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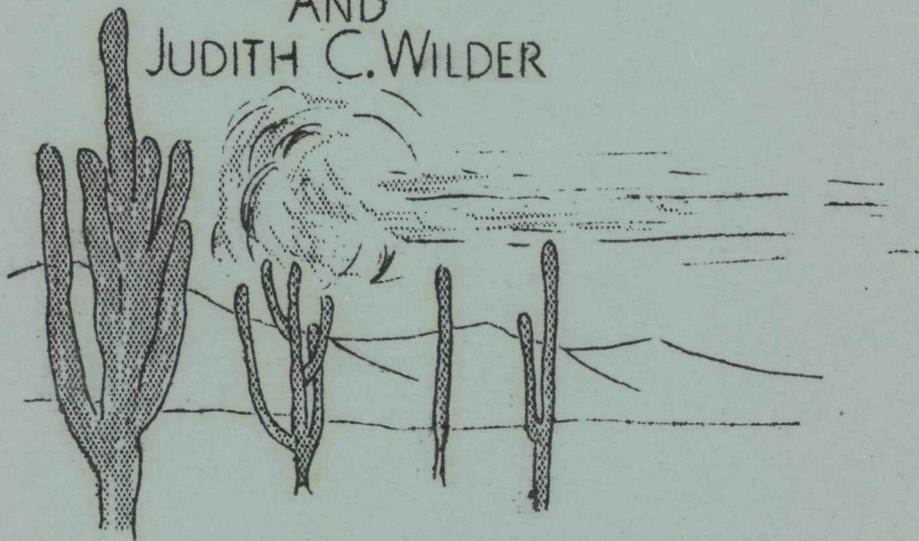
RE-ESTABLISHMENT OF SAGUAROS

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RANDOM PAPERS

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By Carleton S. Wilder and Judith C. Wilder

Counts on sample plots were made in the Saguaro National Monument as a study of the relative abundance of young and mature saguaros (Carnegiea gigantea) from which conclusions might be drawn as to whether this cactus is re-establishing itself satisfactorily.

From casual observation it appeared that where the great, branched individuals grew the thickest the fewest number of small ones, under six feet, would be seen.

If this were true did it mean that the saguaros were not replacing themselves in the places which once evidently had offered optimum growing conditions? Or were they not anywhere replacing themselves at a rate which would produce a forest of similar proportion to the present one? Would the center of population of saguaros on the Monument two hundred years from now be in the same place as at present? Do the saguaros in the most densely populated section of the Monument represent a peak not to be reached again?

Some two hundred years ago¹ all weather and soil conditions were perfect at a spot twenty miles east of Tucson for the germination and growth of Carnegia, resulting in a forest of phenomenal density and vigor. High soil temperature and adequate moisture are necessary for the germination of saguaro seeds.² There were, apparently, a few years of these optimum conditions and the forest was started. The plants are now mature; because of their limited life span, the forest cannot exist in its present size many more years.

1 Life span of the saguaro is about 200 years. Forrest Shreve, The Longevity of Cacti, Cactus and Succulent Jour. VII: 5.

2 Shreve, The Cactus and Its Home, Williams & Wilkins Co., Baltimore, 1931. Spalding, Volney M., Distribution and Movements of Desert Plants, Carnegie Inst. Publication, 1909, p. 127.

Are other plants growing up to replace the doomed ones or will a different vegetation claim this area and saguaros grow elsewhere, if at all?

Method

Three areas representative of the types of places where saguaros grow on the monument were chosen. On each area, thirty 60-foot quadrats were paced off (in one case there were two sub-areas, each with 30 quadrats). The method of selecting these quadrats was as follows:

An arbitrary starting point decided upon, at least ten quadrats in an approximately straight line were paced off and the saguaros counted and classified. Choice of where to count saguaros was thus far kept unprejudiced. The quadrats were selective, however, in the choice of the general area for counting and in consciously tending, once the line was started, to make counts where small saguaros were seen. An area where no saguaros grew was passed over. No definite distance was kept between plots. Ten or 15 plots usually fell within a distance of a half mile or a mile. Since the ground would often be rough and broken, with thickets in the way, plot boundaries were not survey-accurate; plants, however, not legitimately within the quadrat would not be counted. The selecting and pacing off was done rapidly, one saguaro usually being taken as a corner post.

