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Desert Plants

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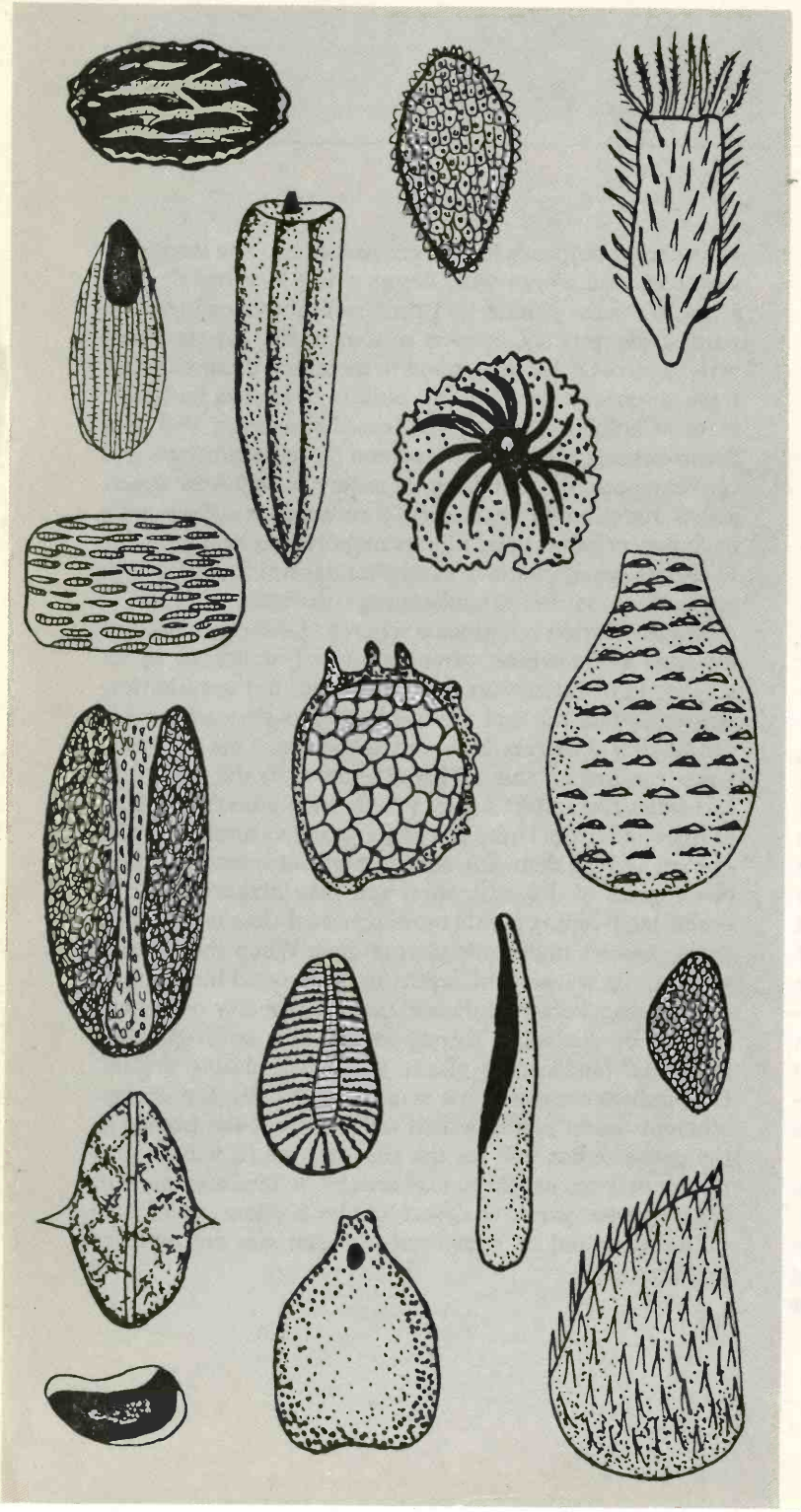

Seeds of desert plants studied recently by plant scientists in India.
See article on page 31.

Desert Plants

A quarterly journal devoted to broadening knowledge of plants indigenous or adaptable to arid and sub-arid regions, to studying the growth thereof and to encouraging an appreciation of these as valued components of the landscape. Subscription price is $10.00 per year.

Frank S. Crosswhite, editor

Published by The University of Arizona
for the Boyce Thompson Southwestern Arboretum

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Editorial

Landscaping With Desert Plants—Natural desert vegetation withstands sun, heat, drought and drying wind. Desert plants have a beauty and perfection all their own —a beauty combining fascinating structural modifications (some bizarre) with simplicity of form, function and phytosociological association. The sclerophylls, microphylls, spines, thorns, swollen stems, succulent nature and other adaptations evoke interest not only by plant scientists but by all persons who come into contact with desert plants.

As desert plants survive in a struggle against the hardships of aridity, they symbolize an overcoming of adversity on a broader scale. Rugged and hardy desert plants represent a beautiful marriage between the solitude of the desert and an irrepressible vegetative life force. No wonder indeed that world religions were born in desert places conducive to meditation and reflection, conducive to decision-making, conducive to strengthening, bronzing and maturation,—places where the innocence and passiveness of plant life could be assimilated and opposite qualities inferred,—where simple values relating to human earthly existence could be extrapolated. The Garden of Eden was a desert landscape where mankind's albeit imperfect earthly existence (epitomized by the earth-bound serpent) caused him to depend on the fruits of the land. The knowledge of good and evil thereby became inevitably revealed, appreciated and lamented. Mankind yet exhibits a strong psychological dependence on plants—a need to be close to vegetation. Mankind also exhibits a strong psychological need to retreat to the seclusion of a place of quiet solitude where thoughts can be sorted out and perfection measured against flaw.

By landscaping with desert plants mankind brings the good values of the vegetation-and-desert marriage into association with his everyday activities. But aside from the colorful flowers and fruits, the green of the vegetation, and the pyschological values, desert plants can be chosen for landscaping purposes to perform functions. The landscape architect who works with desert plants is more than an artist, since the palette he paints from provides mankind with shade, privacy, barriers to foot traffic, separation of activities, cover for the ground to minimize dust, vines for walls to cut the heat-load on buildings, bushes with root mats to hold the soil on banks and slopes, as well as a dozen or more other functional and creature comforts and conveniences. By searching in nature to see how desert plants function in their own communities,—how each occupies its habitat and fills its niche, it has been possible to choose desert plants to carry over natural functions into artifically constructed landscaping situations.

Desertification is a process whereby landscapes become deprived of moisture, often becoming subjected to increased light intensities and heat. Mankind unintentionally compacts the soil around buildings by walking and conducting the everyday activities of life. This results in water running off and not being retained by the soil. Walls and sidewalks reflect a glare which intensifies the amount of light and heat. These phenomena and various activities of man and his domestic animal associates result in various degrees of desertification and may make the use of desert landscaping plants more practical than use of more mesic species under many situations. When the expense of pumping water from depths in the ground increases as energy costs become inflated, many a property owner can benefit by replacing thirsty lawns and water-guzzling broad-leaf landscaping plants with truly desert species. Researchers are even now scrambling to develop energy-efficient desert plants which will better shade homes in the summer but will let the sun through in winter. Our subscribers can expect to read articles on landscaping with desert plants as native desert species are introduced into cultivation and as trials and experiments continue to yield results.

The Double-Cut Technique For Grafting Cacti to *Trichocereus pachanoi* Rootstock

an interview with Dan Bach

Bach's Cactus Greenhouse and Nursery

Editor's Note—The interest in propagation which resulted in publication of the first part of a minisymposium on desert plant propagation techniques in the last issue of this journal also led *Desert Plants* to visit the greenhouses on the northern outskirts of Tucson where Dan Bach raises seedling cacti by the hundreds of thousands, indeed by the millions. After studying horticulture at the University of Arizona (including pioneering research on Jojoba, incidentally), Dan together with his wife Diane (who also owns and operates a wholesale business called *Cactus by Diane*) purchased an egg ranch and commenced a long and painstaking conversion of the immense chicken houses into greenhouses. Over the years Dan has distinguished himself among the world's cactus growers for not only the quality and species diversity but the quantity of his product. Although his business keeps a low profile, as is often the case with a wholesale operation, streams of trucks through the year arrive at his nursery to take on heavy loads destined for air freight forwarding to Europe or to nurseries in the United States. He supplies the seedling cacti to a number of large nurseries which place them into pots and in turn wholesale them to retail nurseries and chain stores. Persons knowledgeable about the cactus business can spot Dan's plants in the very best nurseries and most fashionable department stores as well as in discount nurseries and chain stores, even after they have passed through the hands of various wholesale nurseries or brokers.

Dan's success with propagation rests on a very thorough knowledge of the subject, an inclination to experiment, a veritable passion to do things the right way with the most efficiency, and a genuine willingness to put the work in that is needed to do the job. Aside from growing cacti from seed, Dan perpetuates several kinds by grafting. The following interview with Dan deals with this latter subject.

Desert Plants: Dan, most people understand the reasons behind grafting of woody plants such as orchard trees and techniques for grafting these are rather well known. Now that we begin to see more grafted cacti in nurseries, do you think that the public is gaining an equal understanding of these?

Mr. Bach: Perhaps. Unfortunately some dealers have capitalized on the discordant nature of two very differently shaped and colored species grafted together and sold them under fanciful names such as "moon cactus" or some other gimmick. People buying them may not realize that grafting has been done and may even think that the highly colored part is a flower.

Desert Plants: Yes, we have often been asked by visitors from out of state just how long the "red flowers" on the top of a Ruby Ball graft will stay open.

Mr. Bach: It is true that some commercial grafting of cacti is done to produce unusual looking plants to be sold as curiosities. Often there is no valid horticultural reason for the choice of scion in such instances and the plants are mass produced for supermarkets and other vendors of large quantities of plants. If the retailer will indicate by signs or labels that these are grafts which are being sold, the purchaser in fact will have an educational conversation piece to study and show his friends.

Desert Plants: Yes, what is a real educational experience for one person may be a freak or novelty to someone who doesn't understand it.

Mr. Bach: Exactly. We have several main goals in grafting cacti. One is to produce a larger number of robust offsets in a short time. Just last week I harvested over three hundred good-sized offsets that you see here in these flats from only sixteen grafted mother plants of the yellow-flowered form of *Rebutia krainziana.* Grafting allows us to vegetatively propagate rare or difficult plants much faster than would ordinarily be possible. Grafted plants with many offsets are often quite floriferous. If we cross-pollinate the many flowers which each plant produces we can harvest an abundance of seed to germinate and grow.

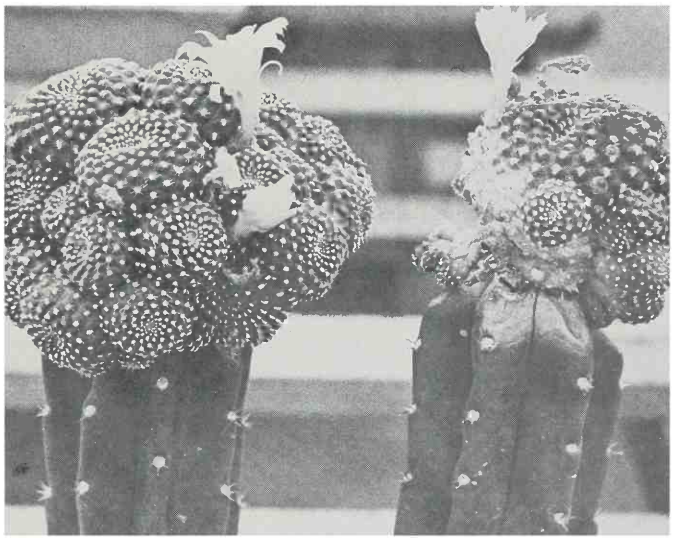
Desert Plants: Are the principles of grafting cacti much different than those for fruit trees?

Mr. Bach: The basic rationale is the same as for grafting woody plants but the techniques are quite different. As in any plant grafting, a receiving plant called the rootstock has its vascular tissue matched to another plant placed above it called the scion. The two plants are held firmly together by various means until the vascular tissues grow together and join the two plants.

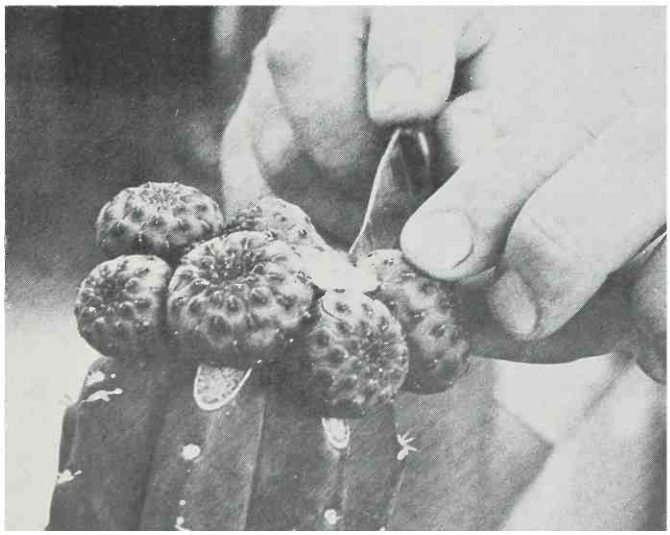
Desert Plants: Now in the case of fruit trees, various kinds of apples may be grafted onto an apple tree, or in the case of pistachios an edible nut variety may be grafted onto a wild pistachio rootstock. In cacti are varieties ordinarily grafted onto closely related rootsotck?

Mr. Bach: No. This sets cactus grafting off from many of the other types. The scion is often a round clustering plant and the rootstock a columnar type which is not even in the same part of the Cactaceae family, let alone in the same genus.

Scions of **Rebutia krainziana** *awaiting grafting.*



Mother plants of **Rebutia krainziana.** *Offsets to be used as scions have been removed from the plant on the right.*



Offsets are carefully cut away from grafted mother plants which have clustered. **Sulcorebutia rauschii** *is illustrated here.*

Desert Plants: You have mentioned that reproduction by both vegetative and non-vegetative means are enhanced by grafting. Are there any other advantages?

Mr. Bach: In some climates with high humidities and precipitation the only way in which some difficult cacti can be grown is by grafting. On their own roots the cacti would die. When grafted to a rootstock which tolerates moisture, the plants often thrive. We sometimes graft cacti which would otherwise require special attention for the resultant ease in cultivation. Some cacti such as the variegated sports of *Gymnocalycium mihanovichii* var. *frederickii* must be maintained as grafts or they die. They occur in bright colors (red, yellow, orange) and contain very little if any chlorophyll. As a result they can not manufacture their own food. They become virtual parasites on the rootstock.

Desert Plants: You have many newly grafted cacti here on your greenhouse benches, so you must do this routinely and efficiently. This reminds a person of a surgeon doing heart transplants. The tissues have to match up just right, don't they. How many of these surgical operations can you do in succession and how long does each take?

Mr. Bach: This month I have been setting aside each day enough time to do forty grafts. This needn't be a long period, because it take approximately forty-five seconds to do one graft from start to finish.

Desert Plants: That seems like a very short time. Is there any technical reason, aside from the need to be efficient, that speed is desirable?

Mr. Bach: Yes, indeed. In the summer here in Arizona the air is quite dry. No time should be lost in applying the scion to the rootstock or the cut surfaces will dry out and the graft will be rejected.

Desert Plants: We understand that your double-cut technique for grafting onto *Trichocereus pachanoi* rootstock relates to this drying-out concept and is your key to success. At the risk of showing your competitors your "trade secret" so to speak, would you demonstrate for our readers how to graft cacti?

Mr. Bach: Certainly. Keep in mind that many successful methods have been worked out. This particular technique happens to be what I use because it is the best for my operation. It is particularly suited to dry, hot climates. To use in deserts in other words.

Desert Plants: Isn't most cactus grafting done in deserts?

Mr. Bach: Quite a bit is done in southern California, Japan and Europe under greenhouse conditions many miles from the nearest desert.

Desert Plants: What are the first steps?

Mr. Bach: First, you need a prepared working area, wiped down with 10% Clorox solution. Mother plants, rootstock and a clean sharp knife, also sterilized with 10% Clorox should be ready.

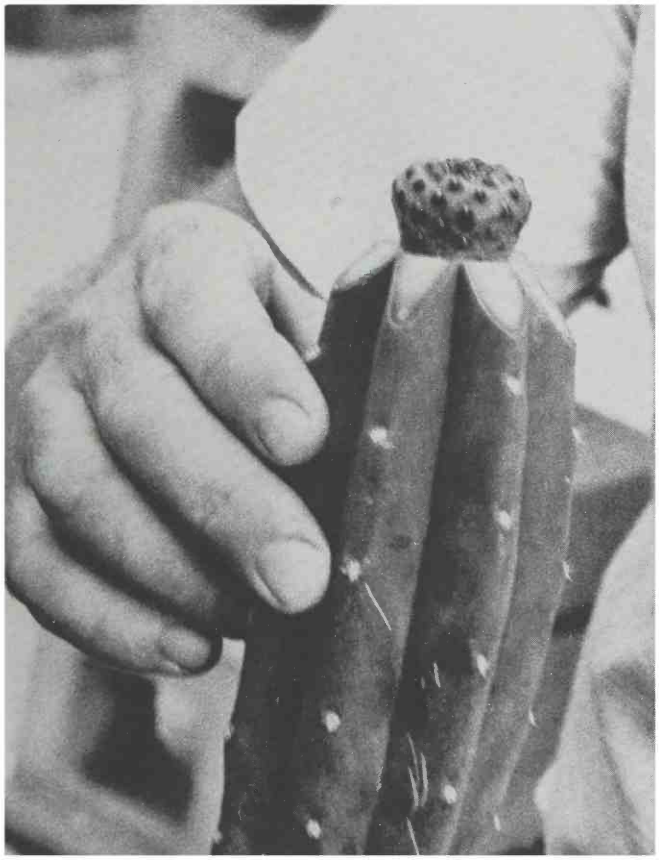
Desert Plants: What species are you using today?

Mr. Bach: For the rootstock I use unrooted tip cuts of the San Pedro Cactus, *Trichocereus pachanoi,* for ease in handling. The understock cuttings are rooted after the grafting is done. The *Trichocereus* will eventually take up water and nutrients for the scion above. For this demonstration the scion I will be using is *Sulcorebutia rauschii.*

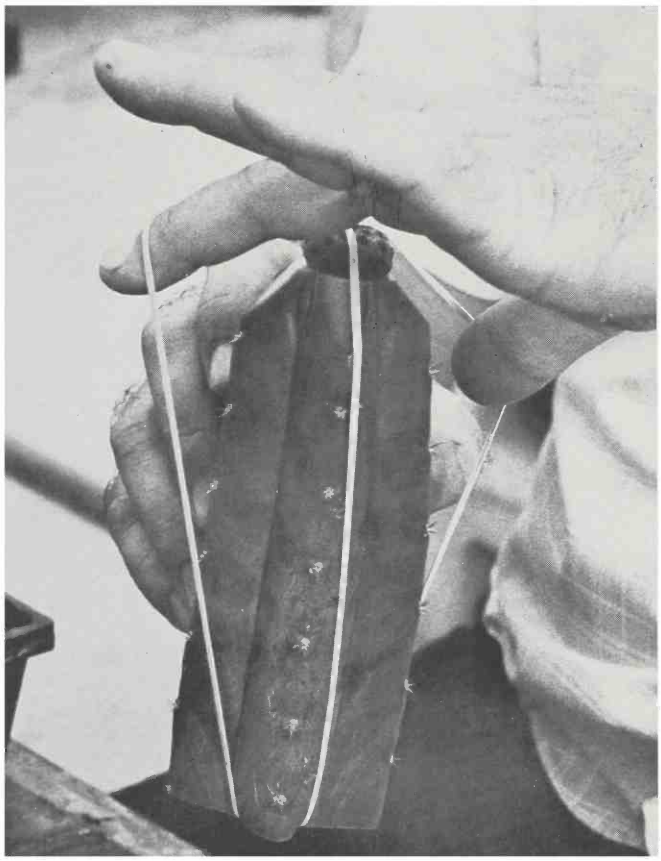
Desert Plants: When considering grafting as a whole in the plant kingdom, isn't it a bit unusual to use a rootstock which is itself unrooted?

Under desert conditions of low humidity, the double-cut technique is a key to successful grafting.

After a fresh cut has been made on the scion, the two plants are brought together and the slice from the double cut removed.



Scion in place on the rootstock and centered so the vascular tissues will match.



Two rubber bands are used in planes at right angles to each other to provide firm and even pressure.

Mr. Bach: It could only be done with a succulent plant such as a cactus which has an adequate supply of moisture and nutrients in storage to carry both itself and a scion through a period of several weeks until adventitious rooting of the understock occurs.

Desert Plants: It appears that the unrooted understock is easier to handle and manipulate than would be the case if it were rooted and potted.

Mr. Bach: Yes. Cuttings of *Trichocereus pachanoi* of an appropriate length should be taken a week before grafting and laid in a shady well-ventilated area so the cut can callous over. This prevents damage to the bottom of the rootstock when rubber bands are applied to hold rootstock and scion firmly together. Length of cutting is primarily determined by the size and softness of the intended scion. For softer, smaller scions, shorter understocks should be used so that rubber bands do no exert as much pressure.

Desert Plants: Is there a particular reason for choosing *Trichocereus pachanoi* as the rootstock?

Mr. Bach: There are several reasons. It doesn't deteriorate as quickly as other species do when used as a rootstock and it is a strong robust grower which will hold and nourish a scion of large diameter. Also it has short almost insignificant spines which allow easy handling of the cactus without prior treatment. I can grow quantities of the understock under nursery conditions in southern Arizona at a moderate cost compared with the expense which would be incurred if the rootstock had to be greenhouse grown. Other species used for rootstocks in Japan and elsewhere are not hardy to freezing weather. When the *T. pachanoi* rootstock is used and the scion is also relatively hardy, the grafted plant can be grown in a patio or yard regardless of moderate freezing weather.

Desert Plants: Aren't other types of *Trichocereus* used for understock occasionally by growers?

Mr. Bach: The next most frequently used *Trichocereus* is *T. spachianus.* It also makes a sturdy rootstock, but the formidable spines have to be burned off before it can be used in grafting. It also tends to develop brown patches on the stem which obscure the chlorophyll-bearing tissues and lessen the rootstock life.

Desert Plants: Does this imply that grafting in cacti is a temporary measure, with the rootstock eventually dying?

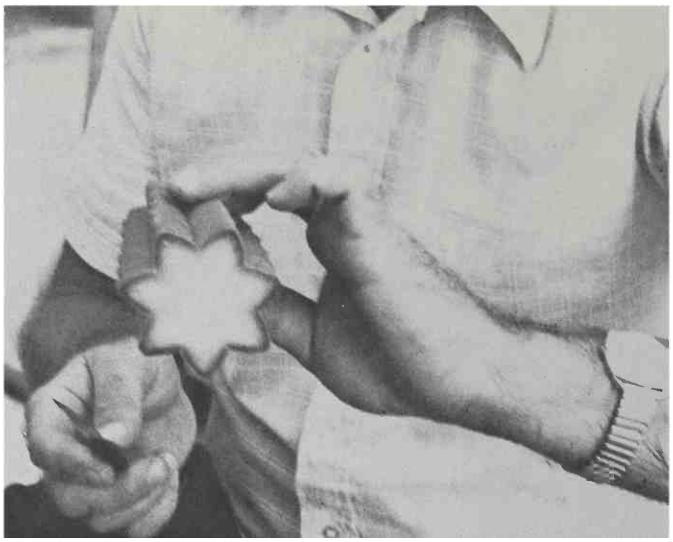
Mr. Bach: This seems to be the case in my experience. Sooner or later the top plant seems to "burn out" the bottom plant and regrafting of the scion is necessary. *Trichocereus pachanoi* lasts longer for me than other kinds of cacti.

