THE UNIVERSITY OF ARIZONA | COLLEGE OF AGRICULTURE & LIFE SCIENCES
CAMPUS ARBORETUM

Sonoran Native Plants Tour

The Joseph Wood Krutch Garden – A Symbol of Our Land Grant Heritage

When the University of Arizona was established as a Land Grant Institute in 1891, Dr. James Toumey, a botanist for the Agricultural Experiment Station on campus, recognized the educational value of the native vegetation that evolved in the Sonoran Desert over tens of thousands of years, and started a cactus display garden that we now know as the Joseph Wood Krutch (pronounced KROOCH) Garden. In the 120 years since the genesis of the University and its cactus garden, the University's practices have advanced to reflect current and evolving understandings of and attitudes toward landscaping and the natural environment.

By 1929 when the garden was moved from the west side to the east side of what is now Old Main, it boasted over 600 species. In its new location the cactus garden stretched from Old Main to Highland Avenue, and was embellished with walkways and benches enjoyed by both students and visitors to the campus. It was shortly after this move that one of the most celebrated species was added to the garden, when eight boojum trees were acquired on a Carnegie Desert Laboratory expedition to Baja California. The distinct-looking tapered trees are now rare and protected by the Mexican government.

Construction started on the new Student Union in the 1950s, and part of the mall was grassed over. Some specimens were dispersed to other areas on campus, and some of the more important specimens were consolidated in a central oval. By the 1970s, the rest of the mall was filled in with turf, but the cactus garden in the central oval remained, and can still be enjoyed in the same location between the Administrative and Koffler buildings. In 1980, the garden was dedicated to Joseph Wood Krutch, an influential naturalist author who loved the southwest, and who left his papers with the U of A.

More recently, the Krutch garden has withstood other proposals for its relocation. In 2001 plans were being made for a new Alumni Plaza, which would include a move back to the West side of Old Main. This inspired friends of the Krutch garden in the Arizona Alumni Association and the Campus Arboretum Committee to form the Krutch Garden Working Group, whose efforts resulted in the

development of a general care plan and statement of goals for the garden in 2004, which included its expansion and improvement. More species were added to the garden in 2007 including ocotillo, hedgehog cactus, creeping devil cactus, senitas, and mammalarias during another "facelift," and a previously undiscovered boojum seedling was found. The Joseph Wood Krutch cactus garden still stands as a symbol of the University's responsibility as a Land Grant Institute to encourage land stewardship by encouraging education and research which sustains our appreciation of and connection to connection our history, and responsibility to our diverse home in the Sonoran Desert.

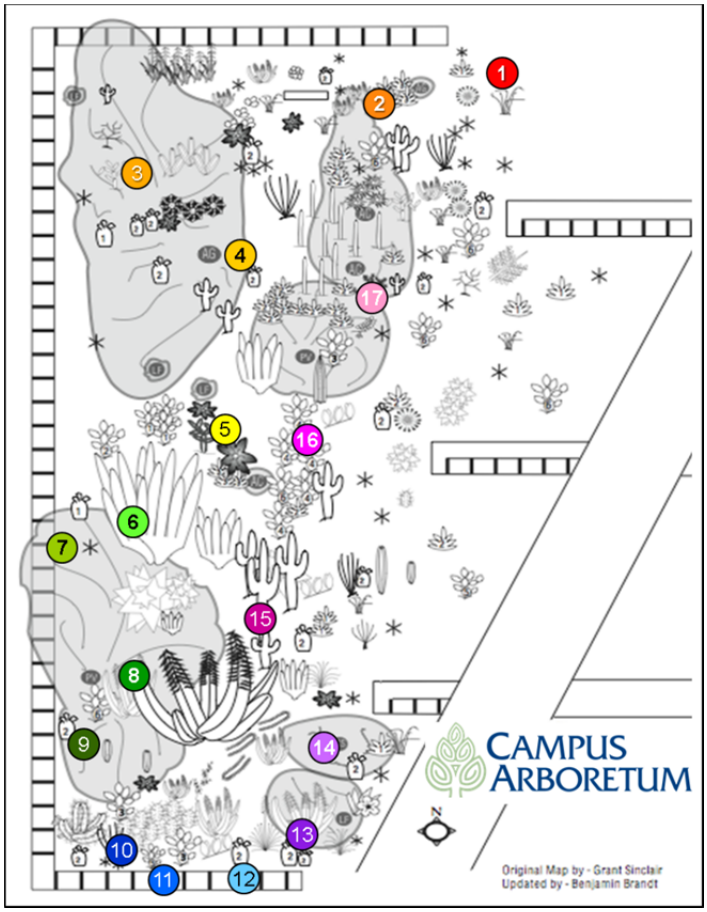
This garden can teach us:

- **Desert Plant Adaptations**
  The native species that occur here today have adapted over millions of years to be able to thrive in the intense sunlight and heat, freezing temperatures, prolonged drought, occasional flooding, and alkaline and nutritionally poor soils. Despite these challenges, native plants have evolved myriad adaptations that have allowed them to survive and thrive here.

- **Desert Ecology**
  Over time, interactions between the organisms here and the surrounding conditions have shaped this into one of the most green and diverse deserts in the world.

- **Our Role**
  Human inhabitants have been a part of this process for a long time. Early hunter-gatherers and agriculturalists paid close attention to the relationships between the plants, animals, climate, and natural rhythms of the Sonoran desert. Native plants were the main sources of food and medicine for people, and people selected seeds from the best crops to plant for the next season. Although, our dependence on the environment is less visible in modern days, our well-being is still tightly linked to plant health through landscape horticulture, design and agriculture. In myriad ways, as gardeners, landscapers, propagators, breeders, farmers and urban dwellers, humans depend on and impact plants capacity to sustain life. The Krutch garden, born at The University of Arizona almost as soon as the doors opened, forges connection with our past and serves as a living laboratory testing sustainability into the future.

This tour will describe the desert challenges plants experience and the adaptations they've evolved to allow them to survive and thrive. For each of the native plants on this tour, we'll also describe the ecological associations of plants and animals as well as the human uses of these native plants. Although only a few of the 60 remaining species will be described, our hope is that your appreciation for desert plant resilience will strengthen your connection to the complex ecosystems we share and inspire you to explore further.



Featured Plants:

1. Ocotillo
2. Night Blooming Cereus
3. Catclaw Acacia
4. Parry's Agave
5. Boojum Tree
6. Organpipe Cactus
7. Soaptree Yucca
8. Senita
9. Engelmann's Prickly Pear
10. Creosote
11. Jojoba
12. Desert Spoon
13. Wolfberry
14. Crucifixion Thorn
15. Saguaro
16. Indian Fig Prickly Pear
17. Velvet Mesquite

1. **Ocotillo** - *Foquieria splendens*

Desert Challenges: Drought/Aridity.
Plant Adaptations:Drought deciduous foliage.
Desert Ecology: Hummingbirds are important pollinators, though nectar-stealing carpenter bees and verdins have been found to effectively pollinate[6]. Antelope ground squirrels feed on flowers and seeds that fall to the ground[6].
Ethnobotany: Native people, including the Seri, Cahuilla, Yavapai, Pima, Tohono and Hiá ced O'ohdam also consumed the flowers and nectar[2] or used the flowers to flavor water[6]. The Cahuilla used protein-rich seeds to make flour for mush or cakes[2] In both past and modern times, ocotillo stems are used for fencing (sometimes as a living fence), house walls, and ramada roofs[6].

2. Night-Blooming Cereus - *Peniocereus greggii*

Desert Challenges: Hot daytime temperatures.
Plant Adaptations: Night bloom time protects pollen from daytime heat.
Desert Ecology: Thin, scrawny, barely succulent stems, sport nocturnal white flowers which are heavily scented and have long floral tubes[6]. Flower characteristics are well suited for pollination by the hawk moth (*Sphingidae*) which fly long distances for the nectar[6.] All plants in a population bloom at the same time, usually within the same night, and the flowers die at sunrise[6]. Heavy agricultural pesticide use is devastating hawk moth populations through habitat fragmentation [6, 2]. When pollinated, red fruits develop which are eaten by birds [1].
Ethnobotany: Some Gila River Pima communities actively protect these plants [2]. Tuberous root of this plant are used to treat diabetes[6] and the Tohono O'odham used a tonic created by boiling the roots to treat respiratory ailments, headaches, and to aid in digestion[2]. The flowers, roots, shoots and fruits may also be eaten [2]. The unexpected nocturnal blooms enhance this plants mystique and novelty. As a result, it enticed many campus visitors to explore the cactus collection in the early 1900s.

