Combined Progress Report for

Permanent Signage and Web Serving of Database Resources at the UC Davis Botanical Conservatory,

Labeling and Interpretive Signage for Educationally Appropriate Plantings for the Life Sciences District at the UC Davis Campus with an Emphasis on Drought Tolerant Plants,

And

Labels for Educational Plantings in the Life Sciences District at the UC Davis Campus

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Introduction

The UC Davis Botanical Conservatory serves as a significant resource of botanical and horticultural information and uncommon plant material from throughout the world for teaching, research, and outreach for UC Davis, K-12 schools and colleges in northern California, and the public. The collection contributes directly to fulfilling the educational, research, and outreach mission of the University for the State of California. With over 2,700 species of plants in over 150 families, the Botanical Conservatory provides representation of plant diversity from most of the world's bio-provinces and plant families. The collection is especially rich in the floras of Madagascar & Socotra, succulents from the world's deserts, in addition to epiphytes,a world class collection of carnivorous plants, and the family Euphorbiaceae. Much of this plant material is available to other educational institutions through exchanges and to the public through volunteer-run plant sales. The Conservatory serves as one of the major outreach arms of the College of Biological Sciences. Over 7,000 people visit the Conservatory each year. Over 3,000 of those are university, K-12 and special interest groups on staff/docent led tours. Another 3,200 people each year experience portions of the collection through off site plant sales and lectures by Conservatory staff. Web visitation is currently not tracked but the staff regularly receive inquiries by e-mail from our website.

There are very few publicly accessible collections/gardens in Northern California that demonstrate the horticultural potential of many of the plants maintained by the UC Davis Botanical Conservatory, especially for the fast growing population of the Central Valley. Exhibiting these collections in a well-labeled manner will enhance public exposure to plant diversity and increase their understanding of those plants appropriate for Northern California's cool wet winters and hot dry summers. People have a difficult time distinguishing what types of uncommon plants are appropriate for growing outdoors in the central valley and which are better suited as indoor plants. By providing well labeled plants with information such as habitat details and other relevant information, we will work to ensure that the public at large and gardening public in particular can make better and more informed horticultural decisions. See Fig. 1

Fig. 1 This planting of South African plants, primarily Aloes, will engage the public with an interpretive panel dedicated to Aloes and labeling of those plants whose hardiness has been proven over several years.

Goals/Objectives

The goals of these projects have been to provide high quality and easy to read labels and interpretive signage for the plantings around the life sciences district of the UC Davis Campus and Botanical Conservatory and to begin the process of providing web-based horticultural information with an emphasis on Northern California.

Discussion

Metal labels for the plants installed in the Sciences Laboratory Building district are continuing to be prepared, printed and installed. As of this report, 394 of these labels have been printed and are in process of final installation with their respective plants. The research and design layout of another 100 labels has already been completed, and those labels are currently in final approval before submission to the printer. All of the label data is stored in a Microsoft Access database and transferred via a Microsoft Excel file to an Adobe In Design file through cut-and-paste commands to minimize errors.

Even though the process of providing botanical information in the form of labeling is not uncommon, we have found that strict attention to detail has been required every step of the way in order to provide signs that have the quality that reflects this institution. Within the design process, decisions were made on the sizes of the labels and the fonts to be used with respect to readability at a distance. 3x5” labels for small annuals and perennials and 4x6” for larger perennials and trees were chosen. We found that a non-serif font was easiest to read from a distance. The colors of the background and text were also carefully considered. Since there is lots of sunshine for most of the year in Davis we chose a dark background with silver text to minimize glare from the labels as seen below.