Desert Plants: What other species are commonly used as understock?

Mr. Bach: Seedlings of *Myrtillocactus geometrizans* are popular. The mass-produced "moon cacti" in supermarkets usually have a vine-like Night-Blooming Cereus *(Hylocereus undatus)* as a rootstock. Cuttings or seedlings of *Cereus peruvianus* are also frequently used. Some people use *Opuntia* or the leafy *Pereskiopsis.* It is good to have several kinds of rootstock available so that different sized scions can be matched to rootstocks of similar diameter.

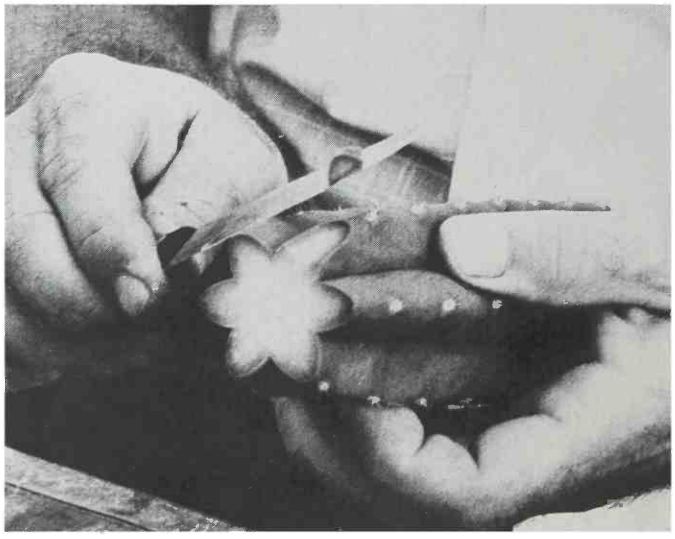
Desert Plants: Is size the important factor?

Mr. Bach: In my experience, yes. Some people will tell you that it is necessary to match up species of scions and rootstock for other reasons. For example, that all *Mammillaria* species regardless of size should be put onto *Cereus* for best growth. I have not found this sort of

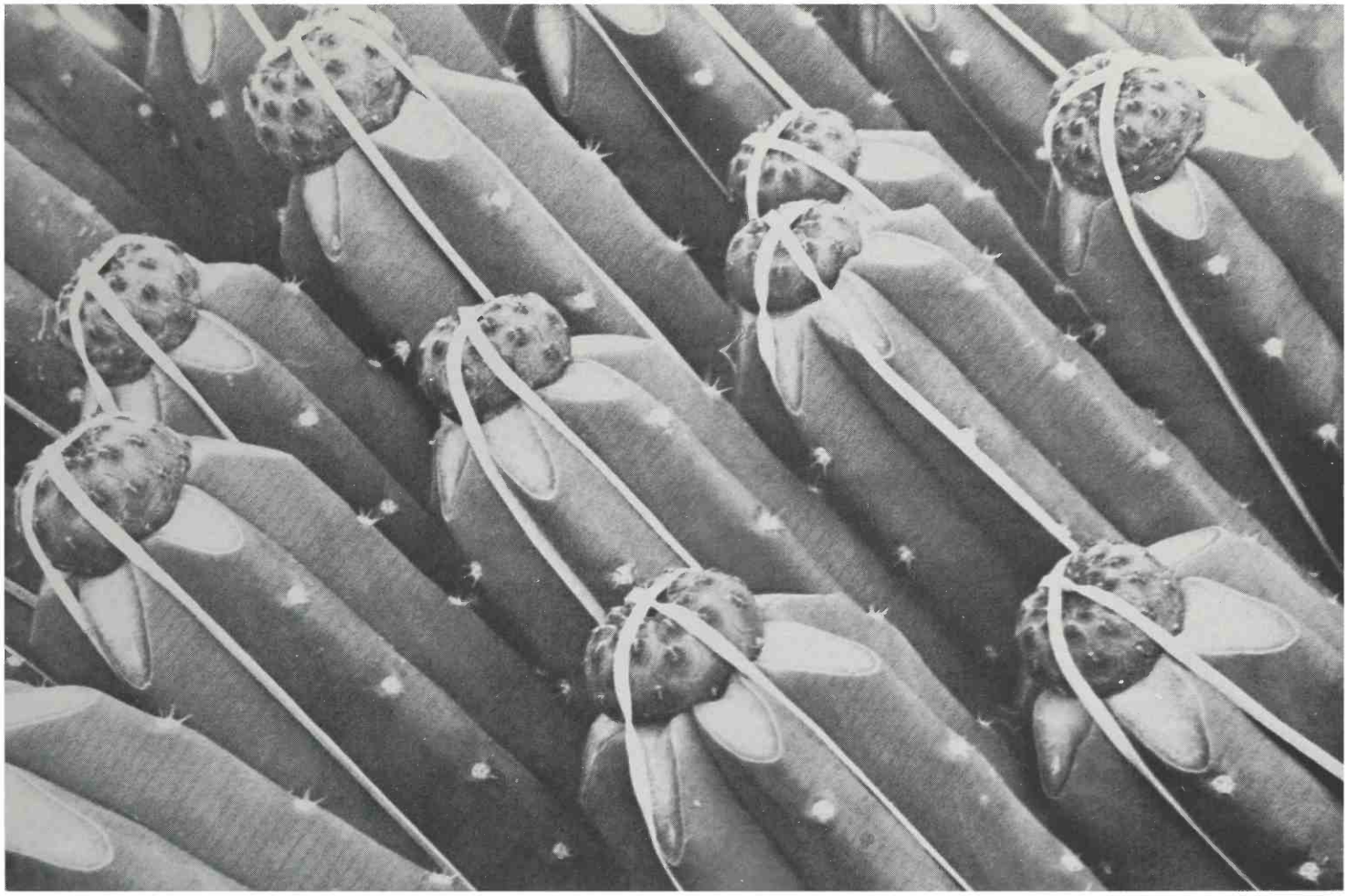


Trichocereus pachanoi *is used as a rootstock before it has formed adventitious roots itself.*

The apical tip is cut far enough down so that the diameter of the vascular system will match that of the intended scion.



Next, the ridges are bevelled to remove the upper areoles.



Sulcorebutia rauschii *newly grafted onto* **Trichocereus pachanoi** *rootstock.*

specificity in the work I have done.

Desert Plants: Maybe people think there should be a specificity because surgeons on television always call for cross-matching of donor organs when doing transplant surgery.

Mr. Bach: Now, the first step in preparing the rootstock to receive the scion is to cut the apical tip from the stem far enough down so that the diameter of the vascular system will match that of the prospective scion. Then the ridges are bevelled.

Desert Plants: The columnar *Trichocereus* has accordion-like ridges as we can see. Why do you cut off all of the ridge tips? Can't you get a good match of vascular tissue without going to that much trouble?

Mr. Bach: A good match is not the only concern. Cutting the upper areoles away eliminates the buds which might have eventually allowed offsets to form on the rootstock so close to the scion that the pressure could have pushed the scion away allowing it to break off. The lower areoles of the rootstock may form offsets eventually, but these can be easily spotted and removed as they form.

Desert Plants: This is really all very interesting and educational.

Mr. Bach: Next, a second very thin cut is made just below the original cut through the diameter of the stem. This piece, like a slice of dill pickle, remains on top of the stem, covering the surface while the scion is being prepared. This double cut technique prevents dehydration of tissues.

Desert Plants: Do you mean that it is really that important for the cut surface to have that protection for just the few seconds that it takes to put the scion in place?

Mr. Bach: It's so important that this is really a key secret to successful grafting. Do no allow either surface to dry out at all. Also, the cuts must be perfectly smooth and flat—no ripples. Both rootstock and scion should also be actively growing when the graft is made. When preparing the scion, try to make the cut which severs the offset from the mother plant just as straight and flat as possible so the offset can be placed directly on the rootstock. If trimming needs to be done, place the offset on the table in front of you for good visibility and use thin cuts. Then raise the offset above the rootstock, the latter having been set upright on its flat base. Remove the cut slice and place the scion where the slice had been, preferably as one operation.

Desert Plants: It doesn't seem that you spent much time in aligning the vascular tissues of the two plants. Isn't it necessary to carefully match them up?

Mr. Bach: With experience, if the correct size scion is matched to the correct size understock and centered by visual inspection from above, there should be sufficient vascular overlap for successful grafting to occur. It is less desirable to spend time aligning tissues because every instant allows the surfaces to dry out and the probability of

an unsuccessful graft to be much higher. After the scion is in place, I stretch a pair of rubber bands in two perpendicular planes around both scion and rootstock. When viewed from the top, the rubber bands should divide the plants into four equal quarters. This ensures that pressure will be evenly applied on all sides. Then the grafted plants should be set aside in a well-lit place and observed after two weeks to see if the graft has taken. The rubber bands can be removed after one week. By this time, if the grafting has been successful, the scion should begin to become more turgid. The rootstock can then be placed into soil mix to form adventitious roots.

Desert Plants: How is this done?

Mr. Bach: Stand each stem in a pot which just comfortably receives its basal diameter with a little room to spare on all sides. Potting soil should be placed to a depth so that the stem rests on it without becoming imbalanced in the pot. Then put a layer of chat between the stem and soil and fill between the stem and pot sides with chat. This ensures good drainage all around the rootstock and keeps it from staying too wet. Roots should extend well into the soil after four or five weeks have gone by.

Desert Plants: The chat is larger than sand but smaller than pea gravel.

Mr. Bach: Yes, it resembles chicken grit.

Desert Plants: How often does the knife have to be sterilized as grafting proceeds?

Mr. Bach: I find that it is sufficient to sterilize the knife after every twelve grafts, unless brownish discolored tissue is encountered in either scion or rootstock. Then the knife is sterilized after each cut until healthy tissue is reached. If only a small amount of grafting is to be done, the knife can be sterilized between each graft. The knife should be extra sharp for best results. I use a stainless steel paring knife which is sharpened to a fine edge.

Desert Plants: Thank you, Dan, for taking time to show us your methods. This has been a quite interesting interview. Our readers will certainly enjoy it and learn from it.

Rootstocks are not placed into soil mix immediately because the rubber bands will remain attached until union between scion and rootstock is complete.

Nourished by the vigorous rootstock, the scion grows from a small button to a robust clustering specimen with turgid offsets.

Observations and Comments on *Pediocactus sileri* in Arizona and Utah

Ralph K. Gierisch
Arizona Strip District,
U.S.D.I. Bureau of Land Management

Acknowledgements

This report is based on information obtained by personnel of the Bureau of Land Management, U.S. Department of the Interior, and specialists working under contract for the Bureau of Land Management. Field studies were conducted by the author in the capacity of Botanist/Ecologist for the Arizona Strip District. The author wishes to express appreciation to the following persons who also contributed field study information used in this report: Dr. David C. Anderson, John Anderson, Carl E. Bezanson, Charles E. Bundy, Dr. Robert E. Coombs, Vear L. Mortensen, Robert W. Sandberg, Frank Smith, Cloyd W. Swapp, Dorothy N. Woodbury, and Dr. Lowell A. Woodbury.

Editor's Note

In 1922, botanists N. L. Britton and J. N. Rose described a new species of cactus, *Utahia sileri*, in a monograph of the Cactaceae family published by the Carnegie Institution of Washington (Publ. 248. Vol. 2. P. 215). They attributed recognition of the species to George Engelmann, a St. Louis botanist who had been dead for a number of years. This was on the basis of their discovery in the dried plant specimens stored in the herbarium of the Missouri Botanical Garden one which seemed to be distinct from all others known at the time and upon which Engelmann had written the name *"Echinocactus sileri."* It was evident that had Engelmann lived longer he would have officially christened the new species with this name, thereby commemorating an early Mormon pioneer of southern Utah, Andrew Lafayette Siler, who lived from 1824 to 1898. But Britton and Rose thought that the plant was so different from other kinds of *Echinocactus* that they established the new genus *Utahia* for it in recognition of the location where they thought Mr. Siler had found it. At the time *Utahia sileri* was finally officially named and described in 1922 there was only one plant of the species known to science, the original dried specimen in the herbarium of Engelmann in St. Louis. Since the plant collector Siler lived in southern Utah, it was assumed by Britton and Rose that the type locality "Cottonwood Springs and Pipe Springs" from which the specimen came was in Utah. They recorded *"Distribution:* Southern Utah." when the species was first described.

The species remained very poorly known and was supposed by many plant scientists to be rare or perhaps near extinction. Eventually it was realized that Pipe Springs (now a National Monument) was actually in Arizona rather than Utah. By the second edition of Lyman Benson's *Cacti of Arizona* (University of Arizona Press. 1950), Pipe Springs was the only locality definitely known for the species. In their book on the *Flora of Arizona* (University of California Press. 1951), Thomas H. Kearney and Robert H. Peebles stated that the plant was locally common in the vicinity of Pipe Springs and that it was known for certain only from northern Arizona. By the third edition of *Cacti of Arizona* (University of Arizona Press. 1969), Benson had seen specimens only from Arizona (not Utah), although he noted that the plant had been reported from Utah by others.

There have been widely divergent opinions on the correct name for this little cactus, Lyman Benson using *Echinocactus sileri* as the scientific Latin name and Utahia as the common English name. T. H. Kearney and R. H. Peebles retained *Utahia sileri* as the Latin name. Recent taxonomic opinion, based on reconsideration of the subject by Benson, is that the cactus is congeneric with *Pediocactus simpsoni* described by N. L. Britton and J. N. Rose nine years before they described *Utahia* and that it therefore should be called *Pediocactus sileri.*

The multiplicity of names tends to hide the fact that up until the studies reported here now by Ralph Gierisch, extremely little information was available concerning this species. The present article now finally reports the species from 11 study sites located in two counties of Arizona and two counties of Utah. Since *Pediocactus sileri* has now been officially listed in the Federal Register as an endangered plant species, the actual locations have been deleted from this article although they are present, together with map names and Section, Township and Range numbers in the copy present in the files of the Bureau of Land Management. By deleting the localities, *Desert Plants* is following the recommendation that the actual localities of endangered species not be revealed so as to discourage unlawful collecting of the plants by persons who might otherwise do so.

Introduction

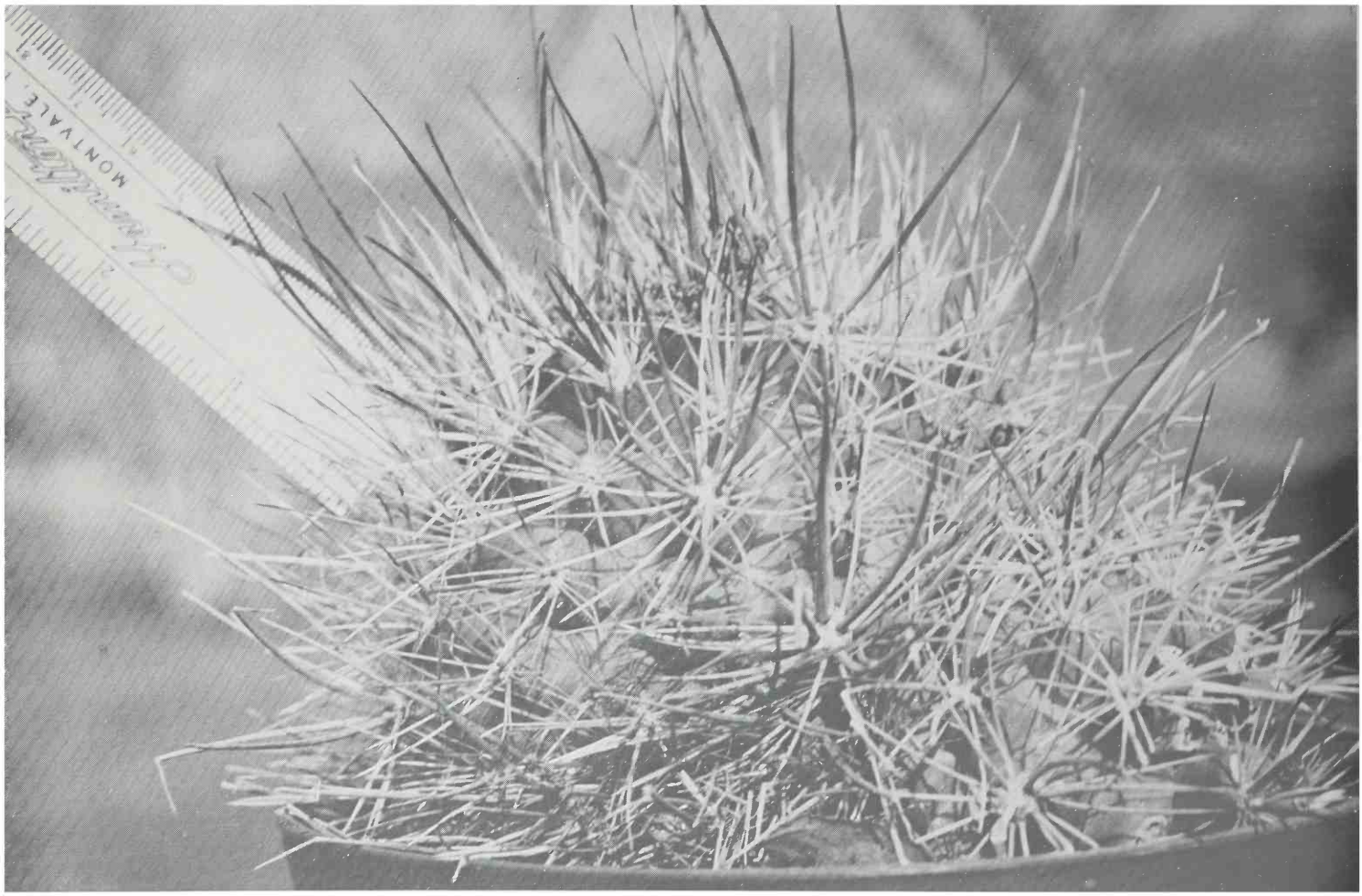
Pediocactus sileri came under observation by the Bureau of Land Management in keeping with its policy to study plant species listed as candidate endangered or threatened under the Endangered Species Act. Subsequently the status of the species was modified in the Federal Register to fully endangered. The Bureau of Land Management in Arizona initiated a program of literature, herbarium, and field searches and studies in 1976 to obtain information needed for management planning requisite to conservation and protection of endangered plants. Field study information was obtained concerning *Pediocactus sileri* during the period 1976 through 1979. This information is summarized and presented under several topics.

Studies during the four year period have shown that this cactus is considerably more common and less soil specific than previously supposed. Information obtained from the studies resulted in the conclusion that this cactus should be listed under the Bureau of Land Management classification "sensitive" and, as such, would be considered in the Bureau's management planning to provide needed conservation and protection.

Pediocactus sileri stems occur singly or in clusters. Clustering results from stem branching and multiple stems. Stems more than five inches in diameter have been found. Some stems are more than 10 inches long. The longest seen was approximately 18 inches. The longest stems are generally leaning or reclining. Central spines are generally less than 1¼ inches long. One specimen found near [location deleted] has spines more than 50 mm long.

Extent of Habitat, Population Estimates and Field Counts

The total area of habitat for this cactus is unknown. More than 400,000 acres of Moenkopi Formation surround the currently known natural habitat in Arizona. In addition, many thousand acres of Moenkopi Formation in northern Arizona may be



Pediocactus sileri. *Central spines are usually less than 30 mm. Spines on this specimen exceed 50 mm.*

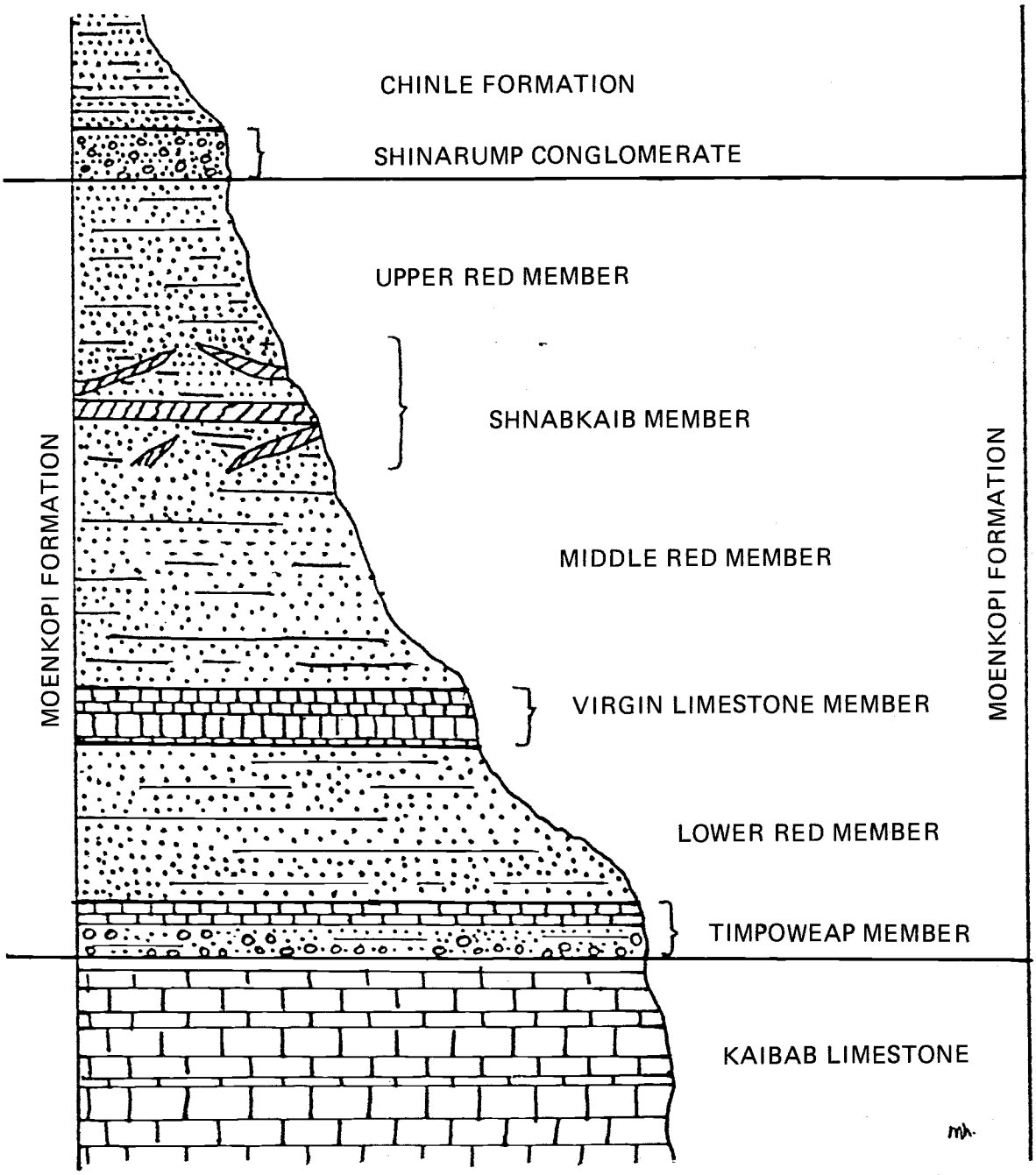


Diagram showing positions of the various members of the Moenkopi Formation and adjoining geologic strata in the study areas.

suitable habitat. The currently known natural habitat in Arizona is estimated at more than 50,000 acres as determined from field inspection and aerial photo studies. The currently known habitat in Utah is estimated at approximately 3,000 acres.