Three major height classes were established, two factors being considered: convenience of measuring and grouping of the plants according to height so that some conclusions concerning the relationship of young to mature saguaros could be reached.³ The height classes are as follows: under two feet, from two to six feet, six feet and over (branched and unbranched). The first height class was established in order to have a record of very young saguaros -- those less than approximately 20 years of age. The second includes all those approximately 20 to 35 years of age. The third obviously includes all those over 35 years of age and was divided into two groups, unbranched and branched. By dividing the last class thus it was hoped that some degree of age differentiation in this large height class might be arrived at, the majority of branched saguaros being taller and representing longer growth than ones without branches.

The four areas will be designated as follows: Lower Desert Floor, Sub-areas I and II, Upper Desert Pocket, and Foothill. A brief description of the character of these areas with regard to topography, vegetation, and saguaro stand will be given. Elevation of all areas falls between 2,600 and 3,000 feet, so there is little significance in difference of elevation.

Lower Desert Floor, Sub-areas I and II

By the Lower Desert Floor is meant that part of the Monument where the land has smoothed out from the Tanque Verde foothills into almost level table-lands a little higher than the valley floor surrounding Tucson, where, also, saguaros grow. The surface soil is sand and gravel with a light covering of winter annuals and six-week grasses. The predominant plants are saguaros and palo-verdes.

³ The only method known so far for determining the age of a saguaro is by its height. Forrest Shreve, *The Rate of Establishment of the Giant Cactus*, *The Plant World*, XIII: 10, p. 237. 1910.

Creosote and mesquite fringe the area, but are almost lacking in the plots counted.

This is the section of the Monument where the saguaros, on casual observation seem to be the tallest and densest. Their relationship here to the palo-verde is interesting. Frequently saguaros were found growing in a circle around a palo verde. If the saguaros were small or medium-sized, the palo-verde tree would still be alive; sometimes a palo-verde dying because of the encircling saguaros would be seen; at other times, in the case of very large or close-growing saguaros, the circle would be plain but the palo-verde would have disappeared entirely or only a dead bush would remain. In other places on the Monument where very young saguaro plants are abundant they are characteristically found under the protection of the low, spreading limbs of a palo-verde.

Counts were made east, west, north and south from the Public Camp-ground, about two miles from the north entrance gate. Straightline counts extended west to the Monument boundary and east to the section line fence. Two lines went north and south, approximately parallel to the road, which follows a slight rise of ground. Sub-area I includes east-west plots and Sub-area II, north-south plots.

Upper Desert Pocket

This area is a flat, desert floor surface immediately beneath the Tanque Verde foothills, slightly higher than the so-called "lower desert floor" but not in itself sloping. The "pocket" is formed by the abrupt Observatory Hill rising about a mile north and west of the curving base of the Tanque Verde mountains. Three lines of counts of ten plots each were made in this pocket -- south, southeast, and east, starting in each case at the foot of Observatory Hill and ending at the base of the foothills. Ribbons of small washes extend down from the foothills through the pocket. These are usually shallow and sandy with a thick growth of cat's-claw and mesquite. In the south line of counts there was a deeper gully with rocky sides where a few weather-scarred saguaros keep root and larger mesquite and cat's-claw trees grow. Between the washes are alluvial flats, sometimes well covered with small herbaceous growth, sometimes showing the effects of sheet erosion by a bare gravelly surface. As on the lower desert plots, palo-verde is the chief plant associating with the saguaros. Creosote bushes grow in the places where saguaros are least frequent. The circles of saguaros around a palo-verde were not noticeable here, tall, mature saguaros standing alone or in a clump of two or three. Small saguaros are abundant, invariably growing close under a palo-verde.

Foothill

The foothill counts were made on a representative area at the north end of the Skyline Loop Road where a series of steep hills leads up to the Tanque Verde mountains themselves. The counts were not made in a straight line but at random over the north, west, and south slopes of a rough, irregular hill which merged to the east with the higher slopes. Following a straight line here would have been impossible and meaningless. The foothills are of granitic origin covered by rocks of boulder

size with steep drops and abrupt outcroppings. Stunted palo-verdes, ocotillos and creosote bushes, Encelia and Franseria compose the vegetative cover. At the base of the foothill in question, a steep wash was cut down from the mountain. Counting was started at the base of the foothill, at the top of the bank of the gully. At this particular place, a spectacular bed of six small saguaros, one of them four inches tall, was found.