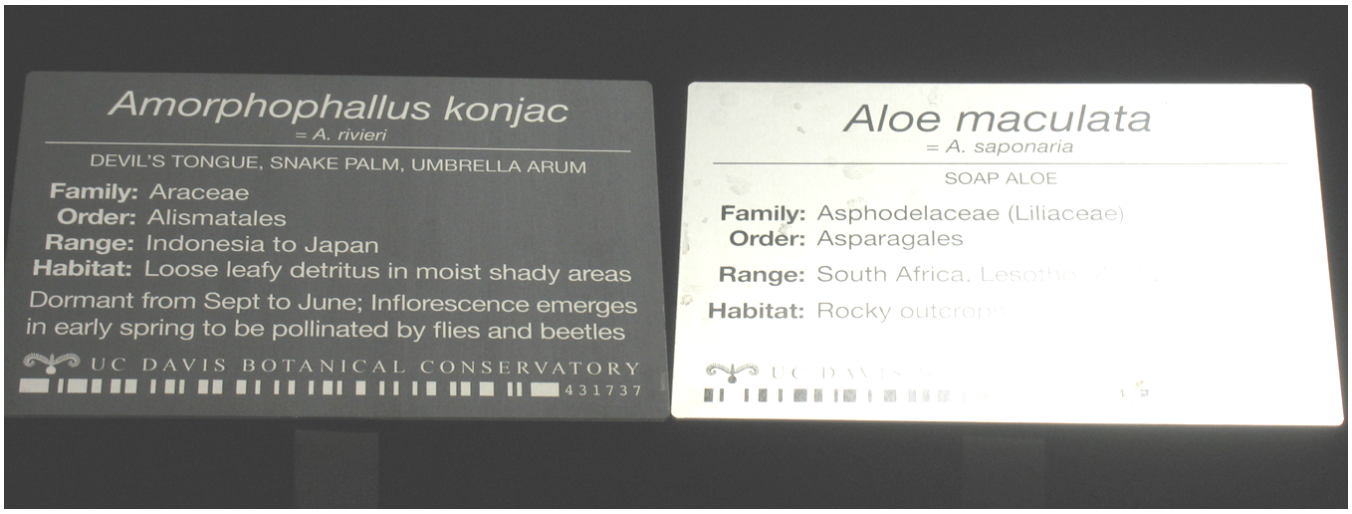

Fig. 2 With abundant sunshine for much of the year, the label on the left was chosen to ease readability and avoid glare from highly reflective aluminum labels.

An accounting system was established for the signs that include a unique barcode embedded into the design for each label. This serves to link the sign to a collection accession, which may be changed in the event of a particular plant's death, thus preserving the usefulness of the sign. In addition, the stakes for each sign were designed to provide some measure of protection from theft by simply angling about three inches of the tip. This secures the signs well and provides extra stability, but also requires more labor for each sign to be installed. Precision Signs in Rochester New York (www.botanicalsigns.com) printed and constructed the signs.

Initially we attempted to install labels with a soil coring device but found this cumbersome. In order to speed the installation process and minimize the chance of physical harm to the installers, a gas powered soil auger was purchased to ease installation.

The research needed for the information on each label has been carried out thoroughly and carefully to present the most current understanding of each plant. See Figures 3-7. Currently accepted plant names for each plant are used, and common synonyms are also presented if needed for clarification. Common names of the plants are presented, including the names used in the regions from which the plants originate whenever possible. The most up-to-date systematic divisions have been used for placing the plants into their orders and families, based mostly on the research done by the Angiosperm Phylogeny Group and the taxonomic treatments for the Jepson Manual. Every sign also presents the plant's native range and affords at least some glimpse of its ecology. This has presented the most trouble in the preparation of the labels, because information of this sort is difficult to establish for so many of the unusual plants that have been installed. Finally, when space on the label has permitted, notes of interest are added to help the reader better understand the plant, or to stimulate associated interest. These notes have included the etymology of a plant's name, interesting ethnobotanical information, warnings of toxicity, and unusual anatomical or morphological features. Everything that is presented on the signs is triple-checked for accuracy, and the authoritative sources of the data are recorded. In each case the goal of the label goes beyond providing basic taxonomic information. It is hoped that these signs may be used just as well as a classroom tool as to encourage the interest of passers-by.

Figure 1: 4x6" label with image of rarely seen flower

Figure 2: 4x6" label with Chinese common name and ethnobotanical information

Figure 3: 3x5" label with taxonomic information and Chinese common name

Figure 4: 4x6" Label with assorted information

Figure 5: 3x5" label with habitat information

The time involved in collecting and checking data, formatting the information into a concise and understandable form, and installation of each of these labels is estimated to be five hours of work. This includes the initial set-up and design of the signs, so current time required for each label is estimated to be slightly lower.