Realistic population estimates are difficult or impossible to obtain because of the extent of the habitat and the very high variability in density. In one high density area, 72 plants were counted from one spot. Conversely, many locations (at considerable distance from roads, stock water, etc., where man-induced factors have a minimum effect) were visited where many acres had to be inspected to find a few plants. The high variability in density (plants per unit area) of this cactus is similar to that of many other species of cactus.

Field counts of plant numbers of this species were made between November 27 and November 29 of 1979 on less than one percent of the currently known habitat. These counts were made at eight locations in Arizona. A total of 1,109 plants were counted in seven observer hours.

Altitude, Slope, Exposure, Geology and Soils

The known altitudinal range is approximately from 2,800 feet to 5,400 feet. The plant occurs on slopes from nearly level to very steep and has been found on exposures facing each of the four cardinal directions. This cactus may prefer northerly and easterly exposures at lower altitudes and southerly exposures at higher altitudes. This has not been studied.

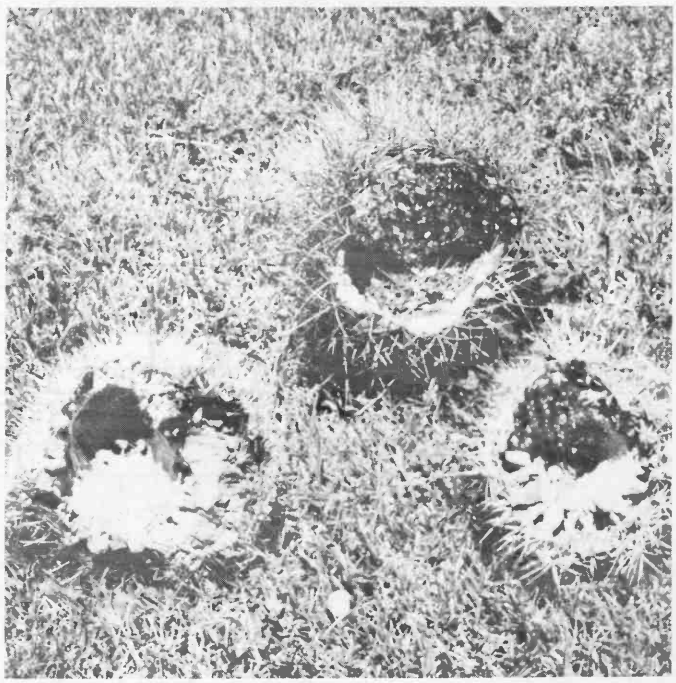
New stems produced by a plant of Pediocactus sileri *which had been partly eaten, probably by rabbits.*

Pediocactus sileri has been found on several geologic members of the Moenkopi Formation. Information on geology and soils obtained at eight study area locations is presented in a later section. No attempt was made to study all variations in geology and soils, nor to estimate the acreage of habitat applicable to a geologic entity or soil. The cactus occurs on red and gray (white) gypseous and/or calcareous soils and shales. Soil texture varies from very gravelly or shaly sandy loam through fine sandy loam to clay loam. In some areas the plants are growing on fractured shale with very little fine textured soil. Fine textured soil varies in depth from negligible to 22 or more inches. Soil pH, based upon studies made to date, ranges from 7.2 to 8.8.

Natural Enemies

Rabbits occasionally forage on *Pediocactus sileri*, consuming the apical portion of the stem, and may eat everything down to the ground line except the spine clusters. Some species of rodents seem to confine their foraging to the lower tubercles. A burrowing rodent approaches the plant from underground, eats the plant tissues, and leaves a "shell" of spine clusters. Insects are also injurious. One plant was found with a large white larva in a cavity in the cortical tissues. Number of plants damaged by insects and the degree of damage is not known.

A large number of dead plants seen may have died from disease. Accurate information concerning this factor is lacking. Geologic erosion is another factor. Many plants become established on steep, rapidly



Cactus "spine shells" may result from foraging by burrowing rodents. The two in the foreground are Pediocactus sileri. *The third shell is* Neolloydia johnsonii.

Pediocactus sileri *growing on red gypseous soil from the Lower Red member of the Moenkopi Formation.*

Pediocactus sileri *growing with a dense crust of lichens on gray (white) gypsum soil from the Shnabkaib member of the Moenkopi Formation.*

eroding slopes. Some reach maturity and apparently even old age. However, it is obvious that some succumb to erosion.

Associated Vegetation

Vegetation associated with *Pediocactus sileri* varies with changes in altitude, soil, exposure and other factors. Associated perennials noted at a few locations are listed in the section below. No attempt was made to record all variations occurring in the habitat, nor to estimate the acreage of habitat applicable to any of the associated vegetation types.

Characterization of Habitat

Area No. 1. Altitude approximately 5,400 feet. Geology transitional between the Upper Red member of the Moenkopi Formation and the Shnabkaib member. Soil moderately calcareous, pH 7.6, 0–12" deep, fine sandy loam. Vegetation consisting of *Pinus edulis, Juniperus osteosperma, Cowania mexicana, Yucca baccata, Y. angustissima, Chrysothamnus nauseosus, C. viscidiflorus, Ephedra* sp., *Artemisia bigelovii,* and *Hilaria jamesii.*

Area No. 2. Altitude approximately 5,200 feet. Geology identified as the Shnabkaib member of the Moenkopi Formation. Soil strongly calcareous, pH 8.2, 0–16" deep, fine sandy loam. Vegetation consisting of *Artemisia tridentata, Ephedra* sp., *Atriplex canescens, Gutierrezia sarothrae, Sporobolus* sp., *Oryzopsis hymenoides, Eriogonum corymbosum, Lepidium* sp., *Castilleja* sp., and a few scattered junipers *(Juniperus osteosperma).*

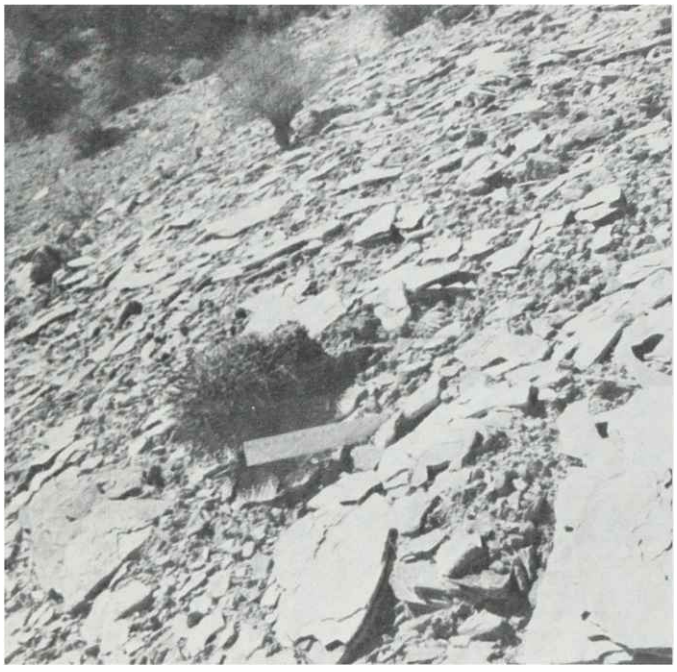
Area No. 3. Altitude approximately 3,200 feet. Geology identified as the Shnabkaib member of the Moenkopi Formation. Soil varying from a) strongly calcareous, pH 8.0, 0–2" deep, very gravelly fine sandy loam, to b) moderately calcareous, pH 8.0, 2–26" deep, fractured shale and gypsum. Vegetation consisting of *Eriogonum* spp., *Ephedra torreyana, Salvia dorrii, Prunus fasciculatus, Hymenoclea salsola, Atriplex confertifolia, Psorothamnus fremontii, Fallugia paradoxa, Cowania mexicana, Sphaeralcea* sp., *Lepidium fremontii, Physaria newberryi, Cryptantha* sp., *Castilleja* sp., *Hilaria jamesii,* and *Amsonia eastwoodiana.*

Area No. 4. Altitude approximately 2,800 feet. Geology identified as the Shnabkaib member of the Moenkopi Formation. Soil varying from a) strongly calcareous, pH 8.8, 0–4" deep, gravelly sandy loam, to b) strongly calcareous, pH 8.8, 4" deep and deeper, fractured shale and gypsum. Vegetation consisting of *Arctomecon humilis, Physaria newberryi, Hymenoclea salsola, Atriplex confertifolia, Ephedra torreyana, Lycium andersonii, Lepidium fremontii, Sphaeralcea* sp., *Eriogonum thompsonae* var. *albiflorum, Krameria parvifolia, Castilleja* sp., and *Delphinium* sp.

Area No. 5. Altitude approximately 4,600 feet. Geology identified as the Middle Red member of the Moenkopi Formation. Soil slightly calcareous, pH 7.8, 0–4" deep, silty clay loam. Vegetation consisting of *Eriogonum mortonianum, E. corymbosum, E. microthecum, E. thompsonae* var. *atwoodii, Artemisia bigelovii, Cowania mexicana, Ephedra* sp., *Chrysothamnus* sp., *Atriplex confertifolia, Salvia dorrii, Gutierrezia sarothrae, Hilaria jamesii, Oryzopsis hymenoides, Cryptantha semiglabra, Euphorbia fendleri, Stanleya* sp., *Sphaeralcea* sp., and *Thelesperma subnudum.*

Area No. 6. Altitude approximately 4,700 feet. Geology identified as the Virgin Limestone member of the Moenkopi Formation. Soil varying from a) moderately calcareous, pH 8.2, 0–3" deep, clay loam, to b) slightly calcareous, pH 8.0, 3" deep and deeper, weathered shale. Vegetation consisting of *Artemisia tridentata, A. nova, A. pygmaea, Eriogonum corymbosum, E. microthecum, E. shockleyi, Ephedra* sp., *Atriplex canescens, A. confertifolia, Chrysothamnus* sp., *Salvia dorrii, Gutierrezia sarothrae, Hilaria jamesii, Petradorea pumila, Cryptantha* sp., *Penstemon* sp., *Astragalus lancearius, Astragalus* sp., *Aster arenosa, Phlox* sp., *Castilleja* sp., and *Thelesperma subnudum.*

Area No. 7. Altitude approximately 4,700 feet. Geology identified as the Lower Red member of the Moenkopi Formation. Soil

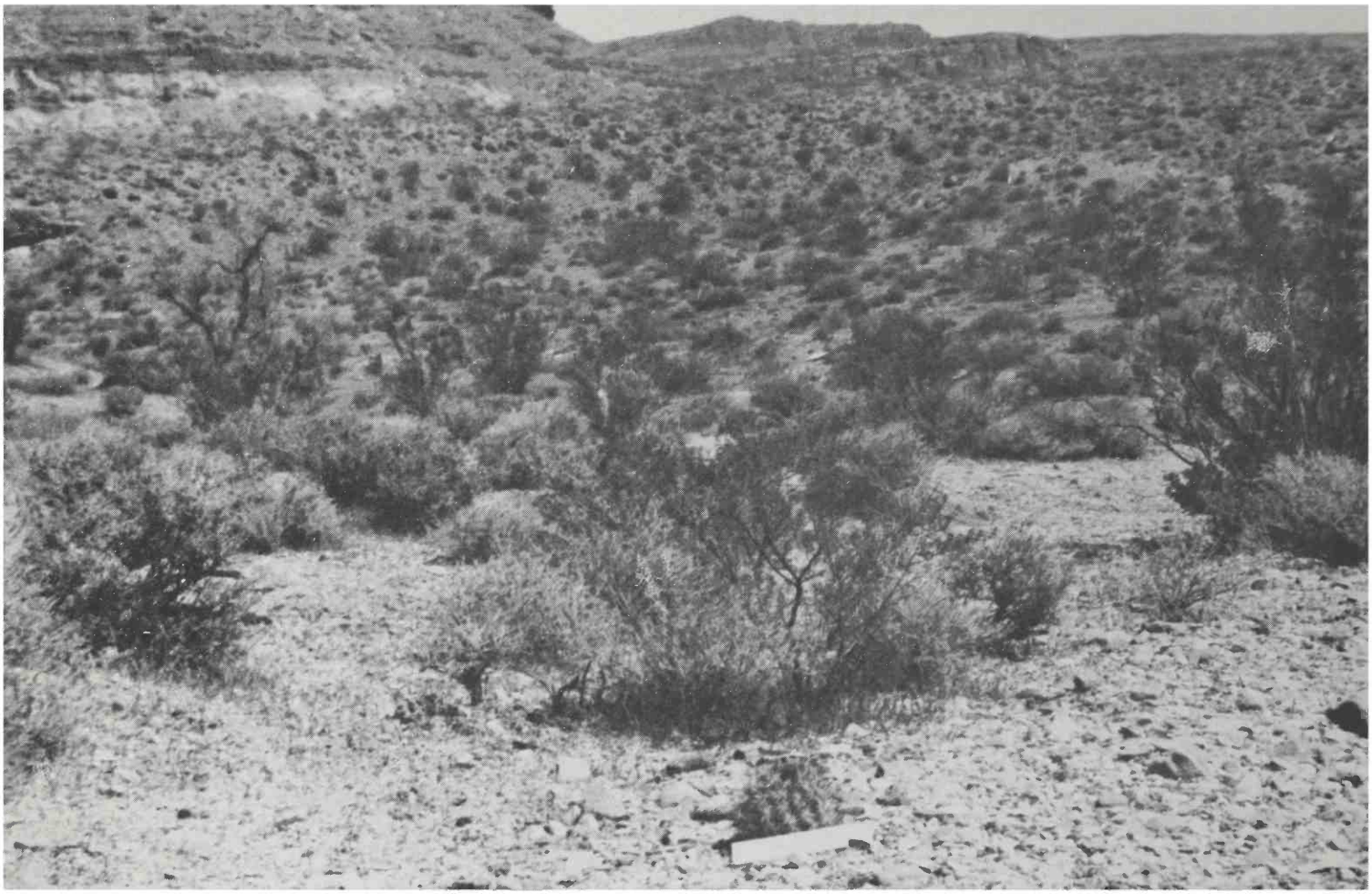


Rapid geologic erosion has resulted in loss of surface soil and has exposed the roots of some plants of Pediocactus sileri.

Pediocactus sileri *associated with* Arctomecon humilis.

Pediocactus sileri *growing on fractured shale of the Shnabkaib member of the Moenkopi Formation.*

Pediocactus sileri *associated with Pinyon* (Pinus edulis) *and Juniper* (Juniperus osteosperma). *Note the Shinarump Conglomerate ledges in the right background.*



Pediocactus sileri *associated with Creosotebush* (Larrea tridentata), *White Bursage* (Ambrosia dumosa), *Four-Wing Saltbush* (Atriplex confertifolia), Lycium andersonii, *and other species of low elevation desert.*

varying from a) strongly calcareous, pH 8.2, 0–7" deep, loam, to b) strongly calcareous, pH 8.2, 7–15" deep, sandy loam. Vegetation consisting of *Atriplex canescens, Ephedra* sp., *Lycium* sp., *Sporobolus* sp., *Chrysothamnus viscidiflorus, Lepidium* sp., *Eriogonum kearneyi, E. inflatum, Hilaria jamesii, Gutierrezia sarothrae, Sphaeralcea* sp., and *Opuntia* sp.

Area No. 8. Altitude approximately 4,400 feet. Geology identified as the Lower Red member of the Moenkopi Formation. Soil slightly calcareous, pH 8.2, 0–22" deep, fine sandy loam. Vegetation consisting of *Atriplex confertifolia, Ephedra* sp., *Gutierrezia sarothrae, Chrysothamnus nauseosus, Sporobolus airoides, Sporobolus* sp., *Hilaria jamesii, Lepidium* sp. and *Suaeda torreyana.*

Area No. 9. Altitude approximately 5,200 feet. Geology identified as the Shnabkaib member of the Moenkopi Formation. Soil strongly calcareous, pH 8.2, fine sandy loam. This appears to be a relatively poor quality site. Vigor of *Pediocactus sileri* is poor and few other plants inhabit the site. Vegetation consists of *Atriplex confertifolia, Sporobolus* sp., *Lepidium* sp., *Opuntia* sp., and *Ephedra* sp.

Area No. 10. Altitude approximately 5,200 feet. Geology identified as the Shnabkaib member of the Moenkopi Formation. Soil strongly calcareous, pH 8.4, loam. Vegetation consisting of *Artemisia tridentata, Gutierrezia sarothrae, Opuntia whipplei, Opuntia* sp., *Oryzopsis hymenoides, Chrysothamnus* sp., *Ephedra* sp., *Hilaria jamesii, Sitanion hystrix, Calochortus* sp., and *Delphinium* sp.

Area No. 11. Altitude approximately 2,900 feet. Soil is from Moenkopi Formation mixed with some alluvial outwash and colluvial material from sandstone, limestone and basalt. The soil is strongly calcareous, pH 7.2, gravelly loam. Vegetation consists of *Larrea tridentata, Ambrosia dumosa, Atriplex confertifolia, Lycium andersonii, Ephedra torreyana, Opuntia echinocarpa, Hilaria rigida, Yucca baccata, Eriogonum inflatum, Gutierrezia sarothrae, Echinocereus engelmannii, Sporobolus* sp., *Krameria parvifolia,* and *Ceratoides lanata.*

The ABCs of Landscaping with

Desert Plants

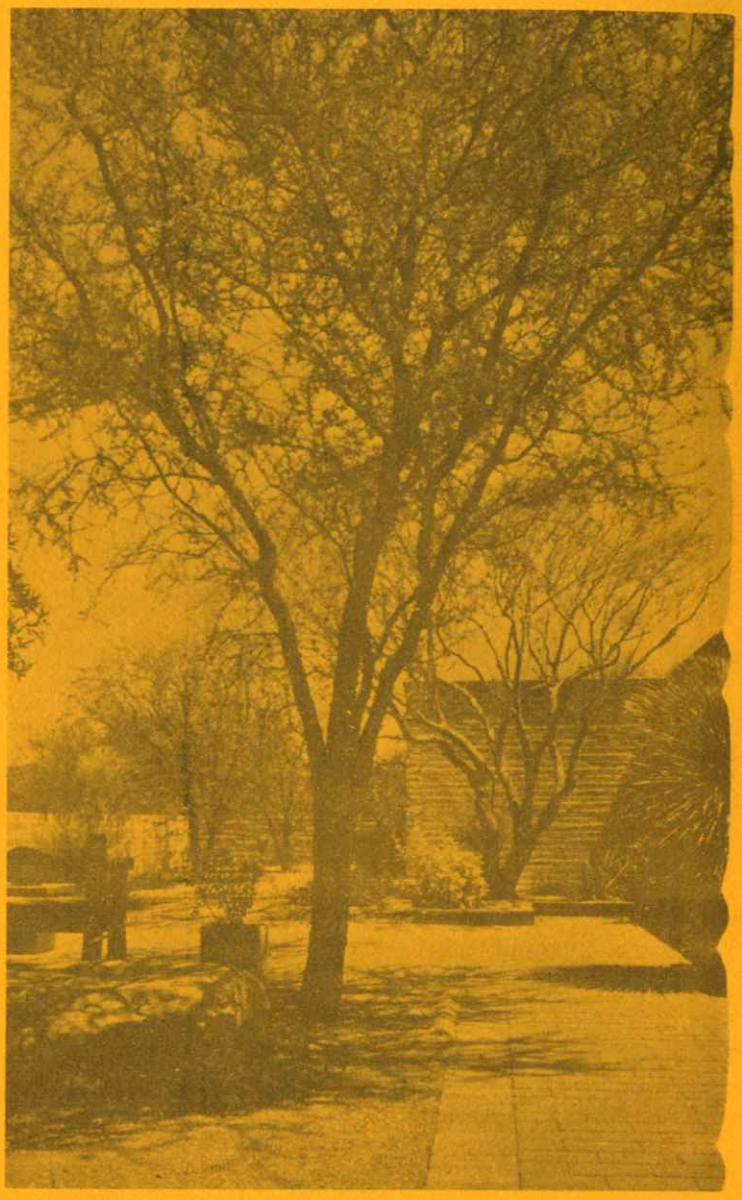


FIGURE 1. A DRY BUT INVITING ENTRY GARDEN USING ACACIA CAVENIA, A. SMALLII AND FOOTHILL PALO VERDE (CERCIDIUM MICROPHYLLUM).

As the population of southern Arizona grew from 334,000 in 1920 to 2,718,000 in 1980, a huge demand for landscaping plants developed. Newcomers who missed the dense vegetation of home looked for plants to buy in local nurseries. Not infrequently lush green plants were purchased which had been unloaded the previous day from large trucks bearing California license plates. As long as adequate water was available for irrigation many neighborhoods took on an oasis appearance.

In an attempt to identify desert plants with potential landscaping values, the Boyce Thompson Southwestern Arboretum, the University of Arizona, the Desert Botanical Garden and the Arizona-Sonora Desert Museum began experimenting with growing native wild desert plants as well as low-water-requirement species brought in from Mexico, Australia, South Africa or elsewhere. As successful introductions were displayed and became mature, they made excellent living demonstrations of the potential of drought-tolerant landscaping species.

These institutions have cooperated with the nursery industry in Arizona for a number of years by making seeds and cuttings of desert landscaping plants available to commercial producers of nursery plants. In order to popularize the use of desert plants and thereby reduce user demand on dwindling water resources, each of the cooperating institutions holds a special event in April scheduled for a different week-end at each institution.

During these events the nurserymen who had received seeds and cuttings bring some of the resulting plants to be sold to the public where their virtues can be explained by staff and volunteers of the cooperating institutions. Revenues from these sales help maintain the gardens of drought-resistant plants and help fund the educational programs dealing with use of desert plants.

Because of the success the institutions have had in making people aware of the merits of drought-resistant species, the journal Desert Plants called on Professor Warren D. Jones, a well-known authority on desert landscaping, to outline some of the fundamentals of landscaping with desert plants, some of the ABC's so to speak, in a special supplement. Professor Jones has entitled his summary "Making Desert Plants Work For You."

MAKING DESERT PLANTS WORK FOR YOU

By Warren D. Jones
School of Renewable Natural Resources
and Department of Plant Sciences
University of Arizona, Tucson

This year (1981) might be described as the year of the desert plant in southern Arizona, or the year when desert plants really came into their own. This spring, as in several years past, the Arizona-Sonora Desert Museum near Tucson, the Desert Botanical Garden in Phoenix, and the Boyce Thompson Southwestern Arboretum near Superior held annual plant sales featuring desert species. To say that the events were all successful is putting it mildly. During the two-day event at the Arboretum alone over 12,000 people were counted. Considering that the nearest metropolitan area (Phoenix) lies sixty miles to the west, this is particularly amazing. The plant sales at the other institutions were equally successful and collectively about 18,000 individual desert and drought-tolerant plants changed hands. These plants in their assortment of small pots, one gallon containers, five gallon containers, and larger were tucked away by their purchasers into an assortment of family cars, pickups, camper vehicles or what have you, to be happily driven off in all directions to new homes.

