

Appendix X: History of the “Section 17” Saguaro Survey in Saguaro National Park

Don Swann, Saguaro National Park, 2013

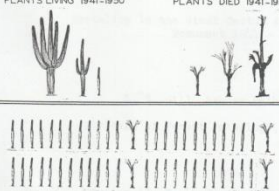
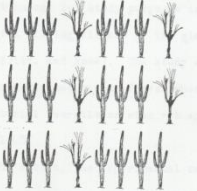
10-YEAR MORTALITY OF GIANT CACTUS 1941-1950 SAGUARO NATIONAL MONUMENT				
PLANTS LIVING 1941-1950	PLANTS DIED 1941-1950	HEIGHT CLASS OF LIVING PLANTS 1941	PER CENT OF CLASS DIED 1941-1950	PER CENT OF ALL DEAD PLANTS
		FEET		
		0-18	5.2	6.8
		19-24	2.4	20.0
		25+	2.4	33.4

Figure from Gill (1950) showing results of the 10-year saguaro mortality study in Section 17.

Summary

In 1941, scientists studied saguaros in a one-mile-square section (no. 17 of R 16E and T 14S) of Saguaro National Park’s Rincon Mountain District as part of an experiment to determine if a contagious disease was killing saguaros in the park’s “Cactus Forest” area. A total of 12,898 saguaros were measured, and monitored in Section 17. Saguaros that appeared to be dying were removed from half the section, while the saguaros in the other half were left in place. After 10 years, scientists found no difference between the two areas and determined that contagious disease was not killing the saguaros. Because long-term monitoring has continued in Section 17 since 1941, many of the records from the 1941 study have survived, including the original maps, reports, and data. In 2011, Saguaro National Park worked with school groups and citizen

scientists to study long-term changes in saguaros by repeating the survey of Section 17, seventy years after the original survey in 1941.

History of the “Section 17” Saguaro Survey in Saguaro National Park

Introduction

Saguaro National Monument was created by presidential proclamation in 1933 (it became a national park in 1994). At that time, the so-called “Cactus Forest,” located in the foothills of the Rincon Mountains east of Tucson, was considered to be the finest stand of saguaros in the world (Steenbergh and Lowe 1983). However, only a few years after the Monument was established, staff and others became alarmed at a major die-off of saguaros in the Cactus Forest.

Scientists from the University of Arizona and the U.S. Department of Agriculture were called in try to understand what was causing the die-off, and if it could be reversed. In 1941, two plant pathologists with the USDA Bureau of Plant Industry, Lake S. Gill and Paul C. Lightle, began a large-scale, long-term study in a one-mile square section of the park. Gill and Lightle also studied saguaros at Organ Pipe Cactus National Monument and throughout the Arizona Sonoran Desert during this period. The section of land in Saguaro National Park, section 17 of range 16E and township 14S (Figures 1-2), was the focus of intense research for several years.

In 1941 it was believed that a contagious bacterial disease may be responsible for the death of the saguaros, which were observed to be oozing a black fluid prior to dying. The main experiment in Section 17 was to test whether removing the diseased individuals would result in a higher survival of those that showed no signs of the “bacterial rot” disease, but the project gathered a significant amount of data on saguaros that continue to serve the Park to this day.

Study design

In the winter of 1941-1942, every saguaro in Section 17 was ranked according to height, examined for disease, numbered, and marked with a wooden stake. Each saguaro visible in an aerial photo was also mapped (Figure 2). In all, 12,898 saguaros were recorded (Gill 1950). More details about original documentation and methods can be found in Appendix A.

To experimentally determine whether removing the diseased saguaros would increase the survivorship of those that showed no signs of the disease, Section 17 was divided into treatment control areas. In the northern half of the section, all saguaros were left alone, and simply monitored. But in the southern half of the section, all saguaros that showed signs of disease were removed by park staff working with Gill and Lightle (Figure 3). The giant cacti were pulled down, sawed into small sections, transported to a pit where they were fumigated with a mixture of kerosene and paradichlorobenzene (a pesticide), and buried (Gill and Lightle 1942; Figure 4).