As for content of the signs, we continue to have difficulties finding some information - most notably habitat information - for many of the lesser-known species. In addition, sometimes there are taxonomic discrepancies to be worked out before we feel comfortable that we are providing current and accurate information.

500-800 more labels will be generated by June 2008 with an emphasis on those plants which are commonly used by the educational activities of the Conservatory. Production of these labels should be faster than the above-mentioned labels since those within the Conservatory will be limited to taxonomic information and native distribution without habitat information due to their smaller sizes.

Although not planned as part of the work for these grants, interpretive materials were developed during April 2007 for the May bloom of the Titan Arum, Amorphophallus titanum. During previous years blooms FAQ's were developed on the UC Davis News Service website but very little existed for on site visitors. A two sided handout was developed to provide visitors with information they could take with them. See below.

THE TITAN ARUM

Amorphophallus titanum

NOT YOUR ORDINARY GARDEN VARIETY

The frilly "petal" of the titan arum is a funnel-shaped leaf called a *spathe*. The spike that comes up from the center of the spathe is known as a *spadix*. This spadix produces several hundred tiny flowers, both male and female, way down near the narrow base where it joins the spathe. For the first several hours after the spathe opens up, the spadix puts out the strong scent ***of a dead animal*** that attracts flies and carrion beetles for pollination. This is the time when the female flowers are ready to receive pollen. The following day, the odor starts to fade as the female flowers become less receptive, and the male flowers begin to ripen with pollen. The flies and beetles become disenchanted with the "meat," and exit the spathe covered in pollen. The difference in timing between the two types of flowers promotes cross-pollination with other titan arums that may be just beginning to flower nearby.

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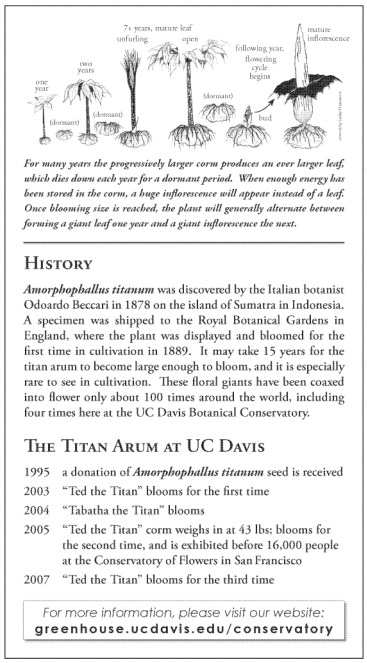


For many years the progressively larger corm produces an ever larger leaf, which dies down each year for a dormant period. When enough energy has been stored in the corm, a huge inflorescence will appear instead of a leaf. Once blooming size is reached, the plant will generally alternate between forming a giant leaf one year and a giant inflorescence the next.

HISTORY

Amorphophallus titanum was discovered by the Italian botanist Odoardo Beccari in 1878 on the island of Sumatra in Indonesia. A specimen was shipped to the Royal Botanical Gardens in England, where the plant was displayed and bloomed for the first time in cultivation in 1889. It may take 15 years for the titan arum to become large enough to bloom, and it is especially rare to see in cultivation. These floral giants have been coaxed into flower only about 100 times around the world, including four times here at the UC Davis Botanical Conservatory.

THE TITAN ARUM AT UC DAVIS

1995 a donation of ***Amorphophallus titanum*** seed is received
2003 "Ted the Titan" blooms for the first time
2004 "Tabatha the Titan" blooms
2005 "Ted the Titan" corm weighs in at 43 lbs; blooms for the second time, and is exhibited before 16,000 people at the Conservatory of Flowers in San Francisco
2007 "Ted the Titan" blooms for the third time

For more information, please visit our website:
greenhouse.ucdavis.edu/conservatory

Content development for the five large interpretive panels has been challenging. Students were hired to perform much of the initial work but their inexperience and limited timing delayed development. Since hiring a nearly full time Labeling and Interpretive Manager, Darrell Brandon, much progress has been made towards completion of these panels. Interpretive Panels were developed and tested using techniques very similar to those used at the UC Davis Arboretum in the development of interpretive panels for the Redwood grove. One of the most challenging aspects has been reducing content to make the signs readable within a 3-5 minute window of recommended time. The final report will show signs near the beginning stages and, as attached, in their completed stages. See attached panels for Aloe, Agave, Cacti, Euphorbia and Cycads below.

