional adaptations of the saguaro to living in its desert environment are its waxy coating and its spines. The spines provide shade and reduce evaporation by disrupting wind currents. Also, moisture condenses on spines, falls to the ground, and can be absorbed by the saguaro's roots.

Ecological Role

The saguaro cactus provides shelter, food, and moisture to a wide variety of desert species. The Gila woodpecker (*Melanerpes uropygialis*) and the northern flicker (*Colaptes auratus*) are two bird species that peck cavities into the saguaro, whose interior provides a cool home as the birds raise their offspring. The nests may last for decades (Burquez 2008). After the cavity-makers are finished with the nests, other birds will move in (such as the elf owl



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Gila woodpecker (the saguaro's clusters of spines are also obvious)



PHOTO: NPS

Elf owls in saguaro nest

[*Microathene whitneyi*], cactus ferruginous pygmy-owl [*Glaucidium brasilianum cactorum*], and purple martin [*Progne subis hesperia*].

Various insects also use the abandoned cavities. Larger birds, such as red-tailed hawks (*Buteo jamaicensis*), Harris's hawks (*Parabuteo unicinctus*) and great horned owls (*Bubo virginianus*), build nests at the bases of saguaro branches and use the plants as hunting platforms. When a saguaro dies, various forms of desert life may benefit—microbes, fungi, arthropods, and vertebrates. Dead saguaro skeletons can remain in the desert for decades, slowly decomposing, although little is known about their ecological role (Burquez 2008).

A saguaro cactus may be 90% water by mass, and an individual can store more than 4,000 liters (L) of water (Anderson 2001; Gibson and Nobel 1986). Saguaro fruits contain an average of 19.4 milliliters (ml; 0.66 fluid ounces) of water and 6.6 grams (g; 0.2 ounces; dry mass) of fruit pulp and seeds. While saguaro seeds are dry, but rich in carbohydrates, proteins, and lipids, the fruit pulp is watery and contains simple sugars. Therefore, species that consume the seeds, the fruit pulp, or both seeds and pulp derive different benefits from the saguaro.

Bats are night-time visitors to the flowers, whereas bees, other insects, and birds are day-time visitors (Alcorn et al. 1961). These species serve as pollinators. Long-nosed bats (lesser, *Leptonycteris curasoae*) and white-winged doves (*Zenaida asiatica*) rely heavily upon the nectar. White-winged doves, among other species, consume both fruit pulp and seeds, re-

ceiving both moisture and energy-rich sugars from the saguaro (Wolf and del Rio 2003). In one study, Saguaro fruit accounted for more than 60% of the diet of white-winged doves between June and mid-September (Wolf and del Rio 2003). Also, in an examination of a group of avian consumers over a 10-day period in June, these researchers determined that saguaro accounted for: 60-70% of the diet of house finches (*Carpodacus mexicanus*), varied buntings (*Passerina versicolor*), brown-headed cowbirds (*Molothrus ater*), and lesser goldfinches (*Carduelis psaltria*); 50-60% of the diet of canyon towhees (*Pipilo fuscus*) and mourning doves (*Zenaida macroura*); and 40-50% of the diet of six other species, including brown-crested flycatcher (*Myiarchus tyrannulus*), cactus wren (*Campylorhynchus brunneicapillus*), verdin (*Auriparus flaviceps*), and curve-billed thrasher (*Toxostoma curvirostre*). Almost half of



PHOTO: © J. WALLER

Mature saguaro cacti

the species in which saguaro comprised more than one-quarter of the diet are considered mainly insectivorous (Wolf and del Rio 2003). Saguaro fruit, along with insects, are given to Gila woodpecker young by their parents (Martindale 1983). Fruit that falls to the ground provides sustenance for a variety of animals, such as coyotes, foxes, skunks, javelinas, squirrels, woodrats, reptiles, and insects.

Native people have used and continue to use the saguaro in a variety of ways. The Tohono O'odham people traditionally harvest the saguaro fruit when it is ripe. They use the fruits to make wine, jams, and jellies, and the seeds as chicken feed. Fruits are gathered using long poles made of saguaro ribs. The wood may also be used for building, starting fires, or making canes. At Tonto NM, the prehistoric Salado people used saguaro ribs in the construction of their floors/ceilings.