3. Cat Claw Acacia - *Acacia greggii* (wait-a-minute bush)

Desert Challenges: Low Nitrogen soils
Plant Adaptations: Symbiotic associations.
Desert Ecology: Legumes form mutually beneficial associations with nitrogen-fixing bacteria in the soil. As a result, they are able to produce protein-rich seeds that support many wildlife species, especially insects[6]. Blossoms provide nectar for insect pollinators (bees, flies, and butterflies)[6].
Ethnobotany: O'odham drink tea from roots for stomach and kidney problems[6]. Seeds are ground into coarse meal and made into cakes or can be stored, roasted, ground, and made into bread[2]. Fragrant dried buds or blossoms were carried in sachets as perfume. The Seri and Yaqui use wood in bows[6]. Others used the wood for fuel and construction of baskets, hunting and fishing tools, fences and furniture.

4. Parry's Agave - *Agave Parryi*

Desert Challenges: Survival/reproduction.
Plant Adaptations: Vegetative propagation.
Desert Ecology: Pollinated by insects and hummingbirds and seeds are dispersed by wind[6].
Ethnobotany: This plant was a staple of the Native American diet[2]. The leaves and hearts and stalks were roasted, sunbaked and eaten[6] and the long central stalks can be boiled, dried, or eaten raw[2]. Heads and/or stalks were steamed, mashed and allowed to ferment, then distilled into *mescal*[6]. The juice was drunk fresh as *aguamiel* (honey-water), or fermented into *pulque*[6]. Some of the many uses include: alcoholic and nonalcoholic beverages, syrup, fiber, cordage, clothing, sandals, nets, blankets, lances, fire hearths, musical instruments, hedgerows, soap, medicine, and ceremonial purposes[2]. Its colorful juice was used as a multipurpose paint and some native women used it as rouge.

5. Boojum - *Foquieria columnaris*

Desert Challenges: Drought.
Plant Adaptations: Succulent stems.
Desert Ecology: Distinct, tapered succulent stem with light gray bark, and horizontal, spiny branches produces leaves when sufficient moisture is available and clusters of white, fragrant flowers on the tops of primary stems in mid to late summer[6]. Although the Boojum is endemic to Baja, California and is not truly a Sonoran native, there is a small population on the Gulf coast of Sonora[6]. In Baja, the plants often topple from high winds and some bend and form loops[6]. Different populations of insect species pollinate in different years in response to environmental cues that are not fully understood [6]. (Natural History note: Boojum is a common name given to the plant by Godfrey Sykes in reference to the mythical creature in Lewis Carrolls book, *The Hunting of the Snark.*)

6. Organ Pipe Cactus - *Stenocereus thurberi*

Desert Challenges: High light.
Plant Adaptations: Vertical habit.
Desert Ecology: White or pale purplish flowers are borne on the top of each vertical stem[2] that are pollinated by insects and long-nosed bats[6,5].
Red fruits called "pitahaya dulce" ripen in the summer (June to August) [5]. The fruits can grow as large as oranges[2] and taste like watermelon[1].
Ethnobotany: The edible fruit was a favorite among native peoples[2] and was ceremonially celebrated at harvest. It was eaten fresh, as jam, or prepared as fruit leather, syrups, wine, mashed seeds produce oily paste used as butter [6]. The seeds could be made into flour in times of food scarcity (also "second harvest" from excrement) [5,2]. Woody ribs used in construction of fences, ceiling beams[5]. The flesh was used as a compress for aches[6] or to soothe snakebites and the Seri used it, mixed with animal fat, as a boat sealant[6,5].

7. Soaptree Yucca - *Yucca elata*

Desert Challenges: Extreme temperatures and drought.
Plant Adaptations: Vertical rhizome grows deep in soil.
Desert Ecology: The species is unique among yucca with vertical rhizomes that grow downward for 3-5 feet[8]. This depth provides protection from temperature fluctuations and a means to reproduce vegetatively. The creamy white flowers developing on a central stalk in May or June[6] are pollinated almost exclusively by the yucca moth (*Tegeticula yuccasela* or *T. maculata*) which lays eggs on the ovaries. The developing larvae depend on seed for food. The plant, in turn, selectively aborts seed to keep the larvae population in check such that, the production of fruit and moth populations are tightly linked[8,6,2]. Mature fruits are dry and cork-like[2].
Ethnobotany: Saponins in the roots (rhizomes), create a soapy lather when mashed used for washing[6]. The fruits, flowers, seeds and stalks are all edible[2], and although Yucca flowers are generally known to be bitter, that of *Yucca elata* are regarded by Tohono O'odham and Apache as having the best flavor[2]. Textiles are made from the leaves, including mats, baskets, ropes, nets, sandals, clothing, mattresses, hairbrushes and dental floss[8,6,2,1]. Leaves are also used as a last resort livestock feed[8].