From March –June 2008 and as part of the completion of the 2007-2008 grant: "Permanent Signage and Web Serving of Database Resources at the UC Davis Botanical Conservatory" multi-page expanded info sheets will be generated for Aloes, Agaves, Cacti, Euphorbia and Cycads. Information gathered to make large interpretive panels for previous Slosson grants will be the content used to produce these sheets. At the end of each will be a list of horticulturally appropriate and inappropriate plants for Northern California.

Completion of the simultaneous work on these grants is expected by June 2008.

This is a progress report for work performed from June 2005 to December 2007.

Aloe

Aloes are members of the plant family Asphodelaceae, a lily relative. There are nearly 400 species of aloe, most of which grow in hot, arid environments. As an adaptation to dry conditions, aloes have thick, fleshy leaves to store water for use in times of drought. Because aloes can survive in such harsh environments, they have often been associated with health and longevity.

Aloe pillansii

Some species of aloe can grow to be quite large. This one, commonly called the giant quiver tree or reusekokerboom, may reach 50 feet in height. It is currently endangered in its native range of South Africa and Namibia.

ARTWORK BY SASHA FLAMM

PHOTO BY KATHLEEN DIGA

"We love *aloe* the plants."
–Ernesto Sandoval

Where does aloe come from?

Even though they are now grown around the world for their beauty and medicinal properties, aloes are originally Old World plants. They are native to sub-Saharan Africa, the Saudi Arabian Peninsula, and to many islands of the western Indian Ocean, including Madagascar. South Africa is the center of diversity for aloes, hosting about 120 native species.

Aloes commonly grow in hot, arid environments, but some species are found in foggy coastal areas or in the cooler temperatures of upper elevations, up to 11,500 ft. Many species grow in poor gravelly soils or on rocky hillsides among scrub and grasses, or cling to cliff faces or exposed rock surfaces.

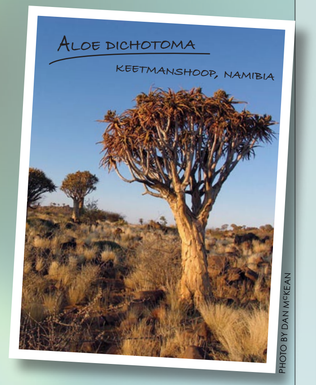


PHOTO BY DAN MPREAN

Adaptations

Aloe survives in hot, dry environments by using a modified form of photosynthesis called crassulacean acid metabolism (CAM). In this system the pores of the leaves open only at night, so the plant can absorb carbon dioxide from the air while reducing water loss from the leaves during the hot day. The powder-like film seen on most aloe leaves is an additional hot-climate adaptation: it is a waxy coating that helps reflect excess sunlight from the plant, and reduce evaporation of precious water from the leaves.

Water is stored in the gelatinous interior of the leaves.

Pollination

African sunbird

PHOTO BY CHRIS DILLON

In Africa, aloes are often pollinated by sunbirds, which are attracted to the nectar produced at the base of each flower. Unlike New World hummingbirds, these small birds cannot hover over the flowers, so they have learned to grasp the tall flower stalks for support as they sip the nectar. Fertilization rates are high for aloes pollinated by sunbirds, which makes them an important part of the aloe life cycle. In the Americas, aloes grown as garden plants are pollinated by hummingbirds and bees.

Miracle cure?

The species *Aloe vera* is a common source for the aloe gel found in many health and beauty products. This gel comes from the fleshy center of the leaves, and is believed by some to contain special healing properties. Frequently used as a topical treatment for burns, aloe gel works simply by hydrating, insulating, and protecting the wound while the body repairs itself. Note: Some species of aloe can cause skin irritation; use prepared products or the *Aloe vera* plant only.