When you stop to think of it, that's a lot of plants of any type and presumably a large percentage are now being or will soon be planted in residential situations. Although the three 1981 events were the best attended to date, events in previous years have always been very popular as well.

Many of the plants popularized by these institutions are now beginning to be sold on a regular basis at retail nurseries in the desert cities. Some nurseries are now choosing to specialize in these plants and deserve much credit for getting across the low-water-demanding landscape concept to the general public. Wholesale growing of such plants has become an important business in Arizona as well. There can be no doubt that there is a wide acceptance of the practicalities of this type of landscape and there is a rising tide of desert plants going into urban and rural areas of the state.

Switching over to a desert landscape has become a badge of honor, or almost a cult or religion with many. With all this devotion to dry land plants, many a residential landscape, not to mention some public ones, have taken on a sort of "wild and wooly" look, often without much logic or planning. Perhaps now is the appropriate time to put down some guidelines, ABC's as it were, to assist a person in developing or switching to a water-conserving concept.

STEP A, DEVELOPING A CONCEPT.

The first step, "A" if you wish, should be to develop a concept, even a "wild and wooly" one if that is your personal preference. The crucial point is to consider fully what sort of garden feeling appeals to you and is appropriate to your situation, --and then to develop a plan of procedure.

Restoring the native cover, or at least the natural look (which may or may not be "wild and wooly"), to a site is certainly one valid approach. Achieving this, however, doesn't mean rushing out to a desert plant grower and buying one of every species to take home and plant. The desert itself is never haphazard or without organization, nor should your designed landscape be. Relating it to the constraints of the site and needs of the persons using it is first priority. Desert landscaping, or any other for that matter, responds to the characteristics and the demands put on the plants by the local site environment. The spacing of plants is sometimes almost geometric on the open desert and the association of species is strikingly modified in relation to topographic variations. Such variations relate to sun exposure, storm run-off, soil composition, or other factors which cause plant associations to be modified.

The arrangements of plants in natural communities spell out for the keen observer the presence of microclimates, differences in water run-off and absorption, soil depth, pH, and a host of other facts about the locality. By observing and responding to these factors in nature's organization, desert plantings instigated by man can become more successful and plausible. So often cacti and easy-to-transplant specimens such as Ocotillos and Agaves are overused in revegetating disturbed areas. These replanted strips often stick out like sore thumbs for years because of the imbalance of these plants to the normal mix of desert trees and shrubs in nature. Re-creating the natural desert look is not the easiest approach to the low-water-demanding landscape. It must be done with subtleness and real understanding to be successful.

The acceptance of this concept, the use of drought-tolerant plants for the designed and organized landscape, is the real breakthrough. The philosophy that successful desert landscape design is not merely creating a cactus garden, has come slowly. Certainly using cacti for accents and as objects of ornamentation is attractive and valid in many settings. But there are very few "building block" landscape categories (e.g. creating shade, shelter or privacy) which this group of plants can successfully fill.

This is not the appropriate point in the planning process, however, to be thinking

about specific landscape categories of plants, --rather it is the time to look at basic concepts and general planning steps. Just how a site is to be used and the functions which are to be accomodated there, must first be determined. Plant forms needed to articulate the design should not be dealt with until later.

The organized and designed garden could be developed to have a wild and natural look or a very trim in-town feeling, --all it takes is planning. Both could function the same while having radically different moods or visual qualities. Both could be done with desert plants and require less water than traditional approaches. A plan should be developed after settling on a concept. Much has been published on this subject and the basic steps to be taken are almost the same as in other climatic zones. First, the area to be landscaped should be plotted on tracing paper. Scales of one inch equal to four feet or one inch equal to eight feet are comfortable to work with, and tracing paper divided into these square modules is available at all drafting supply stores. Plot everything which exists on the site, --buildings, paving, fences, existing trees and shrubs that might be worth saving, good and bad views, prevailing winds, the north point and other relevant features.

Next, list the specific functions and needs which must be accomodated on the site. Most all sites separate into two basic divisions, 1) the public area which is readily available, and 2) the private area with a controlled access. The front area in public view has the basic function of creating a setting for the house or structure. Public access is present. An entry, entry court or terrace (outdoor vestibule) and perhaps some off-street parking may be developed here if desired. The non-public or private area is just what is indicated; this could include outdoor living space, service area or other specialized spaces like a play yard or special garden plot.

All these needs must be recognized and accomodated, no matter what the landscape philosophy is to be. Whether only desert plants are to be used or the wet green concept is adopted, the basic design approach is the same. All these space needs can be laid out on the scaled plot design. Actual square footage can be laid out just as would be done when designing a floor plan for a house. The basic difference is that you have more space to work with and the configuration of the various areas is generally freer and can be less geometric if desired. Circulation into and about the property also needs to be planned and plotted. In the final stage, these need to be drawn accurately on the plan so that the on-the-ground lay-out can be scaled directly from the drawing.

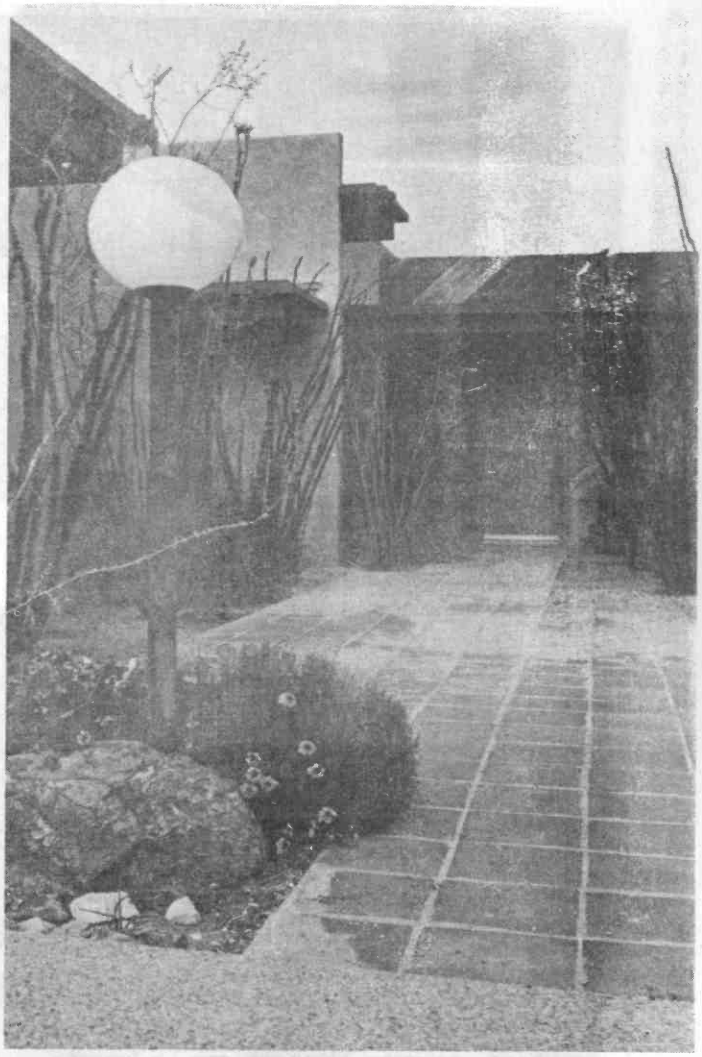


FIGURE 2. THE STRIKING FORM OF OCOTILLO MAKES IT AN EXCELLENT PLANT TO ACCENT AN ENTRY AREA.

Once the functional areas have been determined, it is time to look at just how these areas will be defined and created. Will walls and fences create the spaces of this design? Will shelters constructed of stone or lumber create shade? What will anchor the soil and what will be under foot, --paving, gravel or other ground cover? To what extent will plants be depended upon to partially or entirely articulate the design?

The main reason for suggesting that the plan be put on tracing paper is that extra blueline copies can then be made by a copying center at any time. You can then preserve the original in good condition and not have to use it out in the weather when things get under construction. So, at this point, the basic plan drawn on tracing paper should be duplicated three or four times in order to have plenty of study or work sheets. Transparent prints can also be made on which additional drawing can be done.

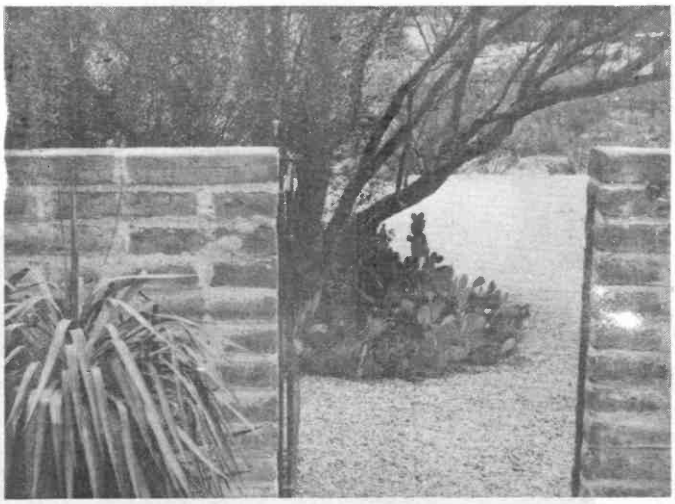


FIGURE 3. DESERT PLANTS MAKE NICE ACCENTS. YUCCA RECURVIFOLIA IS AT LEFT. A PRICKLY PEAR GROWS NEATLY UNDER A PALO VERDE.

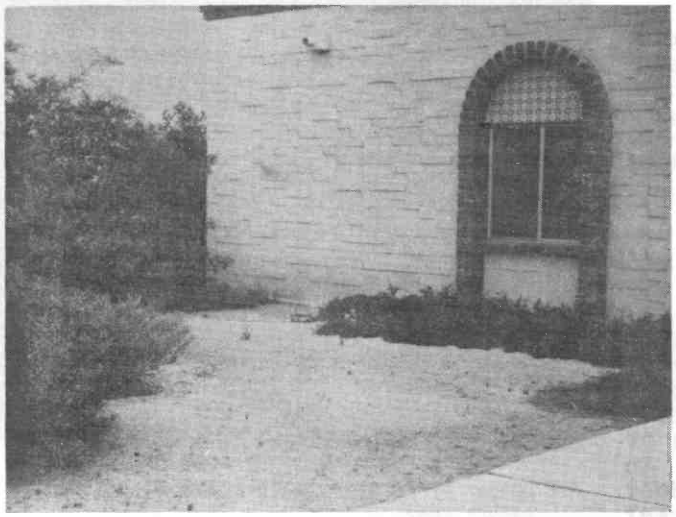


FIGURE 4. LOW PLANTS SUCH AS THIS COYOTE BUSH (BACCHARIS PILULARIS) ARE OFTEN THE BEST FOR FOUNDATION PLANTING.

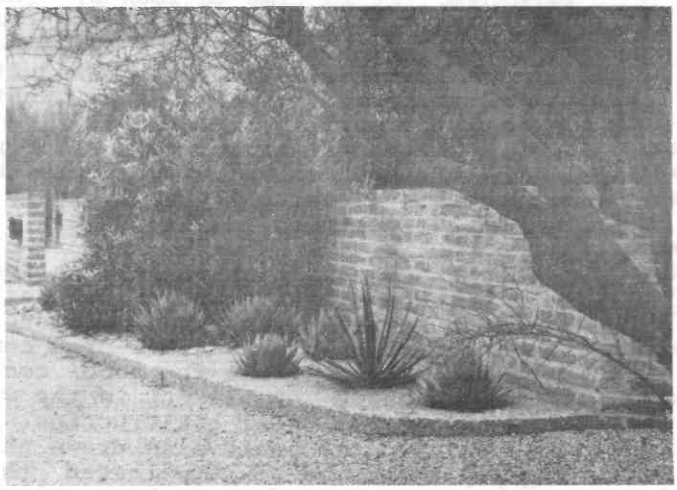


FIGURE 5. DESERT PLANTS CAN LEND A NEAT, TRIM LOOK TO BRICK WALLS, GATEWAYS OR DRIVEWAY AREAS.

This is the stage at which it is logical to start thinking about plants, --not species or varieties of plants yet, --but rather categories of plants to fill certain functional needs. These are the basic "building block" plants. To be effective, they generally have strong form and a dependably good appearance year around. Because of their high visibility, they should not be plants which have off-season tacky periods or are tender or easily damaged by adverse weather conditions. It is important to choose good all-season, all-weather performers for the basic building block categories. These plants must establish the framework, the "bones" of the design, as it were. The design needs or plant categories whould be noted right on one of the basic plan sheets at the point on the plan where it is needed. Some of the common plant categories used in design are listed below.

Screening Plants.
This category is of prime importance. The plants should be tall and dense evergreen shrubs, ones which could be counted on to grow to a height above eye level, and perhaps to do their job in a fairly narrow space.

Space Defining Plants.
These would not necessarily be as tall as the screening plants, although they could be. They are useful as small hedges or possess qualities that are desirable to outline areas, walks, beds or other spots.

Foundation Planting.
This is an often-mentioned category and an area of planting design that is generally overdone. The function of foundation planting is to relate the structure or residence to the site, not to busy it or float it away on a billow of bushes. Often foundation plantings consist of low mounding plants which can be placed along walls and under windows to make a pleasant transition from a building to its surroundings without creating problems by obstructing views and light or overwhelming the structure. Larger shrubs may be appropriate for corners or against blank walls. The size and scale of plants chosen depends on the vertical height and mass of the structure. One good rule to observe is to never totally obscure the way in which the building meets the ground. Planting can be designed off corners, with low horizontal planting under windows or at other areas, leaving enough of the base of the structure showing to indicate that it rests firmly on the ground. Many feel that good plants for this category are of a quieter character with more subtle foliage texture and color rather than plants with bold or bizarre form or with extremely bright foliage or bloom. In other words, don't compete with architecture, but complement it.

Accent Plants.
These are another story indeed. Just as the name of this category implies, these

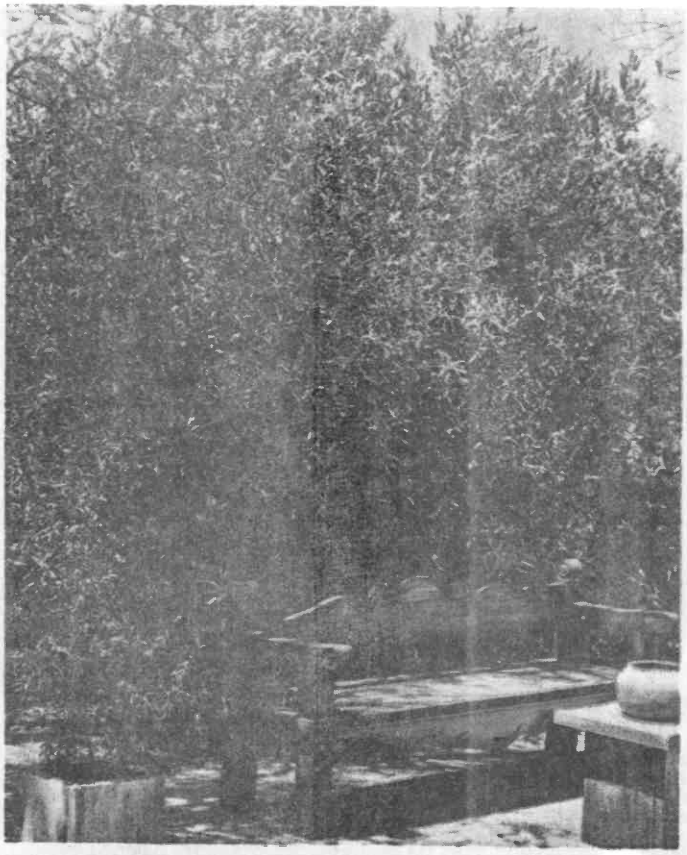


FIGURE 6. ARIZONA ROSEWOOD (VAUQUELINIA CALIFORNICA) IS A GOOD BACKGROUND PLANT THAT CAN BE USED FOR SCREENING.

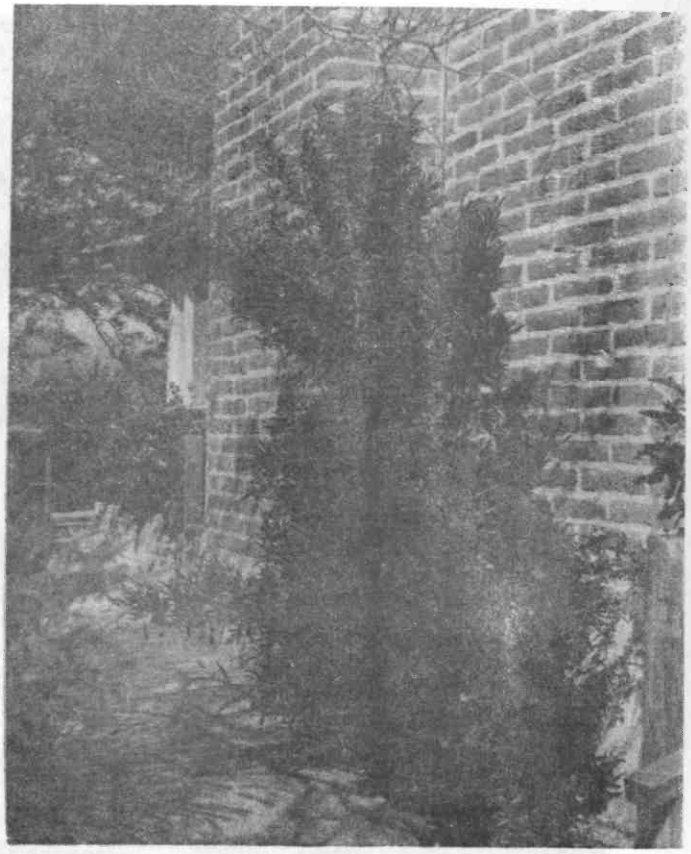


FIGURE 7. DESERT HOP BUSH IS A FINE EVERGREEN SHRUB FOR VERTICAL ACCENT OR FOR A HEDGE IN A NARROW PLACE.

are plants used to draw attention to themselves and their location. While in a sense they could be classed as foundation planting when used to create a striking composition of bold plant form at an entrance, they are used in other ways as well. Such other uses might be to punctuate a path intersection, a gateway or any other landscape focal point needing to be identified or given importance. Bright colorful flowers, fruit and foliage do the same thing, that is, they draw attention and therefore serve as an accent. The length of time the plant maintains this color is the key to its value as an accent plant.

There are very few plants that are colorful for nine months or more. These are classed in the subcategory color plants. They are best incorporated into a planting design to function as a seasonal color display. They should be located where it's not crucial to the design when they are out of color. Locations where they can be viewed and enjoyed when they are showy, but where they will not leave a gaping hole when not in color, are best.

Creating Shade and Shelter.

Plants to create shade and shelter for the areas needing to be cooled, warmed or protected (depending on the season), are of prime importance in desert climates. This is a category where plants serve perhaps the most important function, providing the canopy or roof over outdoor spaces where shade is desirable. This can be achieved in several ways using trees or by using vines grown over a constructed shade structure. Where space permits, trees can make the greatest contribution to modifying the desert environment. They absorb much less heat from the atmosphere and they transpire a great amount of moisture through their leaves to lower the air temperature.

You should analyze the shade requirements on your plan. You should decide if particular shade plants are to be evergreen or deciduous. The advantages of winter sun for outdoor comfort in the garden as well as the house (passive solar heat) have often been noted. Although deciduous trees provide shade in summer and let sun through in winter, they are not necessarily a must for winter sun. This is because the lower angle of the winter sun can allow a patio or terrace to have shade in summer and sun in winter while still using evergreens. If the location of the shade planting is calculated to permit the lower rays of the sun in winter to angle in beneath the canopy, the evergreen tree will work just fine. A solid green canopy

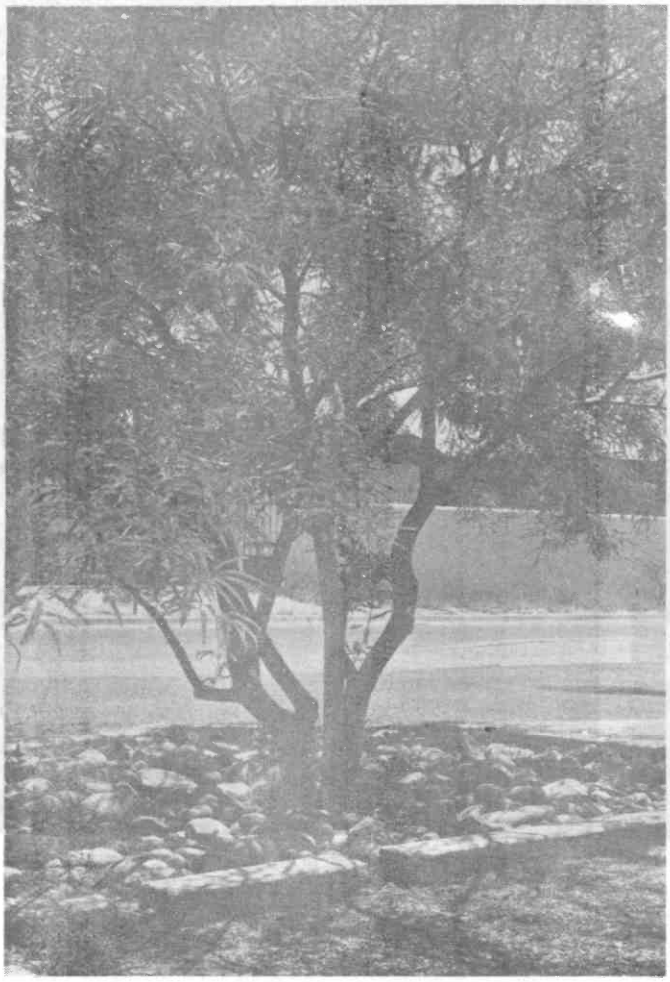


FIGURE 8. SPECIES OF MESQUITE (PROSOPIS) FROM SOUTH AMERICA HAVE EXCELLENT GROWTH CHARACTERISTICS AND GOOD FORM.