Status and Trends

Widespread thinning of cactus forests began around 1900 (Gill



PHOTO: NPS/D. SWANN

Coachwhip preying on bird nest in a saguaro

and Lightle 1942). Early researchers connected the decline in saguaros to climate, plant disease, and/or historical practices such as grazing. Decreases in saguaro cactus populations were recorded at Saguaro NP between 1941 and 1975 (a 51.9% decrease; Steenbergh and Lowe 1983). There does not appear to have been a decrease in the saguaro population at Tonto NM (Bennett and Kunzmann 1991).

The saguaros at Tonto NM were studied by Bennett and Kunzmann (1991) in 1988. The study site they selected, near the visitor center and Lower Cliff Dwellings, contains the most extensive stand of saguaros in the monument. Information was collected on each saguaro cactus on the plot (47 total), including height, number of arms, general appearance, stem turgor pressure, and overall condition. The aspect, slope, and substrate for each cactus was also recorded. Saguaro cactus height ranged from 0.2 m (0.7 ft) to 11.5 m (37.7 ft). There were 55.17 plants per hectare. The authors concluded that a possible reason for the absence of a decline in the saguaros at Tonto NM was the favorable microclimate. The steep hillsides and cliffs at Tonto probably raise temperatures during winter nights by radiating energy collected during the day, and by preventing cold air from collecting around saguaro bases on still nights. Also, the rocky soils at Tonto would allow cacti to have a better root-hold and be less susceptible to windthrow (compared to rockless soil in other areas).

An interesting finding of the study at Tonto NM was that plants between 2.1 and 3.6 m- (6.9 and 11.8 ft) tall were underrepresented in both park populations. Plants of this size are approximately 37-49 years old, which means they would have germinated between 1939 and 1951. Three catastrophic freezes occurred in the region during this time frame, which probably accounts for the missing saguaro size class (Bennett

and Kunzman 1991). A potential concern noted by this work was that the visitor center building could reduce the drainage of cold air from the hillside, leading to a colder microclimate that could threaten nearby saguaros.

The National Park Service (NPS) began a new investigation of the saguaros at the monument in 2009, with field work conducted in the spring of 2010 (Jenny Shrum, NPS, pers. comm). The study established 18 permanent plots— nine in the monument and nine in the adjacent Tonto National Forest. The study will examine the effects of fire and grazing on saguaros using plots that have never been burned, those that have burned once, and those that have burned multiple times. The effects of grazing on saguaros will also be considered, as this activity has occurred on some of the national forest plots. This work is discussed further under Monitoring.

Threats

The saguaro cactus is long-lived and most affected by long-term climate cycles of frost and drought. Within Tonto NM and all national park units, saguaros and other plants are protected from removal and harm by law. The saguaro is also one of the plants protected in Arizona by the Native Plant Protection Act. However, individual saguaros may still be at risk from vandalism, attempted transplant, or theft.

The greatest anthropogenic threat to the saguaro cactus is development, which may result in the loss of saguaro habitat. Related to development is the disturbance of native habitat, which may lead to the introduction and spread of non-native (or exotic) plants. Exotic plants can out-compete native plants for limited resources and lead to an increase in wildfires in areas not adapted to fire. Plants such as buffelgrass (*Pennisetum ciliare*), fountain grass (*Pennisetum setaceum*), and red brome (*Bromus rubens*) have led to an increase in wildfires in the desert, damaging or killing native plants such as the saguaro.

Monitoring

The plots established by the NPS as part of the current study of the effects of fire and grazing on saguaros provide an opportunity for park-wide monitoring of the species at Tonto NM. The nine permanent plots on the monument and nine permanent plots in the adjacent national forest will allow for long-term monitoring of this long-lived Sonoran Desert icon.

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PHOTO: © TIM TIBBITTS

Lesser long-nosed bat (covered in agave pollen), is an important pollinator of the saguaro cactus

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Mature saguaro cactus

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