Funding for this project has been provided by a generous grant from the Elvenia J. Slosson Foundation

For more information on aloes and many other fascinating plants, please visit: greenhouse.ucdavis.edu/conservatory

Agave

Agave is a genus of more than 200 species of succulent plants. From an old legend that they take 100 years to flower, agaves are called "century plants." In fact, some agaves bloom in as few as six years. These plants have been an important resource for indigenous Americans since pre-Columbian times, and are still used today as a source of food and fiber.

Where does agave come from?

Mexico is the center of diversity for *Agave*. Growing throughout the country there are more than 150 native species. The United States has fifteen native species of agave, which are found only in the southwestern states and in Florida. The remaining agaves are distributed throughout the Caribbean Basin, Central America, and portions of Colombia and Venezuela.

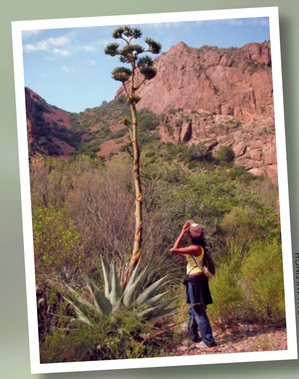


PHOTO BY PALLAVI SINGH

Agave in the Chihuahua Desert

Most agaves grow in dry places on rocky hillsides and graveled plains. Where there is plenty of rain, plants may cling to cliff faces or limestone outcrops. Some species prefer oak woodlands, and still others mixed tropical or temperate forests with thin, rocky soil. Found at elevations from sea level to 2,400m (8,000 ft), a few species can be quite cold-tolerant.

How do we use agave?

In the dry regions where it grows, Agave is one of the few income-producing resources of agriculture. Traditionally, the tough leaf fibers have been used to make crude textiles and rope or twine for many everyday uses. Today, Agave is still the source of the coarse fiber known as sisal, most often used to produce rugs and twine. The agave plant is also the source of a syrup sweeter than honey, a sugary drink known as *aquamiel*, and several alcoholic beverages such as *pulque*, *mezcal* and…

PHOTO BY MARCELO COELHO

Sisal fibers dry in the hot sun.

¡Tequila!

Produced for many centuries, tequila is a uniquely Mexican liquor distilled from the fermented juices of *Agave tequilana*. The plants are field-grown in the state of Jalisco for eight to ten years until just before they flower. Field workers then remove the leaves from the plants and harvest the large agave hearts (called piñas), which at this stage are rich with sugar. The piñas are taken to be baked, mashed, fermented, and finally distilled to produce tequila.

PHOTO BY TEQUILAPHOTOS.COM

Field workers known as *jimadores* load the harvested agave piñas.

Bat pollination

Nectar-feeding bats such as those of the genus *Choeronycteris* (pictured) pollinate agave flowers. They momentarily hover over the flowers and reach in with their long tongues to quickly extract the sweet nectar. As they feed, their faces become covered with pollen, which is then distributed to other agave flowers throughout the area.

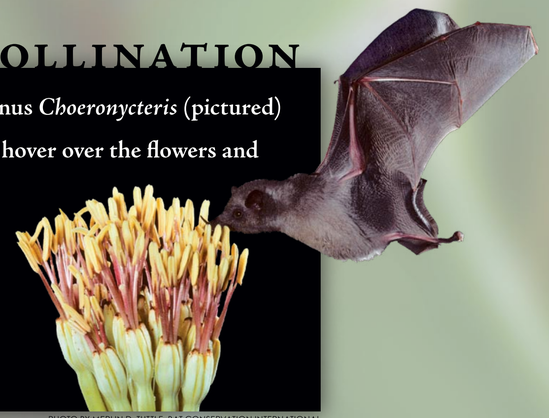


PHOTO BY MERLIN D. TUTTLE, BAT CONSERVATION INTERNATIONAL

The century plant

Depending on the species, agave takes anywhere from six to fifty-five years to grow from seed to flower. That's far from a century, but the energy stored by the plant during this growth produces an imposing flower stalk up to 40 feet tall in some species. The inflorescence can divert as much as 70% of the stored energy from the rest of the plant, which will usually die from the stress. Fortunately, the plant produces offsets and a bounty of seeds to grow and form the next generation.