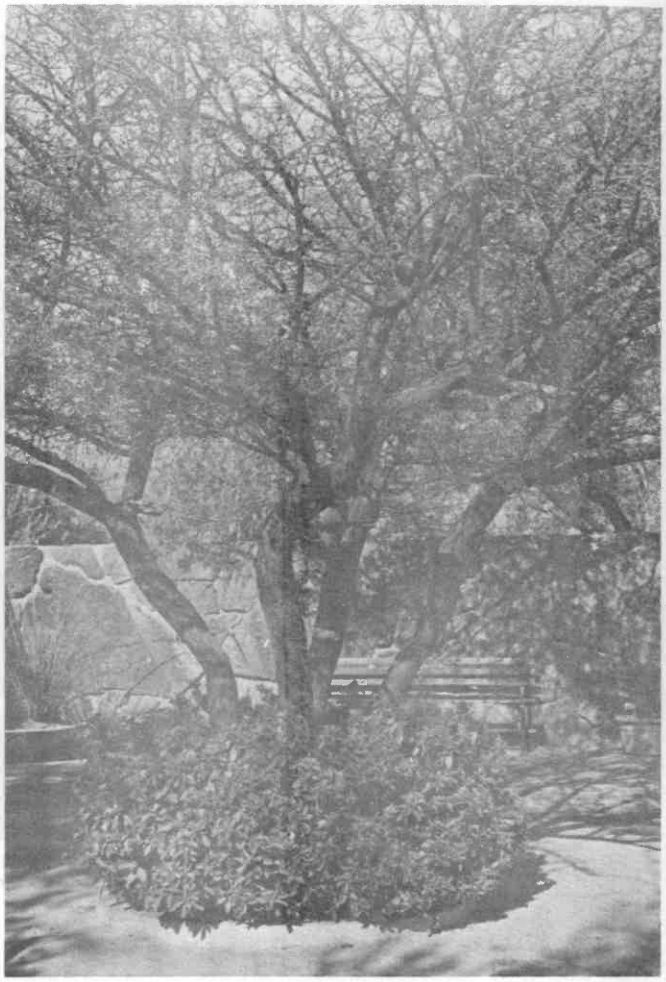


FIGURE 9. SWEET ACACIA IS OFTEN USED TO ADVANTAGE AS A DROUGHT-RESISTANT SMALL PATIO TREE.

overhead has another winter advantage, it traps the warmth longer in the sheltered space, slowing down the loss of winter warmth to the open sky. Microclimates can also be created under these evergreens for smaller plants with borderline winter hardiness because the solid evergreen canopy holds the daytime warmth into the night. Therefore, type of shade needed, deciduous or evergreen, should be noted right on the study plan where needed.

Shade trees, of course, come in all different sizes and shapes and the amount of area to be shaded affects the choice. For instance, the decision might be that just a spot of shade is desirable, requiring only a small tree forming a living umbrella. Or, the site might require an area to be shaded by a tall overstory tree. Whatever the need, trees are generally broken down into the following groups.

1. Small Trees. Species in this group stay under twenty feet tall and generally have a spread of only ten to fifteen feet. Most plants in this category can be used either as large shrubs or small trees, it being a matter of training and pruning as to how they develop. Larger trees are occasionally planted to function in this category because they develop more quickly and are then pruned down to keep them to the patio tree size when they mature. When such larger growing species are used, they must be ones that take regular pruning.

2. Medium Trees. These are most in demand for general shade canopy needs. They are a comfortable size for residential situations, being twenty to thirty feet tall, and may have an equal spread. Unfortunately, it has been a common practice to use trees which ultimately get too large for these situations, resulting in crowding and over-shading in many old residential neighborhoods.

3. Large Trees. These are trees over thirty feet in height. They are useful for overstory shading in large spaces. However this is a category of trees that is nearly non-existent when low water demanding species only are considered. There is a

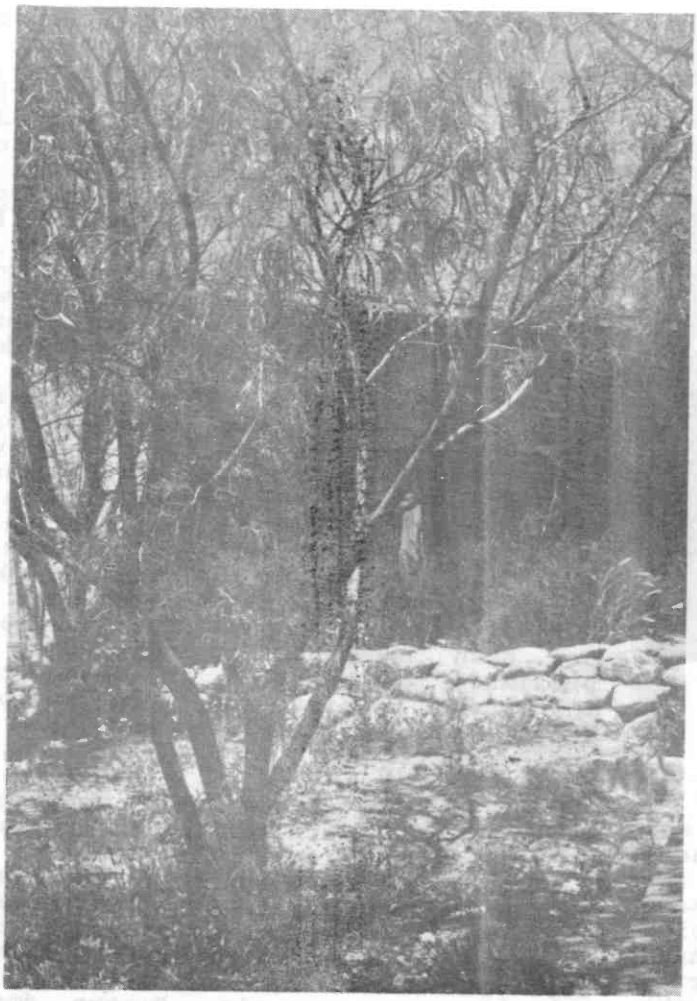


FIGURE 10. DESERT WILLOW IS A GOOD SMALL TO MEDIUM SIZED DECIDUOUS TREE FOR THE DESERT GARDEN.

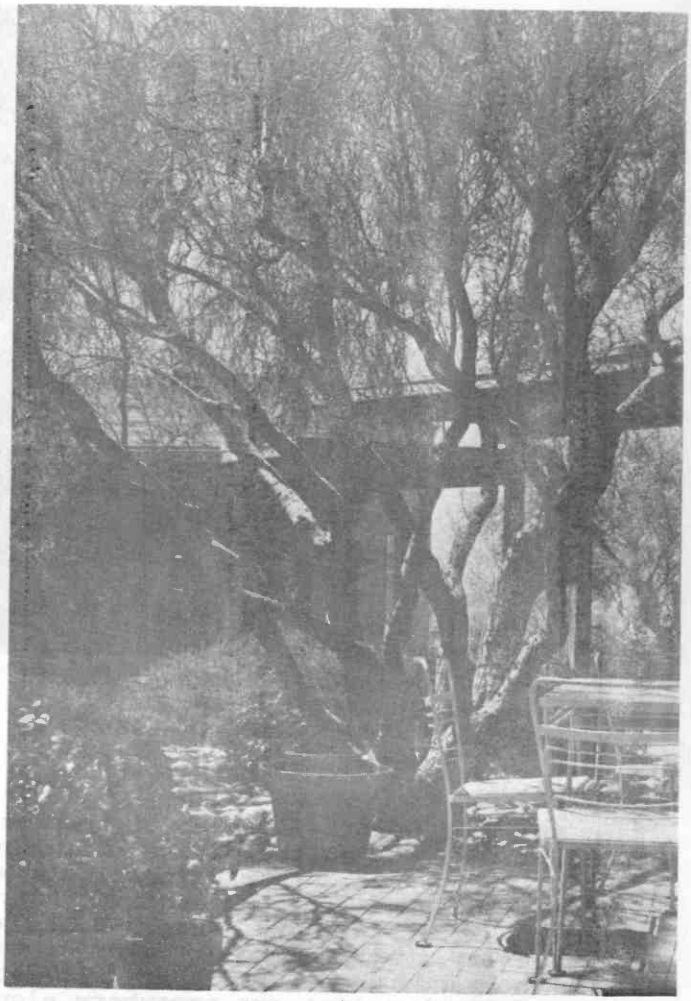


FIGURE 11. FOOTHILL PALO VERDE AND TRAILING ROSEMARY COMBINE TO MAKE THIS A COOL INVITING NOOK FOR BREAKFAST.

fairly good list, though, if you are willing to set up a watering program of widely spaced but deep irrigations.

Ground Covers.

This is the last basic "building block" category which is to be indicated wherever needed on the study plan. Obviously this category provides the floor covering, the ground holder for the spaces being designed. Ground covers naturally divide into two subcategories, walk-on and non-walk-on.

1. Walk-On Ground Covers. These are carpet plants that can tolerate foot traffic to varying degrees. They are usually tight matting plants with a fine textured foliage. All walk-on type plants need fairly regular watering.

2. Non-Walk-On Ground Covers. These can be anything from low trailing plants six inches or more high to great sprawling vines and shrubs used to hold banks and to cover large rough areas. The choice of plants is determined by the scale of the space to be covered. A large embankment might best be covered by a spreading vine or shrub that gets six feet deep while the small cut or full slope might best be stabilized by a low mounding plant that only spreads laterally thirty inches and perhaps achieves a depth of but nine inches.

So much for the basic landscape categories of plants. Once the specific plant category needs are noted on the study plan it is time to move from Step A to Step B. This step must be taken before going on to selecting the plants for the landscape.

STEP B. DETERMINING WATER USE.

Perhaps the most important step in the development of the drought-tolerant landscape is addressing the issue of irrigation and just how much supplemental irrigation you can or are willing to supply. This is a step you should take and a commitment that ought to be made before plants are selected. Yes, desert plants get along on low rainfall in their native habitat and it is only natural for persons to question why it is necessary to worry about water commitments.

FIGURE 12. A "MINI OASIS" CAN BE MADE TO PRODUCE A MAXIMUM COOLING EFFECT WITH A MINIMUM OF HIGH WATER USING PLANTS.

But that beautiful shrub or tree you see prospering out on the desert with no help from anyone but Mother Nature isn't an indication that it could achieve that same success just anywhere. What you are seeing is really a miraculous survivor of perhaps a thousand seedlings that all started hopefully but lost out somewhere along the way. The lucky survivor made it to maturity because it happened to germinate in just the right location where a little extra moisture accumulates when it rains, where a pocket of soil exists that could store that moisture, and where the plant didn't have to compete with any established plants of the same species.

There are many other factors besides water that could have helped that particular plant out there on the desert to succeed. It may have germinated in that special season when the rains came just right. It may have benefitted from several years when the seasons weren't excessively hot or cold. Perhaps there was a scattering of several years when cycles in rodent and insect populations were fluctuating down instead of up. You can be sure that the successful plant survivors had a combination of some of these breaks.

A look at the desert reveals that the spacing of large and small plants is in predictable combinations of species, combined in almost geometric patterns. These combinations and spacing are set by available moisture, topographics, soil type, microclimate and other factors.

When you select one of these beautiful desert dwellers to be your patio tree or if you plant a row of them to help screen out your neighbors, you are forcing the plants into a condition that may not have the necessary ingredients for survival. Therefore, more water may be needed or other factors relating to particular growing conditions might have to be altered to assure that a particular plant will survive in the man-planned landscape. These might include soil type, sun exposure, temperature range tolerances, and so forth. Your site may not have all of these ingredients and any that is missing should, if possible, be added to assure that the plants will survive and prosper. For example, both Arizona Rosewood and Hop Bush make fine hedges in close-together planting, but you would never find them growing that close in nature. Mesquites are often little more than large bushes in the average open desert site. The beautiful mesquite bosques and groves of the Sonoran Desert occur only where there is deep soil with a good moisture supply. The Rosewood and Hop Bush seem not to mind the close proximity in a hedge or the mesquite being pushed up into tree form as long as extra water is supplied and good soil depth exists.

The question of how much supplemental irrigation you are willing to supply has other ramifications. This implies going back to your basic concept, the type of garden you best relate to. The three basics: shade, shelter and privacy, can be achieved on a low water budget, but perhaps you crave to have one area that really represents an oasis. Desert dwellers universally seem to share a special attraction or longing for that cool damp place where there is enough mositure to produce some very luxuriant green vegetation. This may be a small and concentrated spot, but it satisfies a very basic need; the cool green contrast to the harsh aspects of the desert environment. If such a spot (a mini oasis) is in the back of your head, it should be dealt with at this stage of planning. Obviously, it affects irrigation commitments as well as the final plant choices.

Mini oases are best located at the spot in the landscape where the majority of persons living on a site or using it get maximum benefit from it. Such lush areas might be in an inner court, adjoining a terrace or patio or surrounding a swimming pool. They need not be large. Well watered plants are special in both texture and color, and they contribute cooling to the surroundings.

The demonstration garden at the Arizona Sonora Desert Museum has such a spot. At its center the shade seems cooler because the plants beneath the trees are more lush. There are no non-Sonoran Desert plants used at the ASDM demonstration garden, either. Strangely enough, there are many lush oasis-like plants inhabit-

ing most all deserts, and the Sonoran Desert is no exception. These are plants that in nature have the capacity to burst into lush and exuberant growth when there has been abundant rain and then completely retrench into dormancy when the moisture is gone, and stay there until the next time there is good moisture. Many of these plants can present the same good appearance year around if adequate moisture is supplied on a regular basis. So, even if you are an absolute purist, restricting the plants you use to Sonoran Desert natives only, such an oasis effect can be achieved.

These seasonally lush desert natives have an added advantage over exotic plants from wetter climates; an ability to go dormant without dying out as the non-desert exotics would, bounding back rapidly when moisture is once again supplied. This special value makes a good reason for using them. This is true of course of most all the other low-water-demanding landscape plants and makes a good reason for using them as well.

It has already been stated that supplemental moisture must be supplied even to a landscape design which uses desert plants exclusively in order to achieve satisfactory development and growth. Many desert plants will grow amazingly fast when watered freely. The trees in particular have this capacity because most of them in the wild are found bordering desert washes. Here, they must take advantage of a sudden abundance of water after a downpour which may last but a short time. This feast or famine situation has developed plants that can take advantage of seasonal moisture by quickly going into a growth cycle and then hardening off to endure the water famine that is sure to follow. The majority of these species are survivors from a warmer and wetter age, and will gladly accept regular irrigation. For example, Mesquites and Palo Verdes thrive in lawns, showing no difficulty in accepting this bountiful moisture.

This points up the need and desirability for regular irrigation to develop a planting more quickly. Later it can be used to maintain the health and attractiveness of the planting. After a few seasons and when some sort of mature growth has finally been reached, a tapering-off of supplemental watering can be instigated. This hardening-off of the plants requires a careful watchful program of gradually lengthening the interval between each irrigation until a point is reached where the appearance of the plants tells you that this is the amount of water needed to keep the planting healthy and in attractive foliage, blooming in season, but slowing in general growth. The idea is to find the watering pattern which will generally maintain a good all-year appearance.

Supplying supplemental moisture to drought-tolerant landscape plantings presents the same variety of irrigation options that may be used with other types of plantings. Many people establish low water demanding plantings without irrigation systems or any equipment other than some scattered 3/4-inch diameter water outlets and a fifty foot piece of hose. However, a planned irrigation system is definitely worth the cost, if for no other reason than to apply only the right amount of water where it is needed without wasting any in the process.

FIGURE 13. JOJOBA (SIMMONDSIA CHINENSIS) WILL FILL OUT NICELY AFTER CLIPPING TO MAKE AN ATTRACTIVE HEDGE.

Drip irrigation has been a successful form to use on desert plants. Its low cost and ease of installation, especially over rough terrain, has made it attractive to designers and home gardeners. Putting the right amount of water where it is needed without wetting large areas of soil surfaces is not only a water saver but cuts down drastically on weed growth.

The main problem is that each drip emitter wets a tear drop shaped area in the soil and leaves an area of accumulated salts at the outer edge of the wet zone. This has the effect of keeping the roots locked in a container. The cure for the problem is to periodically leave the system on three or four times longer than normal to leach the salts down and away from the roots. This can be done several times a season. The other complaint about drip irrigation is that it is hard to know if an emitter is plugged or malfunctions until a plant is showing real distress. Inspection is difficult, especially after the planting matures.

Weed growth and particularly Bermuda Grass invasion can be a major problem in

FIGURE 14. DESERT DWELLERS DERIVE A PSYCHOLOGICAL BENEFIT FROM VEGETATION. MICROHABITATS ALLOW EXPERIMENTATION.

desert type landscaping. Because of the often prickly nature and wild character of many of the plants, and the use of rock mulches, it is particularly hard to get in and weed or use weed control sprays. This weed problem is probably one of the main reasons that overhead sprinkling is not a popular way to apply water to a low-water-demanding landscape. Certainly, the plants accept moisture gladly any way they can get it, but so will the weeds.

Bermuda Grass is generally considered a high water user but it is one of the major problems, even in a low irrigation planting. This grass may need a lot of water to make a good lawn, but it can also wait in a dormant clump in your desert landscape planting for the next time there is good soil moisture, when it will take a sudden growth spurt and spread further into your planting. Many other weeds also get along just fine on this widely spaced irrigation program. Tumbleweed and Milkweed are two very good examples. However, Rainbird-type irrigation may be the most practical method of water application, especially in revegetation of large disturbed pieces of land, weeds or not.

Bubblers and regular lawn sprinkler heads are often used in an area devoted to a mini oasis type of planting. Here the total area must be moistened with each irrigation because of the stratification of plants from ground covers and understory planting to canopy plants. Low-precipitation heads are good to use when using sprinklers if you plan to let them run for a long time at each watering. They are particularly good to assure deep penetration and little erosion. Bubbler heads work well on large trees and shrubs. They do require that water basins or channels be graded into the topography to receive the water and distribute it evenly. Bubblers are sometimes used just for the trees on the landscaping plan, while the rest of the plant material is irrigated by drip emitters or spray heads.

The basins and trenches needed for water distribution often are conspicuous in a landscape design that is short on leafy ground covers and low plantings. This may be unsightly to many and for this reason this type of irrigation may not be favored. Basins and irrigation channels are difficult to build and complicated to maintain on slopes and steep banks. This often results in elaborate terracing being developed that has nothing to do with the visual goals of the project. These basins and trenches must be maintained in perpetuity, resulting in a problem as shrubs mature and it becomes impossible to see if the water is reaching its destination.

Storm run-off from roofs and paved surfaces usually goes to waste. Most of it is channeled off the property as rapidly as possible and given no chance to soak into the soil and benefit the plantings. This is an important supplemental water source and the best quality water to be had anywhere. It should be salvaged. By collecting this storm run-off and directing it through the planted areas, a surprising percentage of the water needed for a low-irrigation type landscape can be realized. This is accomplished by contouring the site or grading the flow line to meander through as much of the planting as possible, spreading out and ponding under large trees, finally to be channeled off the property should there be a surplus. This round-about surface drainage does a great job of putting deep moisture into the soil.

Curbs about trees in parking areas can be slotted to let water in and tree wells in paved terraces can be depressed to trap water from the surrounding paving. Very often trees like Mesquites and Palo Verdes can receive their total water needs this way without any supplemental irrigation after the first year or so.

With your site all plotted, the basic landscape plan crystallized, and the water commitment and irrigation technique decided, you are ready for Step C, -- the selection of plants. This is the step that is the most fun for many desert plant devotees and also the point where you can "lose the ballgame" as it were, and make some bad landscape mistakes.

STEP C. SELECTING THE PLANTS.

The best way to proceed is to go back to your study sheets and place the plant categories on top of the irrigation study. Choosing plants to fulfill a certain need or category in the landscape scheme is just part of it. The amount of water to be supplied in various areas of the site will affect the selection of plants within the category. For example, a tree to shade a dryer area might best be something like a Mexican Palo Verde (Parkinsonia aculeata) or an Ironwood (Olneya tesota), while the choice for a mini oasis could be Net-Leaf Hackberry (Celtis reticulata) or a clump of Sonoran Palmetto (Sabal uresana). There is not space here to make a complete list of landscape categories, but these samples will give some guidance. Most growers can help you determine just which of the desert type plants that they carry are more drought resistant than others, which are hardy, whether they are evergreen or deciduous, and other special qualities or needs each plant may have. Below is a partial list to get you started.

Trees are the first category of plants to choose for a planting plan. Because of their size, they dominate the scene. All of the other plants should relate well to them and must accept modified conditions created by the trees.

Large Trees above 30 feet in height are in a category in short supply among true desert natives. Tamarix aphylla, the Athel Tree, is the most drought-resistant. Generally it is kept to a smaller size because of its brittleness. Aggressive roots and messy foliage drop make it less than desirable except for background planting (way back) and for windbreaks. Eucalyptus as a clan have a number of large species that are quite drought-resistant, but almost all need widely separated but regular watering. Eucalyptus camaldulensis is the tallest. Eucalyptus viminalis is another large tree possibility. Pinus halepensis, the Aleppo Pine, and Pinus brutia eldarica (locally referred to as the Mondell Pine), are other large trees that get along on widely spaced irrigations.

Medium Trees (20"-30") include a few more true desert species. The Mesquites, especially the South American ones Prosopis alba and P. chilensis, are canopy trees par excellence. They produce very comfortable shade to have around a home and are the most nearly evergreen of the Mesquite species. The Blue Palo Verde (Cercidium floridum) and the Mexican Palo Verde (Parkinsonia aculeata) are more desert types, but can be used to provide shade and make lush spots too. They don't mind plenty of water even though they are quite drought resistant.

Silver-Dollar Eucalyptus (E. polyanthemos) and Tiny-Capsule Eucalyptus (E. microtheca) are two medium-sized trees that make good evergreen shade with a little supplemental irrigation. They are well behaved in a close-in residential situation which is not the case with many other types of Eucalyptus. Desert Willow (Chilopsis linearis), really not a willow at all, although resembling one, is a desert tree that can get to the medium tree size in favored spots. It is a good deciduous tree.

FIGURE 15. PARKINSONIA ACULEATA, TRULY A DESERT TREE, MAKES ADEQUATE SHADE FOR LUSH PLANTS OF THIS "MINI OASIS."

Small Trees are more abundant in the desert than larger ones. With most examples it's just a case of how much water is available and what sort of pruning and training they receive whether they stay a shrub or become a tree. Aside from occurring as a medium tree, Desert Willow may remain small and fit into the small tree group. Sweet Acacia (A. farnesiana) and its hardier counterpart Acacia smallii are good examples of the patio-sized tree. They are easy to train and produce an abundance of fragrant little yellow puffball blossoms. Others are more apt to be shrubs, but can be trimmed up into very fine small trees; Arizona Rosewood (Vauquelinia californica), Texas Olive (Cordia boissieri) and Mescal Bean (Sophora secundiflora) are large broadleaf evergreen shrubs. They can be trained into patio sized trees and all are quite drought resistant.

Screening Plants are an important category needed to achieve privacy, create protection from wind, control dust and such.

FIGURE 16. DECOMPOSED GRANITE (CALLED "D.G.") MAKES A GOOD WALK-ON GROUND COVER IN PLACE OF A LAWN. EUCALYPTUS MICROTHECA, GAZANIA AND HESPERALOE PARVIFLORA COMPLETE THIS LOW WATER USING GARDEN.

Two of the above candidates for patio trees, Vauquelinia and Sophora, also can be excellent screening plants. They fill out well and keep foliage all the way to the ground. Dense evergreen shrubs from the desert are not abundant but Hop Bush (Dodonaea viscosa) though somewhat tender, can be trimmed into a fine narrow hedge. It is attractive in its natural environment. The evergreen Sumacs, Rhus choriophylla and Rhus ovata, are also good screening plants but better for wider spaces.

Space Definers need to be strong of form as has been mentioned earlier. Jojoba (Simmondsia chinensis) and Texas Ranger (Leucophyllum frutescens) are two excellent gray-green desert shrubs for lower hedging and, of course, the Texas Ranger has beautiful pink flowers. For low outlining and trimming, Lavender Cotton (Santolina chamaecyparissus) and Dwarf Rosemary (Rosmarinus officinalis prostratus) can make excellent drought-resistant low hedges.