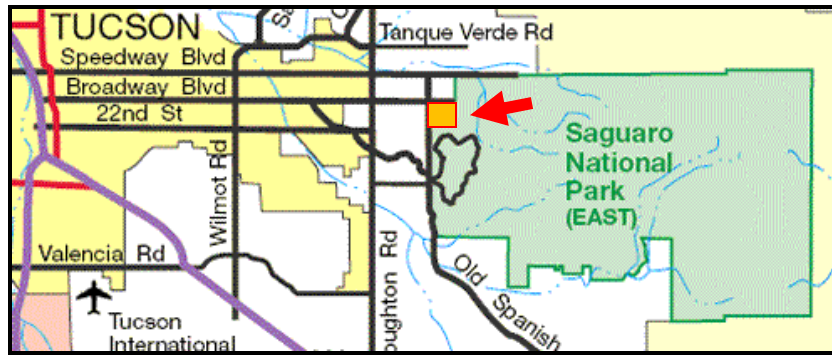


Figure 1: Location of “Section 17” (indicated by orange square), Rincon Mountain District, Saguaro National Park.

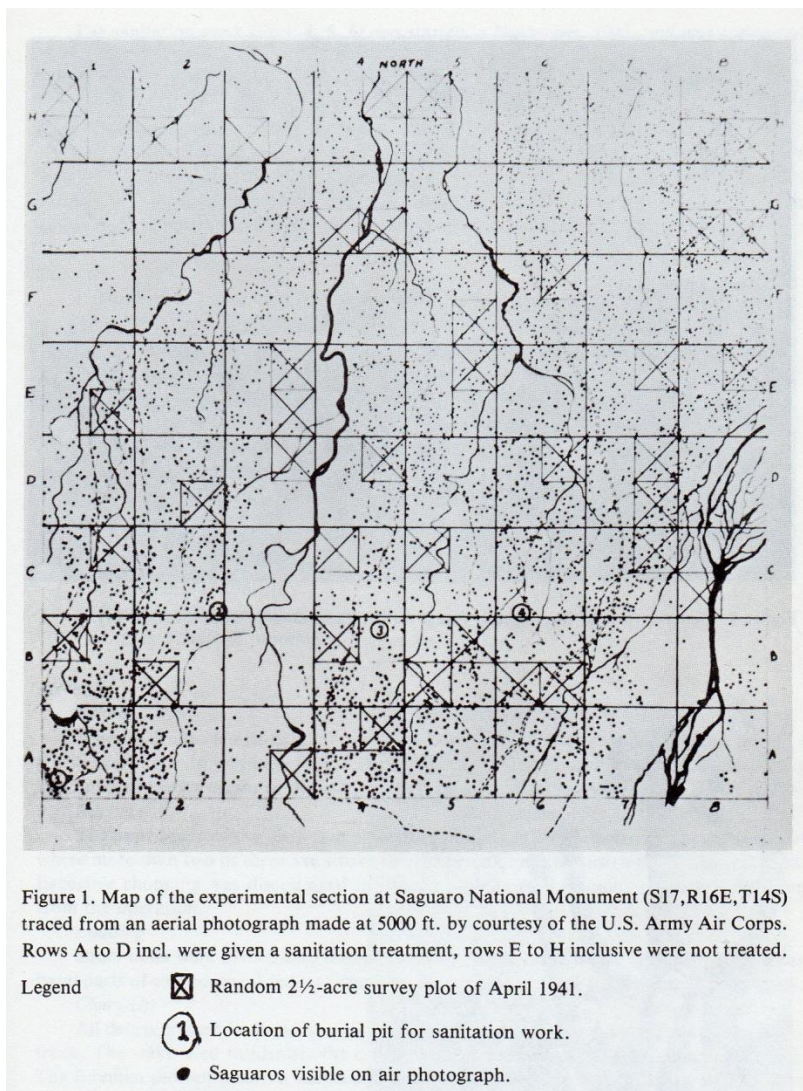
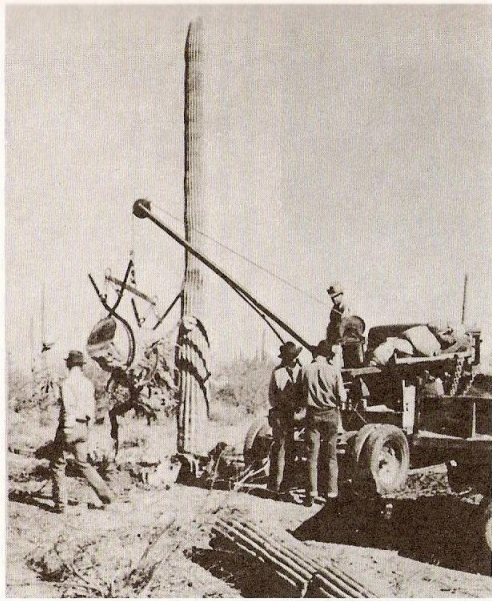
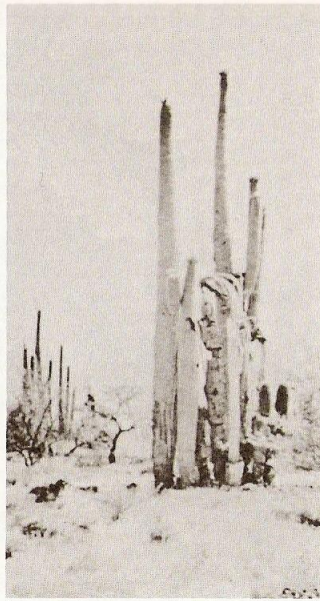