The largest number of saguaros under two feet in height was found on the foothill area and the largest number in proportion to saguaros over six feet high. Overhanging rocks afforded advantageous spots for germination and early growth. The same rocks evidently limited the number which grew into fine tall specimens of saguaros.

Results

Table 1 shows the numbers of saguaro plants in three representative areas and in three height classes (which imply age), and the percentage the number for each class is of the total for the area.

The sample plots showed that on the Lower Desert Floor saguaros are two and a half to four times as thick as in the Upper Desert Pocket. In the Foothill they are about the same as on Sub-area I of the Lower Desert and about one and a half times fewer than on Sub-area II. These numbers, derived from totals, are illustrative mainly of tall, half-grown or mature plants. If only young plants are considered the picture is just the opposite. In one case there were twice as many saguaros under two feet in height in the Upper Desert Pocket as on the Lower Desert, and in the other, 21 times as many. In the Foothill plots there were, moreover, twice as many under two feet high as in the Upper Desert. Actual numbers range from one on Sub-area II to 43 on the Foothill area. Numbers of saguaros from two to six feet are more uniform throughout the Monument, the sample plots indicated, numbers ranging from 10 to 12 on the Lower Desert areas to 24 and 28 on the Upper Desert and Foothill areas. In every case the percent of the total is largest for plants six feet and over. On the Lower Desert Floor they constitute 91.24 percent and 97.22 percent of the total number of saguaros on Sub-area I and II, respectively; 55 percent of total Upper Desert saguaros counted; and 69.53 percent of the Foothill saguaros (where it will be remembered the largest number of very small saguaros were found). In every case except in the Foothill there were more plants in the two to six feet group than in the less than two feet group. The percentage of branched saguaros in the six feet and over class was about twice that of the unbranched ones in every case except in the Foothill where it was just one percent more. In other words, there were approximately an equal number of half grown and mature saguaros on the Foothill area, while on the other areas mature trees predominated over half grown ones as well as over infant ones.

The results of the saguaro counts on the Lower Desert Floor areas substantiated observations made at large over that part of the Monument that small, obviously very young saguaros are almost entirely lacking. The figures show that the saguaro is not continuing to establish itself in this vicinity.

Table 1. Numbers of saguaros in three height classes on three representative areas, Saguaro National Monument.

Heights	Areas							
	Lower Desert Floor				Upper Desert Pocket		Foothill	
	Sub-area I (east-west)		Sub-area II (north-south)		Number	Percent	Number	Percent
Under 2 feet	10	3.98	1	0.25	21	21.00	43	18.45
2 to 6 feet	12	4.78	10	2.54	24	24.00	28	12.02
6 feet and over								
Unbranched	82	(32.67)	130	(33.00)*	17	(17.00)	80	(34.33)
Branched	147	(58.57)	253	(64.21)	38	(38.00)	82	(35.20)
Total	229	91.24	383	97.21	55	55.00	162	69.53
TOTAL	251	100.00	394	100.00	100	100.00	233	100.00

*Adjusted .01.

Of the total of 645 saguaros counted on the Lower Desert, 11 were less than two feet in height, 22 were less than six feet but more than two feet, while 612 were over six feet high -- 212 unbranched and 400 branched, this latter figure indicating an overwhelming number of tall, mature, many-armed individuals.

Density figures are interesting as illustrative of the present distribution of saguaros on the Monument. The average density on the Lower Desert Floor -- the region which is responsible for the Monument's existence -- is 10.75 saguaros per quadrat. Actual numbers ranged from four saguaros in a quadrat in one instance to 28 individuals in two other quadrats. In both of the latter cases there were no saguaros less than six feet in height, and of the two totals of 28 tall ones, 22 were branched in one instance and 19 in the other.

Average density in the Upper Desert Pocket quadrats is only 3.33 saguaros per quadrat, and in the Foothill, 7.77.