Foundation Plant lists would include the above plants too as they are broad, spreading and moundy when not trimmed. Dwarf Coyote Bush (Baccharis pilularis), Humming Bird Flower (Zauschneria latifolia) and Mexican Honeysuckle (Justicia spicigera) are all good low plants for foundation planting also. The last two have attractive bloom in season.

Ground Cover lists are short for desert gardeners. There are no true walk-on types, Common Bermuda Grass (Cynodon dactylon) and Lippia (Phyla nodiflora) come the closest to the category. They will survive on very low irrigation, but they probably won't look like much. Many people have gone to decomposed granite, D. G. as it is called. This crunchy material is pleasant to walk on and comes in some nice natural colors. Tans and rust colors are the most popular. Trees and other plants can be watered through it and it drains well after rains.

Higher ground covers can be achieved on the desert with some supplemental irrigation. The old standby Creeping Rosemary (Rosmarinus officinalis prostratus) is still one of the best ground covers we have. Some other promising ones are Trailing Indigo Bush (Dalea greggii), Lavender Curls (Santolina chamaecyparissus) and Australian Saltbush (Atriplex semibaccata), all good choices.

Notes on the Flora of Arizona VI

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Although the flora of Arizona is well known and documented, new plants are continually being reported for the state or our knowledge of ranges extended. The new discoveries may represent overlooked species, plants previously misidentified, newly introduced weeds, or commonly cultivated species which have become established and are now a part of the native flora. The following species fall into one or more of these categories.

Polypodiaceae

Notholaena incana Presl. was collected on a south facing wall of rocky canyon to Hardshell Mine, south of Harshaw, Santa Cruz County by Dave West, August 1979 (*ARIZ 217541*). [*ARIZ serial numbers in this article refer to herbarium specimens deposited in the Herbarium of the University of Arizona at Tucson.*]

This fern is rare in Arizona and was not included as a part of the flora by Morton in Arizona Flora (Kearney and Peebles, 1951) even though a specimen in the Herbarium of the Royal Botanic Gardens, Kew, England is marked "*Santa Rita, Arizona, March 1881, Lemmon.*" Rolla Tryon likewise questioned the Lemmon specimen and excluded Arizona as part of the distribution of the species in his monograph of the genus (Tryon, 1956). Alan Zimmerman (personal communication) has reported the presence of specimens in the herbarium at Western New Mexico University which were collected in New Mexico in Guadalupe Canyon, a canyon which extends across the southeastern corner of Arizona.

Gramineae

Eragrostis superba Peys. is an African grass which was introduced about 1944 by the Soil Conservation Service in range seeding tests. It has become established in southern Arizona with specimens in the herbarium from Davidson Canyon, Cochise County (*Martin, October 1958*) and several collections from Pima County. These latter include specimens from Interstate 10, 25 miles northwest of Tucson (*Barr 67–164*); 13.7 miles north of Sonoita along Highway 83 (*Van Devender, August 1976*); 8 miles south of Mountain View on Highway 83 (*McLaughlin 55*); west of Santa Rita Experiment Station boundary along the Greaterville-Continental Road [*J. & C. Reeder 6968*].

Leguminosae

Phaseolus supinus Wiggins and Rollins was first collected by Kearney and Peebles between Nogales and Ruby in Santa Cruz County. This specimen was questionably identified as *P. leiospermus* Torr. and Gray and was so reported by them in *Arizona Flora* (Kearney and Peebles, 1951). It has been recollected (*Buhrows 144, 147*) from Hank and Yank ruins, Sycamore Canyon, Atascosa Mountains, Santa Cruz County (*ARIZ 126688, 216828*). Buhrows has determined the plant to be a perennial with fusiform roots, while *P. leiospermus* is described as an annual. This not only is a new species for Arizona but also for the United States. *Phaseolus supina* previously was known only from the type locality between Colorado and Mazatan in Sonora, Mexico.

Leucaena leucocephala (Lam) de Wit. is a widely dispersed tropical shrub or tree which has become established along the east side of the Colorado River, 100 yards below Laguna Dam. Specimens collected by Bill Rinne on May 10, 1978 are deposited in the University of Arizona Herbarium *(ARIZ 210279, 210285, 210293).*

Loasaceae

Mentzelia lindheimeri Uline & Gray is a species new to Arizona. Three collections in the herbarium *(ARIZ 32425, 206199, 206217)* were either misidentified or undetermined. Dr. Henry Thompson supplied the identification and kindly suggested that we add the citation to this note. All collections were made by L. N. Goodding in Cochise County. A collection in September 1909 *(LNG 448)* and one in September 1961 *(LNG 326–61)* came from the Mule Mountains. The third collection, also September 1961 *(LNG 191–61)* was made on the Fort Huachuca Military Reservation.

Mentzelia oligosperma Sims is a new species for Arizona. It was collected in Middle Canyon, Whetstone Mountains, Cochise County *(Van Devender and Martin, September 1976, specimen ARIZ 201575).* The determination was confirmed by Dr. Henry Thompson.

Lythraceae

Ammannia auriculata Willd., tentatively included in the flora of Arizona by Kearney and Peebles (1951), can now be considered as a definite member of the flora. A collection from Hooker's Cienega, southwest of Bonita, Graham County was made by Jenkins and Yatskievych, *number 79–760 (ARIZ 217626).*

Several specimens in the herbarium fit the description of *Ammannia robusta* as given by Graham (1979). This is a new species record for Arizona although it falls within Graham's distribution pattern.

Araliaceae

Hedera helix L. and *H. colchica* Kod. have both been introduced into Ramsey Canyon, Huachuca Mountains, Cochise County and represent new state records. These were apparently planted as ornamentals around the Mile-Hi Guest Ranch and around the Bledsoe home. They have now escaped cultivation and have become established in the canyon. Both species have been collected by George Yatskievych, *numbers 79809 and 79–811 (ARIZ 217769, 217768).*

Apocynaceae

Vinca major L., a commonly cultivated species, has become naturalized as an escape in Ramsey Canyon, Huachuca Mountains. It is well established and apparently spreading in the lower canyon area above the Mile-Hi Guest Ranch. A collection by Yatskievych, *number 79–805* is deposited in the herbarium *(ARIZ 217767).*

Convolvulaceae

Ipomaea Xleucantha Jacq. is an introduced weed infesting a cotton field 70 miles east of Blythe, California. It was collected by Stan Heathman *(October 4, 1979, specimen ARIZ 217292).* The identification was confirmed by Daniel Austin. A specimen collected by J. J. Thornber in 1930 from the Santa Cruz Valley and identified as *Ipomaea triloba* L. in *Arizona Flora* (Kearney and Peebles, 1951) has been tentatively referred to *I. Xleucantha.* The earlier population does not seem to have persisted and possibly this new infestation will not become established.

Polemoniaceae

Ipomopsis frutescens (Rydb.) V. Grant [= *Gilia frutescens* Rydb.] has never been added to the flora of Arizona although a specimen was collected northeast of the Gap, Coconino County *(Haskell and Deaver, 4734)* in August of 1954. This species has come to our attention recently by two new collections. Bundy and Coombs *(no. 2900, specimen ARIZ 216760)* collected it on the Paria Plateau, Pinnacle Valley, T39N, R5E, Sect 4 in Coconino County. Gierisch *(no. 4687, specimen ARIZ 221796)* collected it in Potter Canyon, T40N, R5W, Sect 9 in Mohave County. Both of these add to the confirmation of this species in Arizona.

Solanaceae

Physalis ixocarpa Brot. was brought to the herbarium for identification by Stanley Heathman. It was collected August 16, 1979 on Willow Springs Ranch, Black Mountain, Mohave County. Although it is a native of Mexico and a common weed of central and southern California, this is the first record for Arizona *(ARIZ 216565, 216595, 216617).*

Scrophulariaceae

Lindernia anagallidea (Michx.) Penn. *(ARIZ 217190),* collected from Hooker Cienega, south of Bonita, Cochise County *(Yatskievych et al. 70–683)* represents a new species record for Arizona and the first definite record of the genus in Arizona. *Lindernia dubia* was previously reported by Pennell from the Santa Cruz River in Sonora. Correll and Correll (1972) questionably listed Arizona as part of its range.

Compositae

Xanthisma texana DC, a species primarily from Texas and Oklahoma, has been collected in Lower Garden Canyon, Huachuca Mountains, Fort Huachuca Military Installation, Cochise County *(Yatskievych 78–592, specimen ARIZ 212943).* This new locality represents a considerable range extension and may have resulted from a recent introduction through the movement of military personnel.

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Bizarre Seed Patterns in Plants of the Indian Arid Zone

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Abstract

A comparative study of seeds of 46 plant species which abound in cultivated fields of the Indian arid zone has been made. A variety of new seed patterns discovered, some bizarre, are described. Seeds were categorized on the basis of their weights into five groups. The seeds of *Polycarpaea corymbosa* were found to be lightest of the species studied. Most frequently the seed weight varied among species of the same genus and among different genera of the same family. Similarly great variations in seed size were met. In general, lighter seeds were small in size and heavier ones large. The seed surfaces varied from smooth and glossy to ornamented and rough. The seeds of *Farsetia hamiltonii* possessed wings which increased their surface area. The color of the seeds in most cases was brownish-yellow to dark brown. Only few seeds were black. Description and illustration of the diversity will perhaps hasten an understanding of the developmental sequences and adaptive values (under arid conditions) of the bizarre seed patterns.

Introduction

Characteristics of seeds, more than any other characters which plants possess, require precise integration and coordination between different functions for successful reproduction to occur, especially in arid zones. Moreover, the adaptive values of seed size and shape, seed output (i.e. number), as well as food storage in the seed, may conflict with each other to such an extent that reproductive efficiency in a particular habitat may represent a compromise among the conflicting demands. Seed shape involves a compromise among the forms most efficient for packing, dispersal, landing and seedling establishment. Seed size represents a compromise with seed number.

Among the most significant factors by which natural selection can guide the direction of evolution in higher plants are those concerned with seed size as it affects the vigour and establishment of seedlings in new locations (Stebbins, 1976). Larger seeds produce more vigorous seedlings during the early stages of growth, with optimal competitive ability (Black, 1959). Bhat (1973) found that in two varieties of *Indigofera glandulosa* the emergence force is closely correlated with the seed weight. A greater emergence force by virtue of a heavier seed weight would be an asset to a variety distributed mainly in arable fields (where seeds become buried due to cultivation practices) in comparison with other varieties distributed for example in grassy fields.

According to Heintze (1927) families with small scobiform (having the appearance of saw-dust) seeds are primitive. Takhtajan (1959) considered larger seeds as basic and smaller size advantageous as an adaptation to save building material. Janzen (1969) interpreted the smaller seed size of species vulnerable to predation or destruction as a greater subdivision of the reproductive effort, the dispersal of a greater number of seeds resulting in a greater probability of some escaping destruction. Corner (1954) distinguished the families of tropical and woody plants into two categories on the basis of seed size, 1) megaspermous, and 2) microspermous.

All of the large-seeded angiosperms are tropical or subtropical. *Lodoicea maldivica* produces the largest known seeds. In this species two enormous and equal seeds are

united in one dispersal unit of 45 cm in length. The smallest known seeds are produced by orchids, saprophytes (e.g. *Monotropa*), or total parasites (e.g. *Orobanche* or *Rafflesia*). Seed weight varies among species over a range of ten orders of magnitude, with the extremes represented by the orchid *Goodyera repens* (0.000002 g) and the double coconut palm *Lodoicea maldivica* (1,800–27,000 g) according to Harper et al. (1970).

Although variations in seed shape are classically interpreted almost wholly as adaptations, some features of shape may be imposed on a seed by the conditions within the ovary in which it develops. A study of the interaction of size, number and shape of cacoa seed suggests that the ovary does indeed sometimes restrict the space in which the seeds develop and influences the shapes which they attain (Glendenning, 1963). Much of the great variety in seed shape is obviously related to dispersal. The potential for diversity and modification of shape is greatly increased by the incorporation of extra-ovular (i.e. non-seed) structures in the dispersal units. The testa of the seed itself may exhibit diversity, for example having outgrowths like plumes or being expanded to form wings.

Seed shape relative to predation has been reviewed by Harper et al. (1970). The role of structural adaptation in seeds to minimize predation was studied by Pulliam and Brand (1975). These authors found that seeds with a smooth outline were difficult for ants to carry. Seeds with conspicuous awns, hairs or projections, and which usually required husking by sparrows, were easily carried by them.

Seed colors are generally adaptive with regard to the visual orientation of seed predators. This is well illustrated by mourning doves differentiating between grey (toxic) and cryptic (palatable) seeds from the same plant of dove weed, *Eremocarpus setigerus* (Cook et al., 1971). The color of the seeds in *Anagallis arvensis* (Pandey, 1965) is known to maintain viability of these seeds for 50 to 60 years. This may be due to the seed coat acting as a sunlight filter, keeping the enclosed embryo exposed to the effects of far-red light.

Materials and Methods

Seeds for the present study were collected from the cultivated fields of the arid zone of India. They were cleaned and stored in polyethylene containers. Weights of 100 seeds of each kind were taken on a single pan electric balance, in triplicate. Size of the seeds was measured by using a pre-calibrated microscope (X = 100,50). In cases where the seeds were large, measurements were made with the aid of scale calipers. Size of each of 10 seeds was determined and an average calculated. Standard deviations for seed weight and size were then calculated. The shapes and colors of small seeds were determined using the microscope and of large seeds by the naked eye. Finer details of the seeds such as the presence of hairs, projections or depressions were observed with the microscope.

Results

The observations of seed weight, size, shape and color are presented in Table 1. On the basis of weight, seeds were categorized into five groups. 1) seeds less than 8 mg per hundred, 2) seeds 8–80 mg per hundred, 3) seeds 80–250 mg per hundred, 4) seeds 250–500 mg per hundred, and 5) seeds over 500 mg per hundred. Species composition of each of these groups is indicated below.

Group 1. Weight of 100 seeds less than 8 mg. This group includes the seeds of *Anticharis linearis (Fig. 1.1), Oldenlandia aspera* (Fig. 1.2), *Polycarpaea corymbosa* (Fig. 1.3), *Eragrostis ciliaris* (Fig. 1.4), and *E. tremula* (Fig. 1.5). The seeds of *Anticharis linearis* have a slightly hairy membranous outgrowth. Although these seeds appear to be yellow, some white striations are present on them. Seeds of *Polycarpaea corymbosa* were found to be the lightest in weight of all plants investigated in the present study.

Group 2. Weight of 100 seeds between 8 and 80 mg. This group includes the seeds of *Chloris virgata* (Fig. 2.1), *Tragus biflorus* (Fig. 2.2), *Dactyloctenium aegyptium* (Fig. 2.3), *Digitaria adscendens* (Fig. 2.4), *Cyperus rotundus* (Fig. 2.5), *Pulicaria crispa* (Fig. 2.6), *Vernonia cinerea* (Fig. 2.7), *Corchorus depressus* (Fig. 2.8), *C. aestuans* (Fig. 2.9), *C. tridens* (Fig. 2.10), *Gisekia pharnaceoides* (Fig. 2.11), *Amaranthus hybridis* (Fig. 2.12), *Heliotropium marifolium* (Fig. 2.13) and *H. subulatum* (Fig. 2.14).

Small hairs are present at the apical end of the seeds of *Pulicaria crispa* and *Vernonia cinerea*. The surface of *V. cinerea* seeds is also covered by hairs, some of which are bifurcated. Seeds of *Corchorus depressus* are round on one side and pointed on the other (Fig. 2.8). In *C. tridens* ridges are present on the seeds. In *Gisekia pharnaceoides*, some projections are present (Fig. 2.11) which swell in water. Hairs appear on these projections only when the seeds are kept in water. Seeds of *Heliotropium marifolium* are densely hairy on the dorsal side (Fig. 2.13) but those of *H. subulatum* have no such hairs (Fig. 2.14).

Group 3. Weight of 100 seeds between 80 and 250 mg. This group includes the seeds of *Indigofera cordifolia* (Fig. 3.1), *I. linifolia* (Fig. 3.2), *I. oblongifolia* (Fig. 3.3), *I. hochstetteri* (Fig. 3.4), *Celosia argentea* (Fig. 3.5), *Cleome viscosa* (Fig. 3.6), *Withania somnifera* (Fig. 3.7), *Farsetia hamiltonii* (Fig. 3.8), *Convolvulus microphyllus* (Fig. 3.9), *Aristida adscensionis* (Fig. 3.10), *Cenchrus setigerus* (Fig. 3.11), *C. prieurii* (Fig. 3.12), *C. biflorus* (Fig. 3.13) and *Alysicarpus vaginalis* (Fig. 4.1).

Cleome viscosa seeds are transversely striated and have a wavy outline (Fig. 3.6). Seeds of *Farsetia hamiltonii* are covered by white transparent papery wings which appear to double their size (Fig. 3.8).

Group 4. Weight of 100 seeds between 250 and 500 mg. This group includes the seeds of *Alysicarpus monilifer* (Fig. 4.2)., *Borreria articularis* (Fig. 4.3), *Digera muriculata* (Fig. 4.4), *Oligochaeta ramosa* (Fig. 4.5), *Crotalaria medicaginea* (Fig. 4.6), and *C. burhia* (Fig. 4.7).

Seeds of *Borreria articularis* are ellipsoidal in outline. One end is round and the other truncate. A deep groove is present on the ventral side but the dorsal side is smooth. Seeds of *Digera muricata* are covered by the persistent perianth.

Group 5. Weight of 100 seeds more than 500 mg. This group includes the seeds of *Cucumis callosus* (Figs. 5.1, 5.2), *Phaseolus trilobus* (Fig. 5.3), *Sesbania bispinosa (Fig. 5.4), Melothria maderaspatana* (Fig. 5.5), *Trichodesma sedgwickianum* (Fig. 5.6) and *Tribulus terrestris* (Fig. 5.7).

Seeds of *Cucumis callosus* showed two forms, A and B (Figs. 5.1, 5.2), similar in shape and color but differing in size. Seeds of *Melothria maderaspatana* are conical at one end and round at the other. Slight projections are present on the seeds (Fig. 5.5). Seeds of *Trichodesma sedgwickianum* are smooth dorsally but rugose on the inner or ventral side (Fig. 5.6). The cocci of *Tribulus terrestris* possess two long and two short spines. A few hairs are also present on the dorsal side (Fig. 5.7).

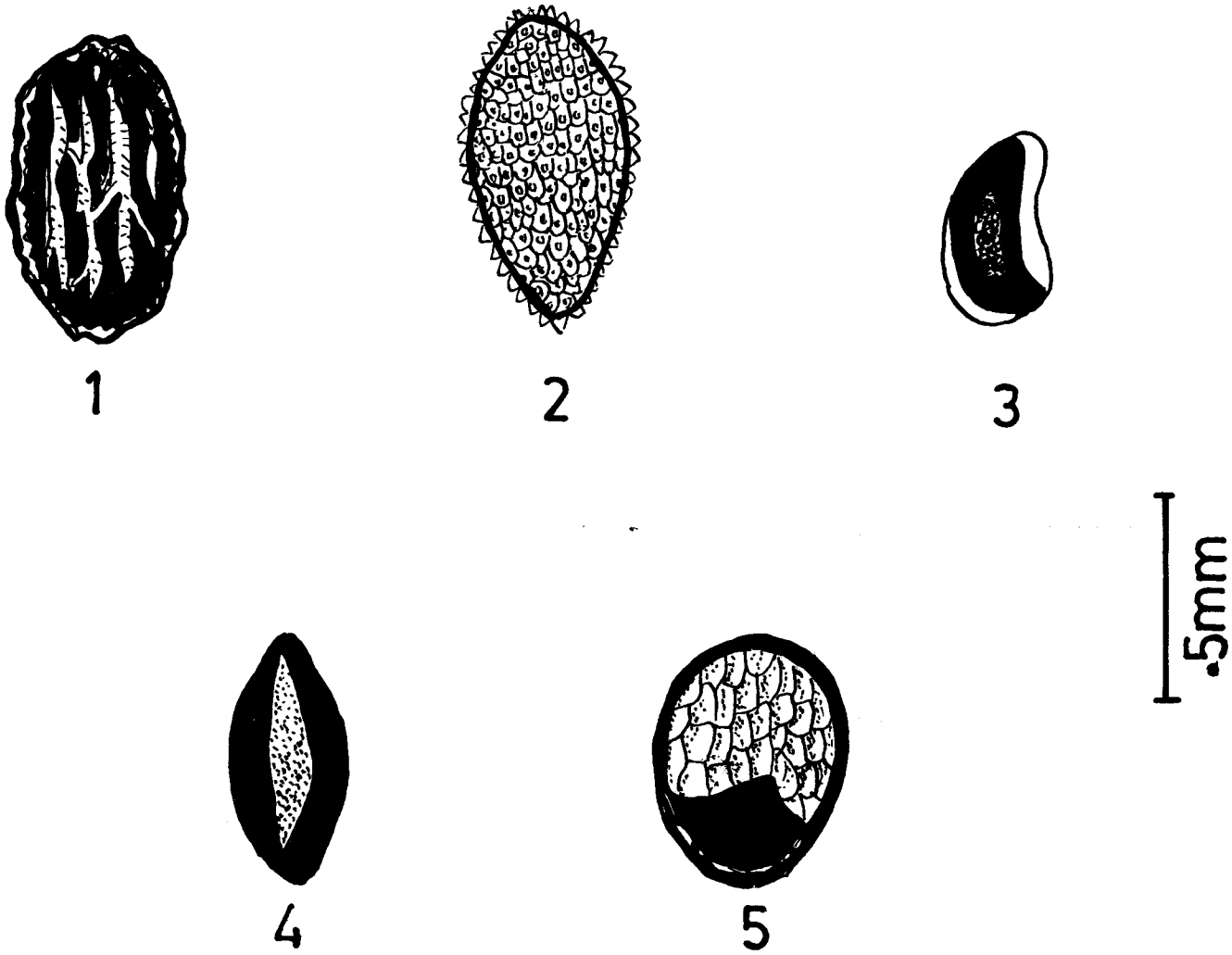


Figure 1. Details of seeds of **Anticharis linearis** *(1),* **Oldenlandia aspera** *(2),* **Polycarpaea corymbosa** *(3),* **Eragrostis ciliaris** *(4), and* **E. tremula** *(5), as seen with a microscope using low power.*

Discussion

Despite the economic importance of seeds, only a very little information is available on seeds of desert plants, including those of India, with regard to comparative external morphological characters such as shape, size, peculiarities of surface, color, as well as the ecological importance of these. This has made the identification of isolated seeds more difficult than need be. Not only do these characteristics vary between species, but to a great extent, variations (particularly of size) also occur within a given species. A comparison of these characteristics in a group of related species having different ecological requirements should provide useful information on the adaptive basis of their differentiation. In Plantago, the external morphology of seeds is quite variable and has been used for species identification by Misra (1964). The presence of hairs in *Heliotropium marifolium* and their absence in *H. subulatum* helps to identify the two types of seeds.