8. Senita - *Lophocereus schottii*

Desert Challenges: Extreme temperatures.
Plant Adaptations: Apical meristem protection.
Desert Ecology: Mature, flower-producing stems are densely covered in long, bristly, gray spines[6]. Pink nocturnal flowers emerge through the bristles, followed by small red fruit[6].
Mutually beneficial relationship exists with a moth which pollinates the flowers and uses developing fruit for food for larvae[6].
Ethnobotany: Mexican name borrowed from Indian name, *sina*[6]. Senita roughly translates in Spanish to "little old woman" [6]. The tipais used for treatment of diabetes[2], and used for food and was traded by the Seri, Tohono O'odham, Hiá ced O'ohdam, Eudeve, and River Pima[2].

9. Engelmann Prickly Pear - *Opuntia engelmannii*

Desert Challenges: Survival/Reproduction.
Plant Adaptations: Copious fruit production and vegetative propagation.
Desert Ecology: Although pollinated by bees and other insects[6] the prickly pear also propagates vegetatively as its pads are modified stems which root readily upon contact with the soil[6]. It is a host for cochineal[6] and produces copious amounts of fruit which may persist into the fall and be eaten by and seeds dispersed by mammals, birds, rodents, desert tortoise, cactus beetle[6]. Massive, mounding habit provides a safe habitat or shelter for desert animals including rodents and birds[6].

Ethnobotany: Prickly pear fruit have sweet red pulp used for jams, candies, juices, the pads, prepared as nopalitos, may help control blood sugar and reduce cholesterol[6,2]. The boiled pads may also be used in adobe plaster, as was done in the restoration of San Xavier Mission[6].

10. Creosote - *Larrea tridentata*

Desert Challenges: Herbivory (Food scarcity).
Plant Adaptations: Chemical protection.
Desert Ecology: The chemicals produced by this plant create a volatile fragrance after rainfall, which is described by desert-dwellers as "the smell of rain" [6]. This evergreen shrub with small yellow flowers, produces a small , wooly fruit[6] when pollinated by insects (especially bees). More than 22 species feed only on creosote flowers including the creosote grasshopper, and creosote katydid[6]. The shrub often acts as a nurse plant for *Echinocereus, Mammallaria, Peniocereus*[6], Although all members of the species are drought tolerant, living for up to two years without rain[6], some have evolved changes in ploidy count (chromosome copy) which confers another level of evolutionary adaptation to different environmental conditions[6]. This plant can clone itself by sending up satellite shoots [6,5]. As peripheral shoots are sent up, inner shoots die, leaving a cluster of new growth in the form of a "doughnut" [6,5]. A creosote from a single seed found in California is sixteen meters in radius, and is estimated to be about 10,000 years old[6,5].
Ethnobotany: The secondary metabolites and resins produced by this plant, caused many to refer to it as "greasewood" and for many native people to use it medicinally[6]. Among these medicinal applications were treatment of smelly feet, infertility, tea for cold/sore throat/cough/fever/congestion, stomach problems, bowel regulation, tea from roots for ulcers, UTIs, herpes, shingles, rheumatism, arthritis, liver and kidney problems, fertility issues, paralysis, swelling, diabetes, tumors, cancer, painkiller, sanitizer, wound healing agent[5]. It was also noted for its usefulness in treating nausea, menstrual cramps, intestinal discomfort, and dandruff[5]. The Seri smoked galls formed by creosote gall midge like tobacco (6)
Creosote is currently marketed as "chaparral tea" [5]. The resin was also used as glue and for waterproofing[6].