Funding for this project has been provided by a generous grant from the Elvenia J. Slosson Foundation

For more information on agaves and many other fascinating plants, please visit: greenhouse.ucdavis.edu/conservatory

Cactus

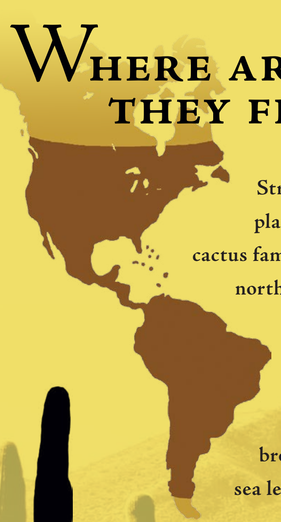
All cactus are members of the succulent plant family Cactaceae, which includes about 3,000 species. They are exclusive to North and South America, growing mostly in hot and arid environments. Their characteristic spines are actually reduced leaves, an adaptation that conserves water and provides protection from herbivores.

The saguaro cactus, an icon of the American West, is native to the Sonoran Desert.

It is listed as an endangered species.

Carnegiea gigantea
SAGUARO

Where are they from?



Strictly New World plants, members of the cactus family grow from 56° north latitude in Canada, to 43°south latitude in Patagonia. Their range in elevation is also broad, extending from sea level to 15,000 ft.

PHOTO BY RISS STORES

Flowers and flower buds of the saguaro cactus.

Environmental adaptation

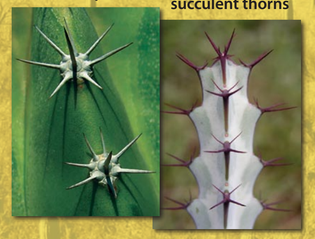
PHOTO BY DANIEL BOSMA

These giant cardon (*Echinopsis atacamensis* subsp. *pasacana*) grow at 12,000 feet above sea level on a salt flat in Bolivia. Few other plants can grow in the poor soil, cold temperatures and blinding sunlight of this unique habitat.

When it rains, the pleats in the body of this barrel cactus allow it to expand to hold large amounts of water for use in drier times. These folds also shade the plant from the hot sun, channel rainwater toward the roots, and help to preserve an insulating layer of air around the plant.

PHOTO BY JIM ENGLISH

Cactus or succulent?



Sometimes it is difficult to tell a cactus from other succulent plants, but the spines offer a clue. Cactus have a cluster of spines on a small bump called an *areole*. Each cluster is an array of spines radiating from the areole, with one or more spines in the center. Succulents have simple thorns that are usually solitary, or in pairs.

Ever eat a cactus?

DRAGONFRUIT

Several species of the cactus *Hylocereus* have large edible fruits, which are known as *pitaya* or dragonfruit. Native to Central America, they are now grown commercially as a food crop in many tropical areas.

PRICKLY-PEAR

The prickly-pear cactus (*Opuntia ficus-indica*) produces the brightly-colored edible fruit called *tuna*. Also commonly eaten are the paddle-shaped stems, which are known as *nopales*. The prickly-pear is grown in its native Mexico and around the world for food and fodder.

A leafy cactus

Pereskia grandifolia

Members of the genus *Pereskia* are leafy plants, and are considered a living form of ancestral cactus. They may look like typical shrubs, vines or trees, but hidden among the thin leaves are sharp spines that emerge from areoles. This arrangement of the spines along with a typical cactus flower structure are testaments to its cactus heritage.

Funding for this project has been provided by a generous grant from the Elvenia J. Slosson Foundation

For more information on cactus and many other fascinating plants, please visit: greenhouse.ucdavis.edu/conservatory

Euphorbs

The Euphorbiaceae family is one of the largest in the plant kingdom. Commonly called *euphorbs*, members of this diverse group of plants are the source of important products such as rubber, cassava, and castor oil. Euphorbs often grow in unusual ornamental forms, including many species that mimic cactus, and the very popular poinsettia plant.

Euphorb distribution

Euphorbia ingens, or the candelabra tree. Native to tropical Africa, this cactus-like euphorb can grow to be forty feet tall.