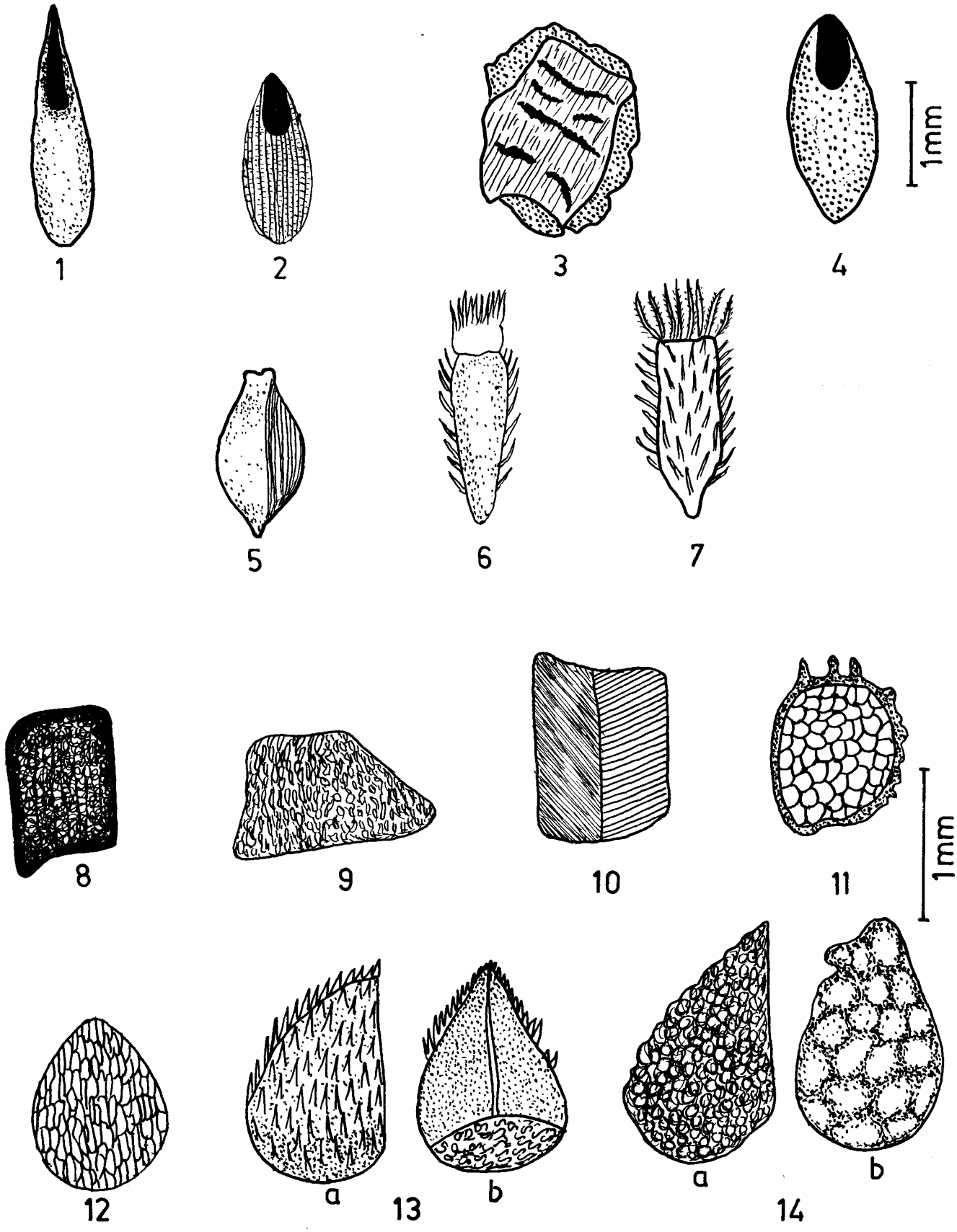
In the present study of seeds of the Indian desert it was found that the seeds of *Anticharis linearis, Eragrostis ciliaris, E. tremula, Oldenlandia aspera,* and *Polycarpaea corymbosa* are particularly light and those of *Melothria maderaspatana, Phaseolus trilobus, Sesbania bispinosa, Tribulus terrestris,* and *Trichodesma sedgwickianum* are particularly heavy in weight. Between species of the same genus, the seed weight may be constant, e.g. in *Heliotropium marifolium* and *H. subulatum* the weight is 63.33 and 65.33 mg/100 seeds respectively on the average. In other species pairs, there is great variation in weight, e.g. in *Corchorus aestuans* and *C. depressus* the weights are 69.00 and 20.00 mg/100 seeds respectively, and 7.50 and 2.83 mg/100 seeds respectively for *Eragrostis tremula* and *E. ciliaris.*

Within a given family a great variation in seed weight could often be singled out. For example, weights of 100 seeds of two members of the family Leguminosae, *Indigofera cordifolia* and *Sesbania bispinosa,* were 81.33 and 992.00 mg respectively. Similarly, in the family Boraginaceae, weights of 100 seeds of *Heliotropium marifolium* and *Trichodesma sedgwickianum* were 63.33

Table 1. Average weight, size, shape and color of seeds.

Plant species	Weight (mg/100 seeds)	Size (mm) Length	Breadth	Shape	Color
Alysicarpus monilifer	279.00± 5.4	2.04± 0.1	1.63± 0.1	Cylindrical	Light brown or yellow
A. vaginalis	244.67± 3.1	2.05± 0.1	1.47± 0.1	Cylindrical	Light brown or yellow
Amaranthus hybridis	36.00± 1.6	1.10± 0.1	0.90± 0.1	Ovoid compressed	Shining black
Anticharis linearis	2.50± 0.0	0.64± 0.1	0.36± 0.1	Cylindrical	Yellow
Aristida adscensionis	123.50± 2.6	4.75± 0.3	0.66± 0.1	Conical	Creamy-white
Borreria articularis	353.83± 1.8	3.15± 0.3	1.55± 0.1	Ellipsoidal	Dark brown
Celosia argentea	92.67± 1.2	1.55± 0.1 (dia.)		Round compressed	Shining black
Cenchrus biflorus	246.33± 3.3	2.48± 0.1	1.65± 0.1	Spindle-shaped	Creamy-pale or wheatish
C. prieurii	212.33± 6.8	2.63± 0.1	1.63± 0.1	Ovoid compressed	Dark creamy-pale
C. setigerus	84.67± 3.3	1.64± 0.1	1.13± 0.1	Gram-like	Dark creamy-pale
Chloris virgata	16.33± 0.5	2.32± 0.1	0.55± 0.1	Conical	Light brown
Cleome viscosa	104.00± 1.4	1.52± 0.1	1.36± 0.1	Round	Brownish-black
Corchorus aestuans	69.00± 0.8	0.78± 0.1	1.31± 0.1	Cylindrical	Chocolate
C. depressus	20.00± 0.0	1.03± 0.1	0.63± 0.1	Cylindrical	Chocolate
C. tridens	39.67± 0.5	1.28± 0.1	0.84± 0.1	Cylindrical	Black
Convolvulus microphyllus	199.00± 2.5	2.21± 0.1	1.19± 0.1	Spindle-shaped	Blackish-white
Crotalaria burhia	482.67± 3.1	2.82± 0.1	2.13± 0.1	Kidney-shaped	Dark brown
C. medicaginea	419.00± 1.4	2.72± 0.1	2.03± 0.1	Kidney-shaped	Grey
Cucumis callosus					
(form A)	770.00± 6.6	6.10± 0.5	2.70± 0.2	Obovoid compressed	Creamy-white
(form B)	515.00± 4.4	4.50± 0.3	2.30± 0.2	Obovoid compressed	Creamy-white
Cyperus rotundus	36.67± 0.5	1.53± 0.1	0.76± 0.1	Spindle-shaped	Dark brown
Dactyloctenium aegyptium	32.67± 0.5	0.94± 0.1	0.83± 0.1	Polygonal flat	Light brown
Digera muricata	363.00± 6.9	2.43± 0.1	2.12± 0.1	Squarish round	Black
Digitaria adscendens	50.00± 1.4	1.93± 0.1	0.77± 0.1	Spindle-shaped	Light brown
Eragrostis ciliaris	2.83± 0.1	0.59± 0.1	0.29± 0.1	Spindle-shaped	Dark brown
E. tremula	7.50± 0.0	0.58± 0.1	0.49± 0.1	Ovoid	Light brown
Farsetia hamiltonii	95.33± 2.4	1.95± 0.1	1.91± 0.1	Round compressed	Dark brown
Gisekia pharnaceoides	19.00± 0.0	0.99± 0.1	0.83± 0.1	Round echinulate	Black
Heliotropium marifolium	63.33± 0.5	1.29± 0.1	0.87± 0.1	Ovoid	Greyish
H. subulatum	65.33± 2.1	1.51± 0.1	0.95± 0.1	Ovoid	Brownish-black
Indigofera cordifolia	81.33± 1.2	1.18± 0.1 (dia.)		Round	Brown
I. hochstetteri	138.33± 1.2	1.83± 0.1	1.59± 0.1	Squarish	Golden yellow
I. linifolia	91.67± 0.9	1.19± 0.1 (dia.)		Round	Brown with black mottlings
I. oblongifolia	193.33± 1.2	1.79± 0.1	1.31± 0.1	Cylindrical	Dark brown
Melothria maderaspatana	1038.00± 42.5	4.70± 0.3	2.82± 0.2	Conical	Blackish-white
Oldenlandia aspera	3.00± 0.0	0.72± 0.1	0.39± 0.1	Conical	Chocolate
Oligochaeta ramosa	382.50± 6.1	5.04± 0.1	1.53± 0.1	Angled peg-like	Light or dark brown
Phaseolus trilobus	821.50± 17.5	2.94± 0.1	1.92± 0.1	Cylindrical	Dark brown
Polycarpaea corymbosa	1.67± 0.1	0.43± 0.1	0.28± 0.1	Bean-shaped	Light brown
Pulicaria crispa	9.00± 0.0	1.58± 0.1	0.46± 0.1	Conical	Dark brown
Sesbania bispinosa	992.00± 14.2	3.69± 0.3	1.85± 0.1	Cylindrical	Light black
Tragus biflorus	25.17± 0.2	1.54± 0.1	0.58± 0.1	Spindle-shaped	Dark brown
Tribulus terrestris	3784.00± 244.9	6.48± 0.6	4.82± 0.5	Triangular spiny	Creamy-white
Trichodesma sedgwickianum	1581.00± 28.6	5.97± 0.1	3.15± 0.1	Conical	Greyish white
Vernonia cinerea	16.67± 0.5	1.69± 0.1	0.54± 0.1	Conical	Light brown
Withania somnifera	144.00± 2.2	2.01± 0.1	1.83± 0.1	Round compressed	Yellow

Figure 2. Details of seeds of **Chloris virgata** *(1),* **Tragus biflorus** *(2),* **Dactyloctenium aegyptium** *(3),* **Digitaria adscendens** *(4),* **Cyperus rotundus** *(5),* **Pulicaria crispa** *(6),* **Vernonia cinerea** *(7),* **Corchorus depressus** *(8),* **C. aestuans** *(9),* **C. tridens** *(10),* **Gisekia pharnaceoides** *(11),* **Amaranthus hybridus** *(12),* **Heliotropium marifolium** *(13; a = dorsal; b = ventral), and* **H. subulatum** *(14; a = dorsal; b = ventral), as seen with a microscope using low power.*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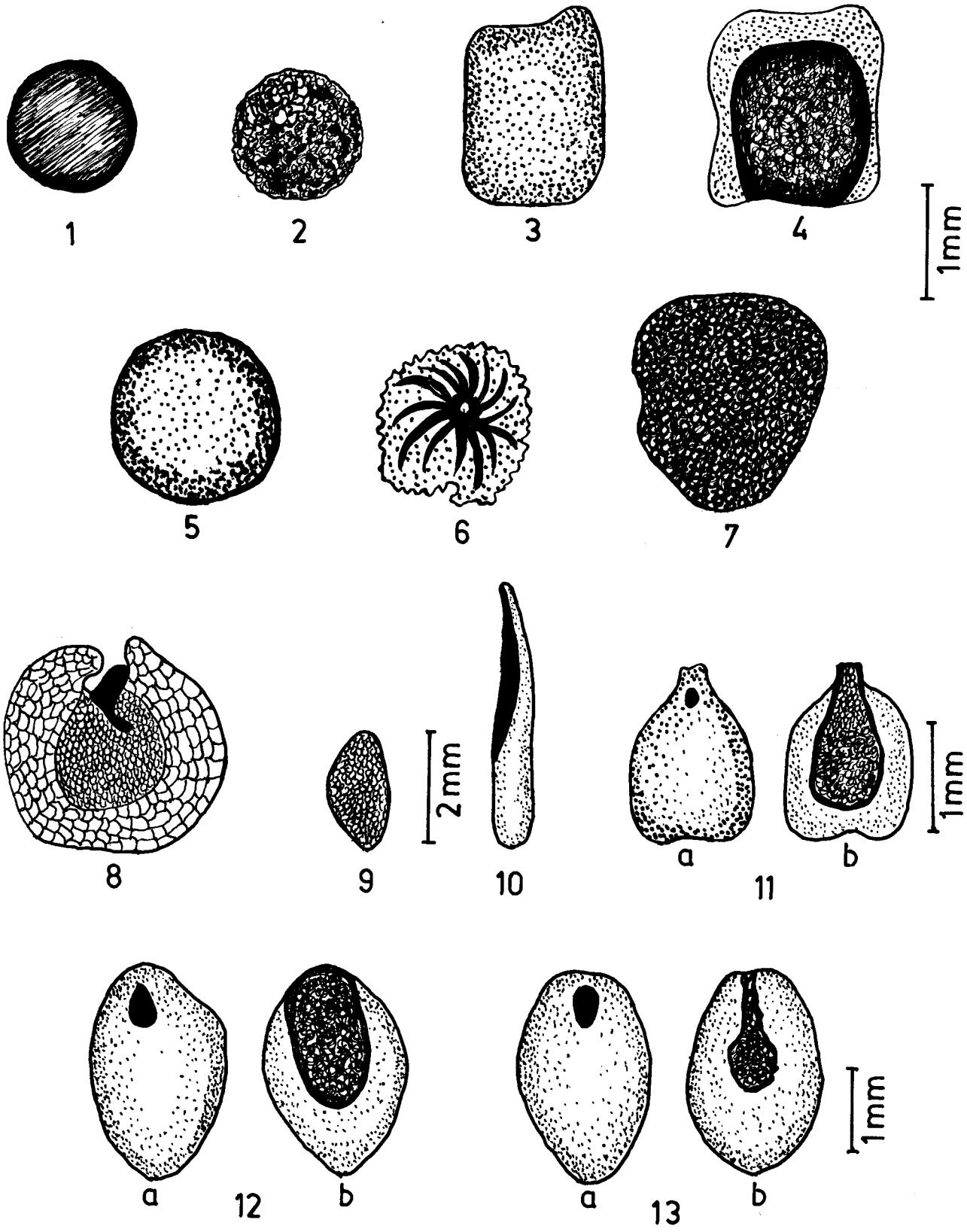
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and 1581.00 mg respectively. Lighter seeds have the advantage of being carried greater distances by wind than large and heavy seeds.

As with seed weight, great variations in seed size may be found within a given genus or family. In general, lighter seeds were also smaller in size and heavier ones were larger. Large seeds may have difficulty in obtaining sufficient water because of their low ratio of surface to volume. The ratio declines as seed size increases. Large or spiny seeds such as *Tribulus terrestris* make poor seed to water contact, with water uptake slow in comparison with water loss.

The surface of the seeds studied varied from smooth and glossy as in *Amaranthus hybridus* and *Celosia argentea* to ornamented and rough as in *Melothria maderaspatana*. The seeds of *Borreria articularis* have a deep groove and those of *Trichodesma* sedgwickianum are rugose on their ventral side. It is easy for ants to carry rough and rugose seeds. The seeds of *Farsetia hamiltonii* have wings which increase their surface area. The wings also allow the seeds to float through the air, facilitating their dispersal by wind.

The success of weeds in agricultural land has often depended on the seed shape that ensures its transport along with the crop seeds through the processes of harvesting, threshing and sowing. Seeds of slightly different shapes may take up quite different positions when they land on the soil surface. The seeds of *Borreria articularis, Cucumis callosus, Trichodesma sedgwickianum,* and others tend to remain in the positions in which they first

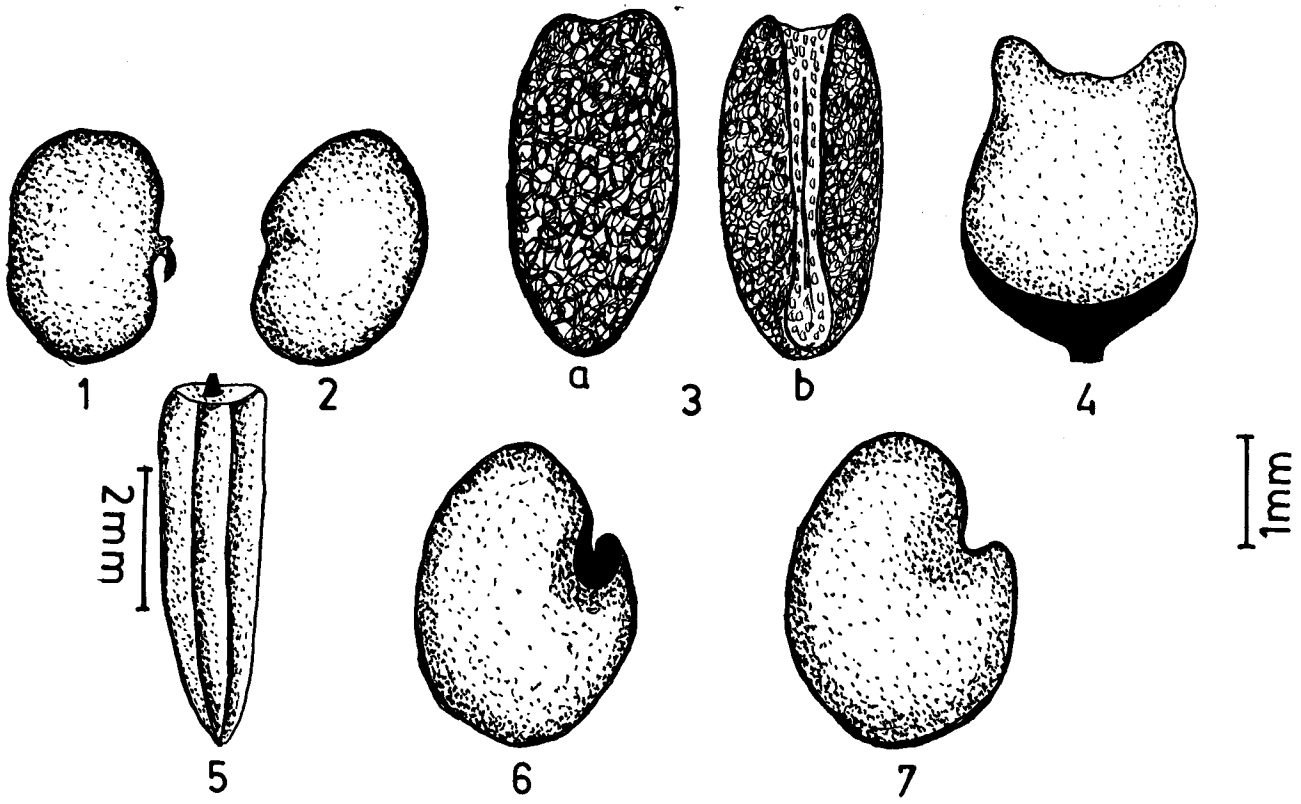

Figure 3. Details of seeds of **Indigofera cordifolia** *(1),* **I. linifolia** *(2),* **I. oblongifolia** *(3),* **I. hochstetteri** *(4),* **Celosia argentea** *(5),* **Cleome viscosa** *(6),* **Withania somnifera** *(7),* **Farsetia hamiltonii** *(8),* **Convolvulus microphyllus** *(9),* **Aristida adscensionis** *(10),* **Cenchrus setigerus** *(11; a= dorsal; b= ventral),* **C. prieurii** *(12; a= dorsal; b= ventral), and* **C. biflorus** *(13; a= dorsal; b= ventral), as seen with a microscope using low power.*

Figure 4. Details of seeds of **Alysicarpus vaginalis** *(1),* **A. monilifer** *(2),* **Borreria articularis** *(3; a= dorsal; b= ventral),* **Digera muricata** *(4),* **Oligochaeta ramosa** *(5),* **Crotalaria medicaginea** *(6), and* **C. burhia** *(7), as seen with a microscope using low power.*

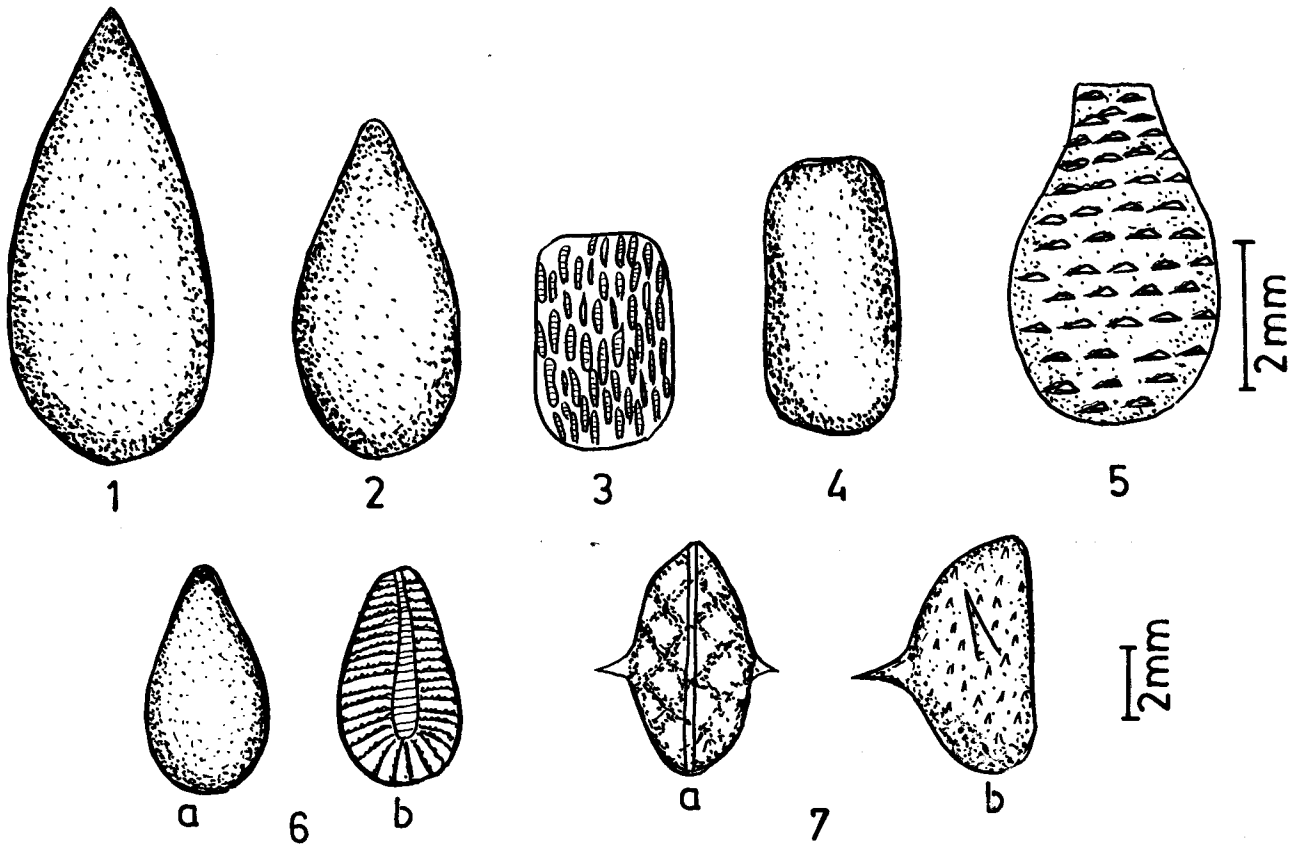

Figure 5. Details of seeds of **Cucumis callosus** *form A (1) and form B (2),* **Phaseolus trilobus** *(3),* **Sesbania bispinosa** *(4),* **Melothria maderaspanata** *(5),* **Trichodesma sedgwickianum** *(6; a= dorsal; b= ventral), and* **Tribulus terrestris** *(7; a = dorsal; b= ventral), as seen with a microscope using low power.*

fall, whereas the rounded seeds of *Indigofera cordifolia* roll into crevices.