A search for small saguaros was made exclusively of the quadrat counts. The results of this point to the same fact as that drawn from the quadrats: there are almost no knee-high saguaros (and no observed tiny ones three or four inches high) where Carnegiea grows the tallest and densest, while in some other places they are surprisingly numerous. All over the Upper Desert and Foothill region, four-, five-, and six-inch plants ceased to be a rarity after it was found that their invariable habitat was under palo-verde bushes. The smallest saguaro discovered was three-fourths of an inch high. It was growing next to one seven inches high. Fifteen years ago at the Desert Laboratory, Dr. Shreve planted saguaro seeds, the seedlings now ranging in height from about that of the three-fourth inch saguaro to the seven inch one, which demonstrates the erratic growth rate of young saguaros and precludes any very close estimates of age of those found in the field.⁴

Conclusions

Quadrat counts and general observation lead to the conclusion that saguaros are not replacing themselves in that part of the Saguaro National Monument, called in this paper the Lower Desert Floor, where at the present time the thickest stand and the largest trees are found. They are, apparently, reproducing satisfactorily in level-floored pockets just below the foothills and on the foothills (or mesas leading up to the Tanque Verde mountains). In fact, the number of young plants indicates the possibility of a denser stand of mature trees in the future than exists on these areas at the present time.

The center of population two hundred years from now cannot be in the same place as it is today because new plants are not coming up to take

.

4 "A four inch plant may be anywhere from 8 to 25 years old. Likewise a tree 15 feet high may be only 60 years old or may be nearly 100. The rate of growth of the main trunk in middle-aged individuals is about 4 inches per year. The age of the tallest trees is probably between 150 and 200 years, depending on the rate of their start and the sort of situation in which they grew."

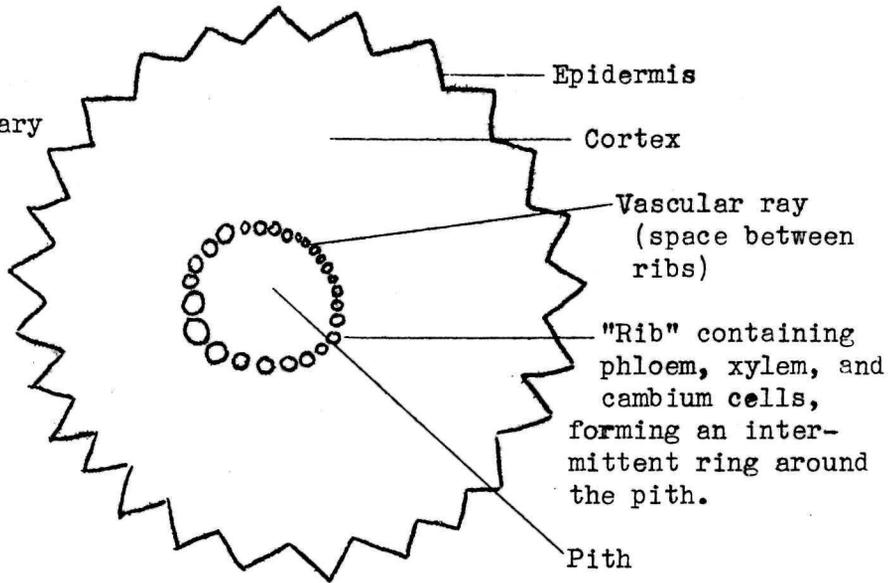
Shreve, The Longevity of Cacti.