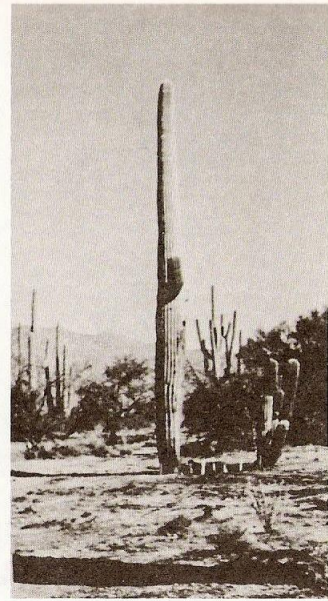
Figure 2. Map of Section 17 (reprinted from Steenberg and Lowe 1983). Each dot represents an individual saguaro. Dark irregular lines are washes.



A



B



C

Figure 5. A portable crane with iron tongs was used to load the heavier butt cuts and stumps (A) and was helpful in removing diseased cacti from group (B) without damaging the healthy members of the group (C).

Figure 3. Photos from the original report (Gill and Lightle 1942, reprinted in Steenbergh and Lowe 1983), showing methods for removing diseased saguaros from the southern half of Section 17.



Figure 4. Diseased saguaros were cut into pieces, hauled to pits, doused with kerosene and pesticide, and buried. Photo source unknown.

Although the original intent of the experiment was for saguaros in the southern half of the section to continue to be removed as they showed signs of the disease, this was not done due to labor shortages during World War II (Gill 1950). However, all cacti in Section 17 were monitored as planned for 5 years, and a subset were monitored for 5 more years.

Results, 1941 – 1950

Data collected on the 12,898 saguaros mapped and monitored in 1941 were published by Gill and Lightle (1942) and in a slightly different format by Steenbergh and Lowe (1983). The largest number were between 12 to 18 feet in height, and the great majority were over 12 feet tall (Figure 5).