11. Jojoba - *Simmondsia chinensis* (pronounced hoe-HOE-buh)

Desert Challenges: High light.
Plant Adaptations: Vertical leaves.
Desert Ecology: Jojoba is an evergreen, sometimes drought-deciduous dioecious shrub that flowers in winter and produces a nut-like fruit in early summer after being pollinated by wind or insects[6]. To protect against pre-mature opening, the flower buds have a chilling requirement that ensures open after late winter rain[6]. The plant serves as forage for desert wildlife (javelina, deer, livestock, bighorn sheep), and the nuts are eaten by rodents, squirrels, birds, rabbits[6].
Ethnobotany: The fruit contains a fine oil (actually a wax) used in cosmetics including shampoo, perfume, lotions and salves for skin problems and sores[6,1]. The O'odham made a paste from the nut used as an antioxidant salve on burns[5]. Natives also used it for a hair styling oil and as a tea for stomach problems and rheumatism. Though considered inedible, the seeds were used as a coffee substitute, or chewed raw to ease sore throat and child delivery[1]. It maintains a high viscosity at high temps and does not get rancid like oils and is cultivated in Arizona due these characteristics and its many cosmetic, medicinal and industrial uses.

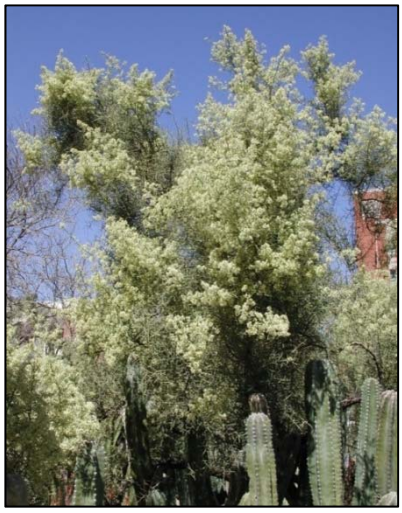
12. Sotol - *Dasylirion wheeleri*

Desert Challenges: Alternating drought and monsoon rains.
Plant Adaptations: Fibrous shallow root system.
Desert Ecology: Root systems can tolerate extreme drought as well as periodic flooding. It has a yellowish- to bluish-green non-succulent rosette, and the inflorescence has thousands of tiny white flowers which are insect pollinated[6].
Ethnobotany: The stalks and seed are eaten roasted in pits and the flower buds are also edible[2,6]. Although it has sometimes been used to make an alcoholic drink, its primary use was for weaving textiles including baskets, brooms, sandals, and mats or for thatched roofs or huts[2].

13. Wolfberry - *Lycium fremontii.*

Desert Challenges: Alkaline soils.
Plant Adaptations: Tolerates pH 6.1-9.0
Desert Ecology: An extremely versatile shrub which tolerates mildly acidic to strongly alkaline soils and grows below 3000 feet elevation and occasionally found up to 6000 feet. It is drought deciduous, blooming in Feb-Mar.[6,]. Bees, butterfly, and hummingbirds pollinate the purple, tubular flowers and other desert creatures use the shrub as habitat - especially birds who eat the fruits[6]. Although the berries are edible for human consumption, (they are related to the Goji berry), be careful as they may blacken your teeth[6,2].
Ethnobotany: Indigenous people ate fruits fresh, mashed, dried, or juiced[6,2] and made a sauce with flour and water[2]. Among the tribes known to rely on the wolfberry are the Hiá ced O'ohdam and Tohono O'odham, Pima, Maricopa, Mohave, Quechan, and Cocopa peoples[2].

14. Crucifixion Thorn - *Koeberlinia spinosa*



Desert Challenges: Aridity.
Plant Adaptations: Photosynthetic stems.
Desert Ecology: Chlorophyll packed stems carry out most of this plants photosynthesis, to conserve water which could be lost through the plants tiny leaves (drought deciduous and small leaves also facilitate water conservation). The shrub forms a dense thicket which provides habitat to small desert animals and food for bird pollinators.
Ethnobotany: Fruit of the crucifixion thorn was a part of the Native American diet[2]. Wood used for construction and furniture. Felger and Moser (1974) state that the Seri burned the wood to produce smoke believed to sanitize the home after disease epidemics[9].