Cross-section of Saguaro

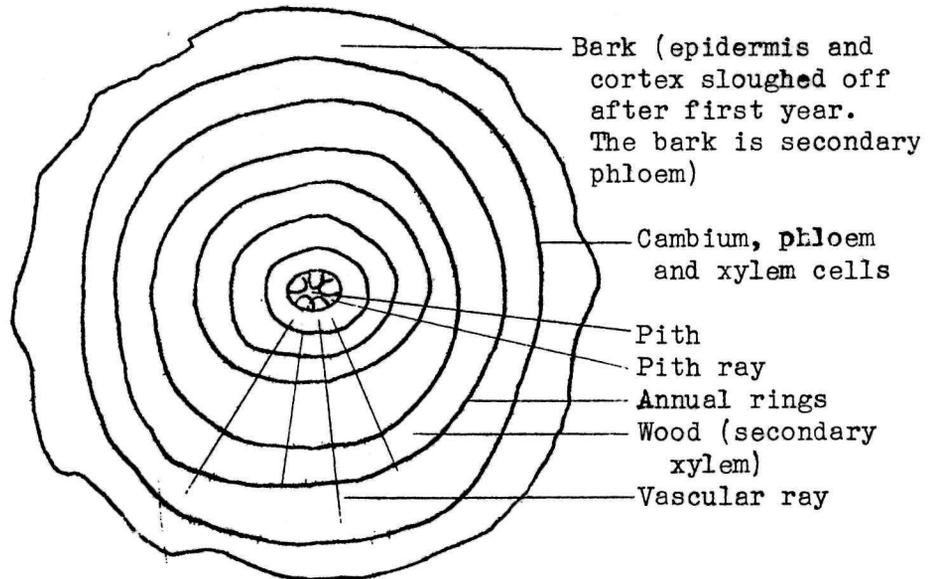
The woody ribs are composed of secondary xylem for the most part.

There were 26 flutes and 26 ribs on this specimen, arranged in the pattern shown.

1/5 natural size



Cross-section of Pine.



Brief comparison: The stem of the saguaro from the pith to the outside of ribs roughly parallels structure of a woody tree trunk such as pine. The proportion of pith is much greater; the vascular rays are so much larger that they form spaces between the wood. The circles of phloem, cambium, and xylem (fibrovascular bundles) follow around the pith (within the "ribs") as in an ordinary tree, though the line is broken by the wide vascular rays. There are no annual rings laid down by cambium growth. The cortex serves the purpose mainly of water storage. The woody ribs conduct water and food materials as well as support the plant. Photosynthesis is carried on by chloroplasts found in the green epidermis. A waxy cuticle covers the epidermis, reducing transpiration of water.

---From interview with Dr. Crooks, head of Botany department, University of Arizona.

the place of the old; it will probably be nearer the foothills, but whether it will be of as great proportions as the present famous stand will not be ventured in these conclusions.

Why are Carnegiea seeds germinating and small plants growing in the vicinity of the Upper Desert Pocket and on the foothills while such growth is absent in the old forest? The answer, which might be revealed by further study, may lie in subtle differences in moisture and temperature; in the effects of erosion and cattle grazing; in competition with the mature plants.

If competition is the factor limiting the reproduction of saguaros, the answer to the question at the beginning of this paper (do the saguaros in the most densely populated section of the Monument represent a peak not to be reached again?) may be that such a phenomenon might be repeated four or five hundred years from now, provided climatic conditions, soil, and other factors were the same as those existing when the present forest originated.

In 1910, Shreve said, "It is bootless at this time to attempt to explain the apparent decadence of the Giant Cactus." ⁵ Through his work on Tumamoc Hill and on a southern slope at the base of the Santa Catalina mountains, he had come to the conclusion that "it is not maintaining itself in either of two (favorable) situations."

We suggest in this paper that Carnegiea is maintaining itself, tending to do so not by continuous re-establishment in one place, but by irregular periods of establishment -- correlated with favorable growing conditions -- and in shifting spots of greatest density.

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5 Shreve, The Rate of Establishment of the Giant Cactus.

SWNM

Archeologist Paul Beaubien at Walnut Canyon wonders whether he has not seen a fairly unusual occurrence. In July Paul had placed some canteloupe rinds outside the cabin for birds and rodents. A gray ground squirrel was eating the rind when a chipmunk on the roof of the cabin began to scold. The ground squirrel took note of the chatter and was seemingly irritated by it. He finally ran up on the roof and chased the chipmunk, catching it and killing it. He then went off, carrying the body.

SWNM

At Casa Grande the difference in actions of various species of birds when imprisoned in bird traps are of considerable interest. Cactus wrens, for example, show considerable spunk resisting capture to the utmost and, when taken in the hand, clenching their toes about the wires of the prison so tenaciously that it requires some time and effort to break them loose. Upon being released, they usually fly to the ground a short distance away and, as they fluff their ruffled feathers into place, upbraid the bander with a series of harsh wren invectives.