Most of the seeds were brownish-yellow to dark brown in color. Only few seeds were black. According to Kozlowski and Gunn (1972), brown and black are the colors found in more than half of all seeds. Conspicuous colors such as red, green, yellow and white are infrequent, the infrequency tending to prevent predation by insects and birds.

Acknowledgements

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Arboretum Progress

Robert T. McKittrick
Boyce Thompson Southwestern Arboretum

Readers of *Desert Plants,* and more specifically of this column, were first made aware of the Arboretum's Advisory Committee in the initial issue of Desert Plants [1(1): 47]. It was apparent from the first consideration of tripartite sponsorship of the Arboretum that an effective arrangement to coordinate the interests at the Arboretum of the three parties had to be achieved. To that end the contract among the sponsors mandated the formation of an advisory committee and gave the members the additional charge of acting as advisors to the Managing Director. The committee membership, totaling six, consists of two qualified representatives appointed by each of the sponsors. Initial appointments were made in the summer of 1976 and all of these appointees still serve today. I would like to introduce you to these six committee members and two alternates, one each appointed by the Boyce Thompson Southwestern Arboretum, Inc. and the University of Arizona.

Committee Members Appointed by Arizona State Parks

Michael A. Ramnes, *State Parks Director.* Born in Washington, D.C., Mr. Ramnes moved to Arizona in 1954. In 1963 he graduated from Northern Arizona University having earned a BS degree with a major in biology and recreation and a minor in forestry. He was employed by Arizona State Parks in January of 1964 as a Park Supervisor. He served in that capacity at both recreational and interpretive parks in the state until 1967. From 1967 through 1971 he fulfilled his military obligation serving as a security police officer in the U.S. Air Force. Upon completion of that tour of duty he returned to State Parks. In 1973 he was promoted to the position of Chief of Administrative Services, assuming the responsibility for the administration of agency funds, construction projects, agency budgets and similar matters.

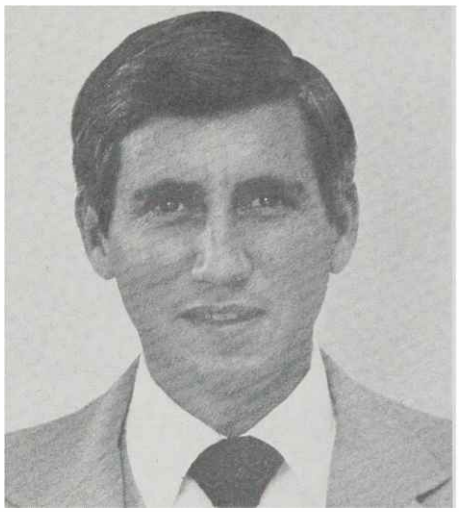
Mr. Ramnes was appointed to the position of State Parks Director in June of 1976, having served as acting Director for the preceding five months. In addition, he serves as a member of the Arizona Outdoor Recreation Coordinating Commission, the Governor's Commission on Arizona Environment, the Arizona Power Plant and Transmission Line Siting Committee, and the Arizona Historical Advisory Commission.

Charles Eatherly, *State Parks Chief of Planning.* Mr. Eatherly is a native of Erick, Oklahoma but grew up in Texas. At Texas Tech University he earned BS and MS degrees in Park Administration with a minor in Planning. He began his career as a Landscape Architect with the Parks and Recreation Department of Maricopa County, Arizona in 1963, moving up to Supervisor of General Services in 1967. In 1968 he accepted the position of Superintendent of Parks for the City of Norman, Oklahoma and left that position in 1970 to become an instructor in the Recreation and Park Administration Department at Arkansas Polytechnic College in Russellville, Arkansas.

In June of 1971, Mr. Eatherly returned to Arizona to take up his present duties with Arizona State Parks. As Chief of Planning, he is responsible for evaluating, developing and coordinating park and agency planning projects and for management of the hiking and equestrian trails and natural areas programs. Mr. Eatherly is a member of the American Society of Landscape Architects, the National Recreation and Park Association, the Arizona State Parks and Recreation Association, and the Association of Conservation Engineers.

Committee Members and Alternate Appointed by the Boyce Thompson Southwestern Arboretum, Inc.

William T. Smith, *Chairman and Chief Executive Officer, Boyce Thompson Southwestern Arboretum, Inc.* Mr. Smith is the only member of the Committee who had a personal acquaintance with Col. William Boyce Thompson, the founder of the Arboretum. Mr. Smith was born in Butte, Montana, the mining town where Col. Thompson spent most of his early years. Mr. Smith's father was a business associate and close personal friend



Michael A. Ramnes, Director, Arizona State Parks.

Charles Eatherly, Chief of Planning, Arizona State Parks.

of Col. Thompson. Mr. Smith was raised in Ely, Nevada but acquired his education at Phillips Exeter Academy, Harvard University and the Harvard Business School.

Upon graduation from Harvard Business School he accepted employment with Newmont Mining Corporation (formed by William Boyce Thompson as the Newmont Corporation in 1921). Mr. Smith carved out a career with Newmont. Prior to his retirement in 1967 he was a member of the board of directors and treasurer of the corporation. Mr. Smith also served as treasurer of the Boyce Thompson Institute for Plant Research, now located on the campus of Cornell University, and as treasurer of the Boyce Thompson Southwestern Arboretum, Inc. It is evident that Mr. Smith's "retirement" in 1967 was a somewhat qualified one since he now serves as Chairman of the Board for both the Institute and the Arboretum, and as President and Director of the Margaret T. Biddle Foundation.

Mr. Smith has recently received two signal honors in recognition of his many years of altruistic service. The Arboretum visitor center was named the William T. Smith Building [Desert Plants 2(2): 37]. A few months later Mr. Smith was named Distinguished Citizen of the Year at its Fall Honors Convocation by the College of Liberal Arts, University of Arizona [Desert Plants 2(3): 182].

Dr. Richard H. Wellman, *Board Member, Boyce Thompson Southwestern Arboretum, Inc.* Dr. Wellman was born in Medicine Hat, Alberta, Canada. He received his B.S. and Ph.D. degrees from Washington State University. Dr. Wellman was Research Fellow on a Union Carbide Corporation sponsored project at the Boyce Thompson Institute at its original site in Yonkers, New York. He subsequently joined Union Carbide and retired in 1974 as Vice President of the corporation and General Manager of Agricultural Products to become Managing Director of the Boyce Thompson Institute. Dr. Wellman retired from that position effective September 1, 1980. He is currently directing a Rhododendron breeding program sponsored cooperatively by the Institute and Cornell University. He continues to serve on several committees of the National Academy of Sciences and as a consultant to a number of commercial organizations.

Wesley P. Goss, *President and Board Member, Boyce Thompson Southwestern Arboretum, Inc.* Mr. Goss serves as an alternate on the Advisory Committee. He was born in Garland, Kansas. He graduated from the University of California, Berkeley in 1922 with a B.S. degree in mining engineering. Mr. Goss, who had previously worked summers as a miner, started that year with United Verde Copper Company as an engineer and subsequently was promoted to shift boss, foreman and Assistant Superintendent before leaving in 1934 to become General Superintendent for the Park City Consolidated Mining Company in Utah. In 1937 he went to Namaqualand, South Africa for Newmont as Mine Superintendent at the O'okiep property. After four years he returned to the United States as Assistant General Manager for Newmont at the Gray Eagle Corporation in northern California. Mr. Goss was made General Manager of Magma Copper Company in 1944, promoted to President in 1953, and appointed to his present post of Chairman of the Board in 1972. Magma Copper Company operates mines at Superior and San Manuel in Arizona.

It should be noted that Mr. Goss devoted a considerable amount of time to furtherance of higher education in Arizona as a member of the Arizona Board of Regents from 1963 to 1970, serving as Board Chairman before retiring from the Board. Mr. Goss presently serves as a member of the Arizona Copper Tariff Board, a position he has held since 1945.

Committee Members and Alternate Appointed by the University of Arizona

Dr. R. Phillip Upchurch, *Head, Department of Plant Sciences, University of Arizona.* Dr. Upchurch was born in Wake County, North Carolina. He earned B.S. and M.S. degrees in agronomy at North Carolina State College, graduating in 1949. In 1953 he completed his studies and was granted a Ph.D. degree in plant physiology by the University of California, Davis. He was commissioned

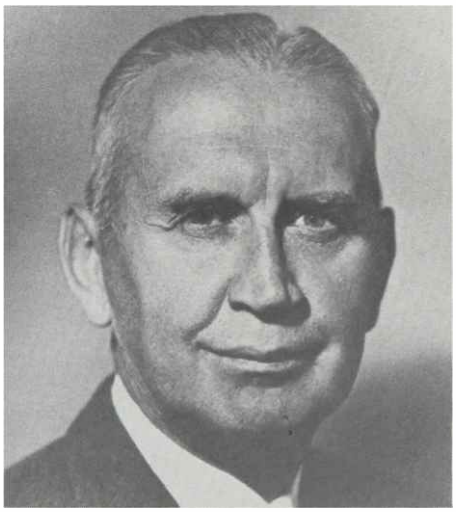
2nd Lt. in the U.S. Air Force (ROTC) in 1949 and served two years of active duty as Project Officer for Research on control of vegetation at Eglin Air Force Base from 1955 to 1957.

Professionally, Dr. Upchurch spent 13 years at North Carolina State University in Crop Sciences (weed science), attaining the rank of Professor in 1964. In 1965 he accepted a position as Senior Research Group Leader with the Agricultural Division of Monsanto Company, St. Louis, Missouri. In 1970 he was named Research Manager and in 1973 Manager of Research. He took up his present position with the University of Arizona in 1975. In 1976 he accepted the responsibility as the Arboretum's primary on-campus administrator. Among a number of additional accomplishments are 1) past service as President of the Weed Science Society of America, 2) founding the Plant Growth Regulator Working Group, 3) service with the Council for Agricultural Science and Technology (CAST) as a current member of the executive committee and as President-elect, and 4) service as a consultant to the President of Eli Lily & Co.

Warren D. Jones, *Professor of Landscape Architecture, University of Arizona.* Prof. Jones was born and raised in Pasadena, California. He graduated in 1937 from Oregon State University with a B.S. degree in landscape architecture and then completed two years of graduate study in that field at the University of Oregon. From 1942 to 1946 he was employed as Landscape Inspector for the federal Public Housing Authority. His territory included areas of Mojave Desert and Colorado Desert in four counties of southern California. This exposure to landscaping in a desert environment began a career-long dedication to the use of native desert plants for desert landscaping. He carried this principle with him into his private practice from 1946 through 1967. Two major desert projects during this period consisted of acting as landscape consultant for all housing projects of the San Bernardino County Housing Authority and for the design of a large retirement community in Riverside County now known as Palm Desert Country Club Estates.

In 1967 he left private practice to teach at the University of Arizona and to continue to search out desert plant species suitable for landscape use. In pursuit of these species he has made numerous plant collecting journeys into Mexico. He was also able to bring back many plants from the Middle East when he worked in Saudi Arabia during 1974 and 1975 as a member of the University of Arizona group working on the King Faisal Specialist Hospital project. This led to a number of other Middle East consultations. He recently returned to Arizona from a plant consultation trip relating a new Saudi Arabian town on the Red Sea.

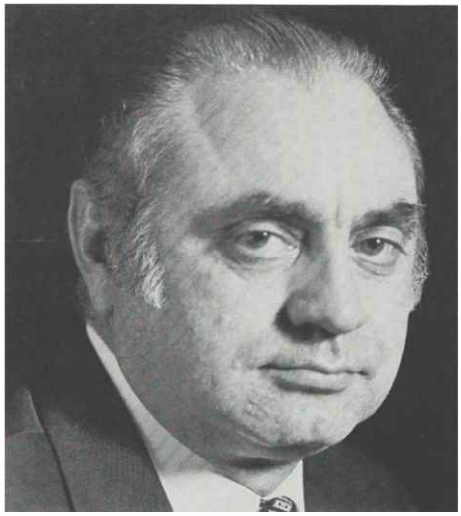
Mr. Jones is a consultant to *Sunset Magazine* for articles on the southern desert region and participated in the preparation of Sunset's *New Western Garden Book.* He has also co-authored several publications on desert landscape plants, the most comprehensive and recent of which is *Plants for Dry Regions* published by H. P. Books. Among other activities, Mr. Jones is a member of the Advisory Board of the Arizona-Sonora Desert Museum, a member



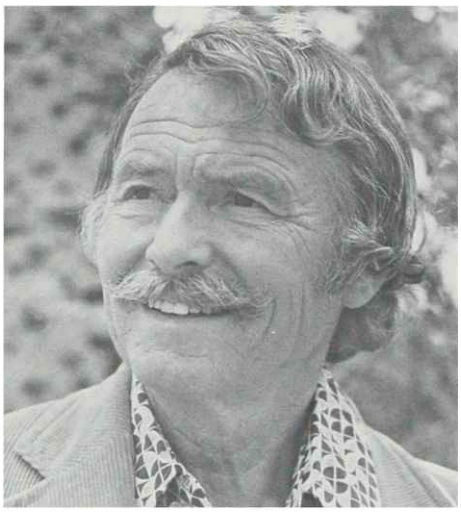
William T. Smith, Chairman and Chief Executive Officer, Boyce Thompson Southwestern Arboretum, Inc.

Dr. Richard H. Wellman, Board Member, Boyce Thompson Southwestern Arboretum, Inc.

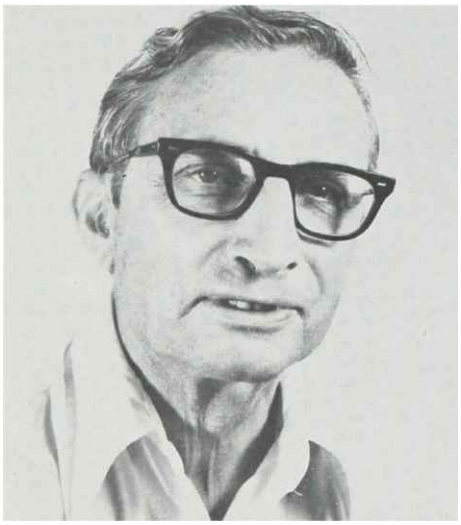
Wesley P. Goss, President and Board Member, Boyce Thompson Southwestern Arboretum, Inc.



Dr. R. Phillip Upchurch, Head, Department of Plant Sciences, University of Arizona.



Warren D. Jones, Professor of Landscape Architecture, University of Arizona.



Dr. Newell A. Younggren, Professor, Department of General Biology, University of Arizona.

of the American Association of Botanical Gardens and Arboretums, a member of the Arizona Native Plant Society Executive Board, and Arizona Trustee for the American Society of Landscape Architects.

Dr. Newell A. Younggren, *Professor, Department of General Biology, University of Arizona.* Dr. Younggren serves as an alternate on the Advisory Committee. He was born in St. Croix, Wisconsin. He earned B.S., M.Ph. and Ph.D. degrees respectively from Western State College in River Falls, Wisconsin (1937), University of Wisconsin (1941) and University of Colorado (1956). Although his research interest was in the slime molds and he has authored several papers on that subject, he has also maintained throughout his career a strong commitment to teaching, co-authoring a number of manuals and textbooks. Evolving from his interest in teaching was a willingness to enter into student counselling and administration. University positions he has held include Assistant Professor, Northland College, 1945–48; Assistant Dean of Students, Bradley University, 1945–54; Assistant Professor, University of Colorado, 1954–61, and Chairman of the Department of Biology, 1958–61.

Dr. Younggren came to the University of Arizona as an Associate Professor in 1962. In 1964 he was promoted to Professor. From 1968 to 1973 he served as Head of the Department of Biological Sciences. From 1968 to 1975 he also served as the on campus liaison to the Arboretum. Among many organizations in which he has served and holds membership are the American Institute of Biological Sciences, the American Association for the Advancement of Science, and Sigma Xi.

The present membership of the Committee brings a pool of expertise from a variety of disciplines. That this mix has served the Arboretum well is indicated by Arboretum accomplishments since the initial committee meeting on August 26, 1976: reprinting of The Magnate, Col. Thompson's biography; the 50th Anniversary celebration; major renovation of the William T. Smith Building; masterplanning progress; compilation of an inventory of all plants in the outdoor gardens; assignment of a Young Adult Conservation Corps work camp to the Arboretum; renovation of the High Trail; installation of the trickle irrigation system; design of the Arid Vegetation Information System; new research projects at the Arboretum and the publication of the *Desert Plants* journal.

Reviews

An Illustrated Guide to
Landscape Plants in Southern Arizona.
Ronald K. Dinchak. Organpipe Publishers. Mesa, Arizona. 1980. 294 pp. $12.95.

Through descriptions and illustrations the author identifies for the reader the most commonly planted landscaping plants of southern Arizona. For each species the landscape uses are enumerated, followed by maintenance requirements. Special lists categorize the plants treated into 1) colorful flowering plants, 2) deciduous and semi-deciduous plants, 3) drought tolerant plants, 4) poolside plants, 5) shade tolerant plants, and 6) useful edible plants. The author suggests six places to observe mature specimens of plants treated, 1) the Boyce Thompson Southwestern Arboretum at Superior, 2) the Desert Botanical Garden in Phoenix, 3) the Arizona-Sonora Desert Museum near Tucson, 4) the University of Arizona Maricopa County Cooperative Extension office in Phoenix, 5) the campus of Arizona State University in Tempe, and 6) the campus of the University of Arizona in Tucson.

The author demonstrates a familiarity with all species treated and appears to have made all of the drawings himself. In most instances a novice should be able to identify the plants from the sketches and descriptions. The maintenance requirements and discussions of diseases, insect pests and freeze damage seem particularly well presented for the space which the book's format allows.

In 1979 Ron Dinchak and his wife Marla won first prize in the large garden category of the *"Arid-zona Landscaping Contest"* sponsored by the Salt River Project and the Desert Botanical Garden. Ron's interests in landscaping, especially with drought tolerant vegetation, led to this publication. He is a life science instructor at Mesa Community College and has an MS degree in botany from Arizona State University.

Tropical Legumes:
Resources for the Future.
Report of an Ad Hoc Panel of the Advisory Committee on Technology Innovation. Board on Science and Technology for International Development. Commission on International Relations. National Research Council. National Academy of Sciences. Washington, D.C. 1979. x+ 331 pp.

The book details legume species which can be grown as root crops, for beans ("pulses"), fruits, forages, timbers, ornamentals, fibers, gums, or for green manure, soil reclamation and erosion control. Although the world's deserts are typically found in the latitudinal belts just north or south of the tropics, some (but not all) of the tropical legumes discussed in the book can be grown in deserts.

The book is extremely well written for readability. Research needs and limitations are clearly stated for each crop and known or potential uses are well presented. Fascinating tidbits of information abound in the book. For example, the Pilgrims in New England survived their first few winters by living on tubers of *Apios americana* and Captain John Smith, leader of the Jamestown colony of 1607, described *Apios* as being "good as potatoes." Cultivation of *Apios* alleviated somewhat the potato famine of 1845 in Europe but was abandoned when potato fungus problems were lessened.

Mesquite *(Prosopis* sp.*)* groves in Hawaii, Peru, Argentina and Chile yield pods which sustain livestock for one or two months of the year without any other feed at all. The food value of Mesquite pods is said to be comparable to that of barley or corn. Mesquite is particularly valuable in deserts because the pods are available during the dry season when little other plant material is present in non-irrigated situations.

The book can be best characterized as a valuable reference and a logical starting point for potential research and development. It is intended for use in developing countries. Research contacts are given for each crop plant as well as selected readings.

Insect galls on Scrub Oak **(Quercus turbinella).** *Such Quercus "nutgalls" figured prominently in the most flagrant case of desert land fraud perpetrated in North America during the Nineteenth Century.*

Land Fraud and Nutgalls. Visitors to the Boyce Thompson Southwestern Arboretum at Superior may want to walk out on the "High Trail" where *Quercus turbinella* is native to examine these plants for insect galls. There is some almost unbelievable history associated with such galls. Insect galls of *Quercus* have been used for centuries in medicine and manufacture under the designation "nutgalls." During the last century James Addison Reavis used nutgalls of *Quercus* in an elaborate hoax to lay claim to a vast tract of land covering the better part of southern Arizona.

Reavis was good enough as a scholar to know that old Spanish land grants in the new world had been written using an ink made from *Quercus* nutgalls and rusty nails. He practiced making such ink and writing with it using a pen fashioned from the quill of a bird's feather.

He visited archives in Mexico City and Madrid, Spain, posing as a scholar conducting research. After the keepers of the archives began to trust him they would sometimes leave the "harmless scholar" alone with old deed books and dusty documents. Upon finding an unused page, Reavis would rip it from the book in secret, or simply remove it if not bound, and hide it in his briefcase. Then in the privacy of his own quarters and with the carefully prepared *Quercus* gall ink, he would painstakingly imitate the old Spanish court calligraphy to forge a document which in some way supported a fictitious land grant to a fictitious Peralta family. On the next trip to the archive he would return the sheet to its original position and conveniently "discover" the defect in the volume, suggesting to the archivist that such a priceless volume should be repaired or rebound. Each new document supported the previous forgeries.

Reavis adopted a young girl and forged an elaborate chain of documents to show that she was a descendent of the Peralta family and heir to the land grant. As she grew up she had no reason to believe that she was not, indeed, "the Baroness of Arizona" as the documents forged by Reavis indicated. Eventually Reavis married her and adopted the name "James Peralta-Reavis" for himself.

Reavis had perpetrated the fraud so cleverly, availing himself of almost forgotten knowledge concerning *Quercus* nutgalls, that he was received by the royal court of Spain as the "Baron of Arizona" and had an audience before Queen Victoria of England as such. The United States government recognized pre-existing land grants in the territories transferred from Mexico after the Mexican War and the Gadsden Purchase. Grudgingly, residents of southern Arizona began paying rent to the Baron for land which they had previously thought was theirs.

The wealthy Silver King Mine near Superior paid royalties for every ounce of silver extracted and even the Southern Pacific Railroad was hoodwinked into paying rent for every mile of track that had been laid down! Readers of this almost unbelievable but true story can pick up a fact sheet at the Arboretum for more details on the Peralta Hoax and to learn how the fraud was discovered.