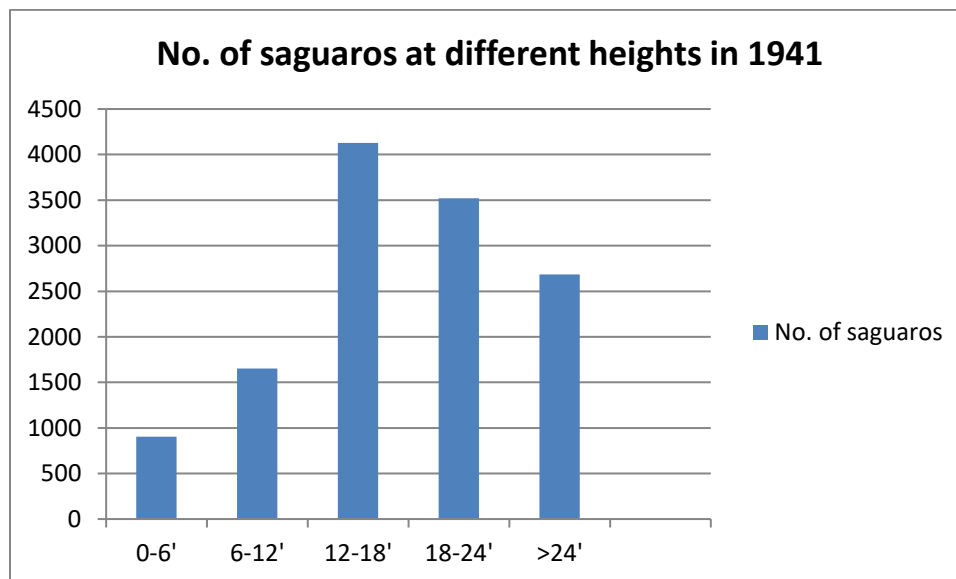


Figure 5. Heights of 12,898 saguaros in Section 17 in 1941. It is not completely clear in the results how Gill and Lightle classified saguaros by height class (they used 0-6', 7-12', etc., and nowhere do they address how they classified plants that were, for example 6.5' tall). Steenbergh and Lowe (1983) interpreted these height classes as 0-6.99, 7-12.99, etc. However, Stanley Alcorn, who inherited other monitoring plots from Gill and Lightle, used the 0-6, 6-12 height classes on his plots (Tom Orum, personal communication). We use Alcorn's interpretation, which seems more likely.

A preliminary report on the Section 17 study (Mielke 1944) indicated that while results of the control work appeared encouraging, other research was beginning to indicate that the disease was not contagious, but rather caused by a bacterium that was possibly carried by a moth. In addition, Mielke (1944) suggested that wood-cutting and over-grazing were major factors in the decline of the saguaro, which did not appear to be reproducing in the Cactus Forest.

However, in 1946 Gill and Lightle (1946) compared the results from the entire section through 1945 and found no significant difference was found in the survival of cacti in the southern vs. the northern halves of Section 17 (Figure 6). Although they expressed uncertainty about the implications of the research, a few years later Gill (1950) reported that results over the 10 full years of data on the six monitoring plots were consistent with the conclusion that the disease did not appear to be contagious. Although Gill was disappointed that the experiment could not be carried out as originally planned, with continued removal of diseased saguaros after 1941, he concluded that “rot” did not appear to be a disease that threatened to wipe out the saguaro as a species. He noted that mortality increased with the size of the plants and like Mielke (1944) pointed out that the continued lack of reproduction in the Cactus Forest was a major problem (Gill 1950).