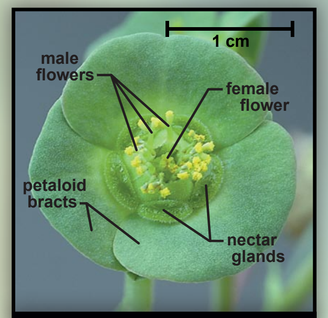
Cassava (*Manihot esculenta*) is native to South America, but is now one of the most important food crops in tropical areas around the world. These cassava roots are bundled and ready for market in Paraguay.

What are euphorbs?

Euphorbs are a group of more than 300 genera and about 7,500 species of plants in the spurge family (Euphorbiaceae). As indicated by the RED areas of the distribution map, they grow nearly everywhere, although most species are native to tropical areas. Euphorbs come in many forms, ranging from tender annuals, to large trees, to fat succulent plants.

Euphorb habitats are just as diverse, and members of the family can be found in places as different as deserts, tropical forests, and alpine meadows. There are eight succulent genera in the family, containing nearly 900 of the total species. Many of the succulent species look like cactus, but there is no relation between the plants so the similarities are only superficial.

Life cycle



The cyathium of this *Euphorbia* sp. is not a single flower, but many tiny flowers that are part of a complex inflorescence.

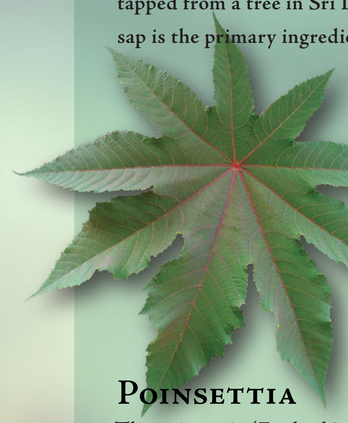
Euphorbs have separate male and female flowers. Many species have a specialized miniature inflorescence (group of flowers) called a *cyathium*. The cyathium is made up of a single female flower surrounded by many male flowers. Pollinators are guided to the inflorescence by petal-like bracts, and are rewarded with nectar from glands surrounding the flowers. After fertilization, the plant produces seed capsules that disperse the seeds with an explosive force. Seeds that land far from the mother plant may have a better chance of survival. Can you think of why this is true?

How do we use them?

Rubber

Natural rubber is produced from the euphorb *Hevea brasiliensis*. Even though this tree is native to Brazil, most production is now in southeast Asia. Here, the milky latex sap is being tapped from a tree in Sri Lanka. This sap is the primary ingredient of rubber.

PHOTO BY PETER SCHEU



Castor

Castor oil is extracted from the seeds of the euphorb *Ricinus communis*. Castor oil and its derivatives are used in the manufacture of many items including lubricants, pharmaceuticals, plastics and cosmetics. Unprocessed, the seeds of the plant are highly toxic.

Poinsettia

The poinsettia (*Euphorbia pulcherrima*) is the best selling potted plant in the United States. In its native range of western Mexico, this showy euphorb can grow to be ten feet tall. Even though it is *not poisonous*, sap from the plant may irritate and should be avoided.

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For more information on euphorbs and many other fascinating plants, please visit: greenhouse.ucdavis.edu/conservatory

Cycads

THE LIVING FOSSILS

Cycads may look like palms or ferns, but they are not closely related to either one. They are a primitive group of plants that have survived relatively unchanged for more than 200 million years. Along with the dinosaurs, they reached their peak and widest distribution during the Mesozoic Era. Today there are roughly 300 species in eleven genera.

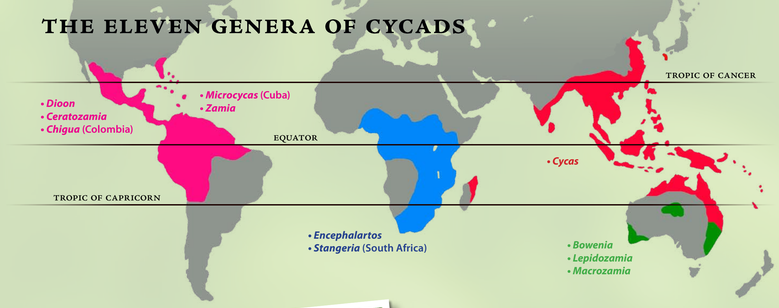
BOTANICAL CONSERVATORY · UNIVERSITY OF CALIFORNIA DAVIS

Where do they grow?