15. Saguaro - *Carnegia gigantea*

Desert Challenges: Limited precipitation.
Plant Adaptations: Ridged stems channel water to shallow roots.
Desert Ecology: Saguaro is an iconic symbol of the Sonoran desert[4]. Saguaro are bat, bird and bee-pollinated and the large red fruits are consumed by birds, especially doves, who disperse seeds[6]. Saguaro generally grow very slowly, but are long-lived. Seeds germinating in protected locations beneath "nurse trees" establish best. Ultimately, however, saguaro outlive the nurse plants and may overtake the tree roots by intercepting rainfall [4,6]. Saguaro begin to flower between 40 and 75 years of age, and grow arms between 50 and 100 years[6]. The plant provides shelter for nesting birds, especially woodpeckers, Elf Owls and often other birds occupy abandoned nests[6].
Ethnobotany:Seri use "saguaro boots" (abandoned, fallen remains of callused woodpecker nests) to carry and store food[6]. Fruits, which ripen in summer during period of food scarcity preceding monsoons, were used as a food source by Pima, O'odham, and Yavapai[6,2]. The Saguaro has special Tohono O'odham significance as their calendar begins and ends based on fruiting time ("Saguaro Harvest Moon", right after the "Painful Moon"), and Saguaro wine was served ceremonially to celebrate the upcoming monsoons[6]. Others ritually discarded the outer fruit wall onto the ground facing upward, to encourage rain[2]. Ribs were not only used for harvesting fruit but also as a building material[6].

16. **Indian Fig** - *Opuntia ficus-indica*

Desert Challenges: Rapid evapotranspiration.
Plant Adaptation: CAM metabolism. As a member of Cactaceae, Opuntia sp. use CAM* metabolism for photosynthesis during which stomata close during the day, when there is high evaporative demand, and open at night to allow CO_2 uptake. CAM is a type of photosynthesis exhibited by many succulent plants in which carbon dioxide is taken up and stored during the night to allow the stomata to remain closed during the daytime, decreasing water loss
Desert Ecology:. Flowers and fruits vary in color from yellow to orange flowers, and reddish-purple or white-yellow fruits[2]. Although, pollinated primarily by bees that specialize in cacti, they rely mostly on vegetative reproduction[6]. The upright and spreading plant provides shelter and forage for wildlife[6].Ethnobotany: Natives cultivated this plant and it is still widely cultivated to this day all over the world[2]. Opuntia are hosts for cochineal, from which a prized red dye can be extracted, and is commonly cultivated for this purpose6. Originally brought to North America by missionaries from "New Spain"[2], its fruits, called "tunas," can be eaten fresh or mashed into jam[3]. The young pads, eaten as "nopalitos", (spines removed)[3] are known to lower blood serum cholesterol and blood sugar levels[2]. The pads are often cooked and eaten with chiles, onions, tomatoes, garlic[2]. The Indian Fig is the most prized of the prickly pear fruits for flavor[3]. Pulp from the pads can be used as moisturizer, sun protectant, as a remedy for warts, kidney problems, and measles, as an anti-inflammatory medicine or to sooth tarantula bites and sores. It is also used in adobe construction: adhesive because of its water resistant properties[6].

17. **Velvet Mesquite -** *Prosopis velutina*

Desert Challenges: Low Nitrogen soils
Plant Adaptations: Symbiotic associations.
Desert Ecology: A highly abundant, bee-pollinated legumes in the SW which forms mutually beneficial associations with nitrogen-fixing bacteria in the soil. As a result, they are able to produce protein-rich seeds that were originally scarified and dispersed by megafauna, and now by riparian weathering and cattle6. The foliage is also eaten by animals[6] and the flowers are sweet and edible[2]. Although generally grown in "bosques," (dense mesquite stands), they are increasingly facing habitat destruction and grown in more dispersed groups or solitary[6].
Ethnobotany: Mesquite was extensively used from pre-Colombian times to present[2]. Tohono O'ohdam still make mesquite flour, and today this practice is becoming commercially viable[6]. The beans, known as pechitas, are a source of starch for indigenous people[2]. The honey is valued[2] as is the charcoal flavoring grilled foods[6], the wood lumber for building material, basketry, and fabric, the gum for making candy, pottery glue, and black dye[6] , the sap for a cold and flu remedy and the roots, bark, and leaves used to treat conjunctivitis, intestinal parasites, acne, dandruff. Piñon nuts and acorns were traded between native peoples in exchange for mesquite[2]. The River Pima, who stored large quantities of mesquite flour[2], had two calendar months that referenced velvet mesquite: the "mesquite leaves moon" and "mesquite flowers moon"[2].

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