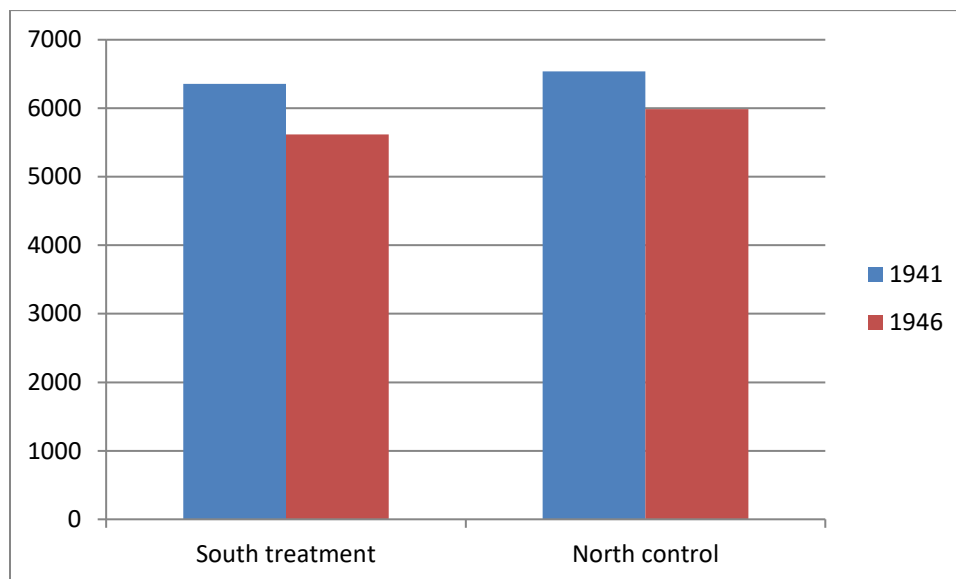


Figure 6. Number of living saguaros in Section 17 showing results of Section 17 saguaro experiment, 1941-1946, based on Table 1 in Gill and Lightle (1946). Removal of diseased saguaros did not increase survival of healthy ones remaining; indeed, more saguaros survived in the northern, control section.

Continued research on saguaros, 1941-present

Due to the negative results of the Section 17 experiment, attention turned to other potential causes of the decline of saguaros in Saguaro National Park. The decline continued for several decades (Figure 7) until the population began to show clear signs of rebounding in the early 1990s. Research in the 1950s focused on the disease called bacterial necrosis and potential insect vectors, while in the 1960s and 1970s the focus turned increasingly to ecological factors such as

the relationship between saguaros and nurse trees, the role of rodent herbivory, and the importance of climate, particularly freezing weather (see McAuliffe 1993, Ahnmark and Swann 2009).

It is noteworthy that, after Gill and Lightle completed their study, the 6 plots subsampled during 1946-1950 continued to be monitored annually – first by Stanley Alcorn, plant pathologist at the University of Arizona, and then by his research technician, Tom Orum, and Nancy Ferguson. These plots also formed the basis of many University of Arizona-based research studies. As of 2013, Orum and Ferguson are continuing to collect data on the 6 plots (Orum et al. 2010) in one of the longest monitoring studies conducted in any national park.

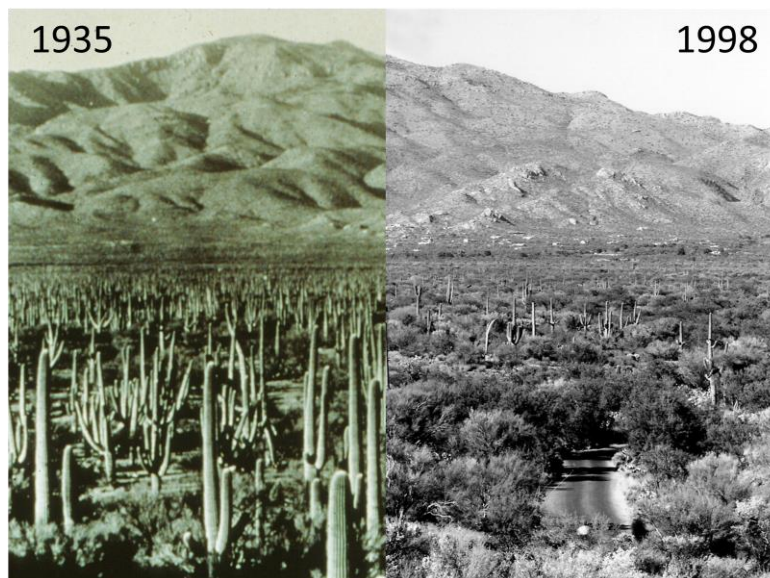


Figure 7. Montage of two photos showing the Cactus Forest, Section 17 area, in 1935 and 1998. Note not only the dramatic loss of large saguaros, but also the increase in nurse trees during the period; young saguaros are currently growing beneath many of these trees.

In retrospect, it appears likely that the immediate cause of the die-off of saguaros in the Cactus Forest in the late 1930s and early 1940s was the delayed effects of two intense freezes in 1937 and 1939. Saguaros are sub-tropical plants that cannot tolerate freezing weather, and older plants are particularly susceptible to freeze. After many years of the wood-cutting (which removed the saguaros' protective "nurse trees") and cattle grazing (which killed young saguaros due to trampling), the Cactus Forest was dominated by older, larger plants that were dying in large numbers. The black fluid they were oozing as they died appears to have been, in many cases, a secondary effect of tissue damaged by freezing, not disease. Similar die-offs were seen (and studied) after freeze events in the 1970s (Steenbergh and Lowe 1983), and older saguaros now also appear to be dying as a result of the deep freeze of February, 2011.