Cycads have a broad geographic range, but are limited to the tropical, subtropical, and warm temperate regions of both hemispheres. They grow in a variety of habitats, from tropical forests to open grasslands or semi-arid scrublands. Many cycads favor poor soils such as sand dunes, steep cliffs, or other low-nutrient areas.

Only one species of cycad has a range extending into the United States. The distribution of the Caribbean species *Zamia integrifolia*, commonly known as the coontie, includes southeastern Georgia and Florida. It is most commonly found in sandy soils or pinelands subjected to periodic wildfires.

THE ELEVEN GENERA OF CYCADS



This recently discovered *Dioon* species, yet to be named, grows in the oak and pine forests of southern Mexico.

This large cycad shows signs of being burned by fire. Cycads are resistant to most wildfires, giving them an advantage over other nearby plants.

Life cycle

You won't see flowers on these plants. Along with pine trees, cycads are part of a primitive botanical group called *gymnosperms*, which have reproductive cones instead of flowers. Each cycad plant produces either male or female cones. Once the pollen is transferred from a male cone to a female cone, a tube grows from the pollen grain to the female ovule and *swimming sperm* are released for fertilization. Brightly-colored fleshy seeds develop on the female cones, which attract birds and a variety of mammals that eat them—and subsequently disperse them.

Each cone scale contains 2 seeds.

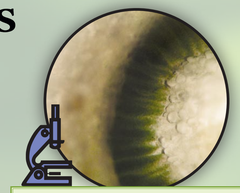
A female cone of the genus *Encephalartos* can reach 15 inches in length.

Pollination

Most gymnosperms depend on the wind to carry their pollen, but cycads are insect-pollinated, particularly by pollen-feeding weevils. Both male and female cycad cones produce an odor that attracts the beetles. In their quest for food the weevils transfer pollen from one cone to another. Most cycads are poisonous, however the neurotoxins in the plant do not affect the weevils. Some weevil species even construct pupa cases from their own toxic feces as a way of protecting their young.

Help from their friends

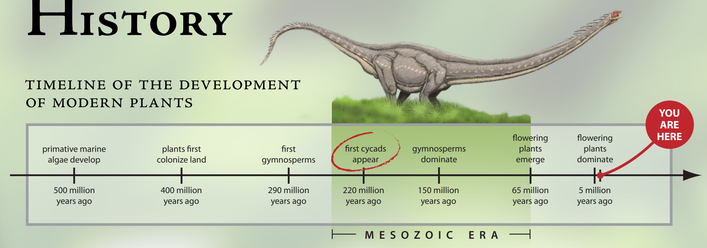
In addition to typical plant roots, cycads have a special type called *coralloid* roots (because they look like ocean coral). These roots are a home for symbiotic cyanobacteria, which convert nitrogen from the air into a form the plant can use. In low nutrient soils, such as the sandy soil in which many cycads are found, this essential nitrogen gives the cycad a competitive advantage over other nearby plants.



This cross-section through a coralloid root of a cycad shows the characteristic green band of cyanobacteria.

History

TIMELINE OF THE DEVELOPMENT OF MODERN PLANTS



How have we used cycads?

The oldest known record of humans using cycads dates back nearly 7000 years, when Australian Aboriginal people used local species as a food source. Both the pith of cycad stems and the seeds contain large amounts of nutritious starch, but also contain toxic compounds that protect the plants from herbivory. Wherever cycads are abundant around the world, local cultures developed surprisingly similar methods of purifying the starch for consumption. The Seminole people of Florida used cycad starch as part of their diet since at least the early 1700s, but lost this valuable food resource to European settlers who commercialized its production. From the mid 1800s until about 1920, starch processing plants were common in southern Florida. The cycad starch was sold as a food staple called arrowroot flour, as well as a laundry starch. The starch mills were dependent on wild populations of the native *Zamia integrifolia*, and closed down when this natural resource was depleted.

After crushing cycad roots into a pulp, the Seminole strained the starch through cloth into deerskin, and then allowed it to ferment.

Funding for this project has been provided by a generous grant from the Elvenia J. Slosson Foundation

For more information on cycads and many other fascinating plants, please visit: greenhouse.ucdavis.edu/conservatory