Also, Mielke (1946), Gill (1950), and many other researchers noted, the Cactus Forest was missing the most important age class of saguaros – the younger ones. As older individuals died in the 1940s, most were simply not being replaced. Gill (1950) predicted that the small classes of saguaro would be “practically non-existent by 1980” in the Cactus Forest.

This prediction was largely correct, but since 1980 a significant change has occurred. Beginning in the 1990s (Turner 1992), scientists began to see a large increase in the number of saguaros in Section 17 and throughout the Cactus Forest – younger individuals, now surviving under the palo verde and mesquite nurse trees that began to flourish after Saguaro National Monument was created, probably due to the protective policies of the National Park Service. Survival of young saguaros surged during the rainy years of the 1980s and early 1990s (Orum et al. 2010, O’Brien et al. 2011). Although this great increase has slowed since, it seems possible that the number of saguaros living in Section 17 is beginning to approach what it was in 1941. However, saguaros are very slow-growing, and the resurgence of the Cactus Forest cannot be seen on a landscape scale (Figure 7). An individual that germinated from a seed in 1970 is about 8 feet tall, and still hidden in the branches of its nurse tree.

The intensive study of saguaros in Section 17 provides Saguaro National Park with a great opportunity to study ecological change in the park’s Cactus Forest. In repeating the 1941 survey during 2011-2012, seventy years after the first survey, we were interested in these questions, including: How many saguaros are there in Section 17 today? How have the demographics of the population changed? Will the Cactus Forest someday resemble what it looked like when Saguaro National Park was created, and if so when?

Appendix: Notes on 1941 data sources and detailed methods

We are fortunate that much of the original data and many details and reports from the original Section 17 study have survived. In 1983, a number of documents that were held at Saguaro National Park were preserved by NPS scientist Warren Steenbergh and published in the *Ecology of the Saguaro* series that he co-wrote with University of Arizona professor Charles Lowe (Steenbergh and Lowe 1983). Although the location of the original photographs is unknown, the park possesses a copy of the original map of the saguaros in Section 17 (copies in Resource Management office and at the Western Archeological Conservation Center). The original log books, with the records for all of the 12,898 saguaros, have been preserved by long-time saguaro researchers Tom Orum and Nancy Ferguson, who have generously provided the park with a copy.

Prior to the experiment, beginning in 1940, engineering students from the University of Arizona divided Section 17 into a total of 64, 10-acre blocks. Each corner was marked by a wooden stake. In September, 1941, work began on collecting data on all saguaros in the section. Every living saguaro was identified with a wooden numbered stake. The numbers started with No. 1 in the in

the Southwest corner of each 10-acre quadrat, and progressing in north-south strips to the east edge of the quadrat.

Data collected on saguaros in southern half of Section 17 coincided with the removal of diseased saguaros on this half between November 1941 and January 1942, and continued through March 1942 on the northern half. Data collected on each cactus included height to the nearest 6 feet; serious mechanical injuries, if any, due to removal of nearby diseased saguaros; extent and degree of disease condition; and misc. notes. The data were recorded in the log books. It is not reported what method the researchers in 1941 used to measure height. Following the original establishment of the study, all saguaros were examined annually through 1945, and notes were made regarding their disease condition or death. Between 1945 and 1950, these notes were only made on a subsample on 6 of the original 64 blocks.

At some point during 1941, all of the saguaros were recorded on a map (Figure 1) that was traced from an aerial photograph taken from 5000 feet by the U.S. Army Air Corps. Different versions of this map exist; on the version published by Steenbergh and Lowe (1983), the burial pits, main plots, and subplots are clearly marked. Unfortunately, because the saguaros on the map are not numbered it seems unlikely that we will be able to locate, with certainty, those that have survived until today.

The 6 plots used to monitor saguaros during 1945-1950 (Gill 1950) are the same ones now monitored by Tom Orum and Nancy Ferguson (Orum et al. 2010). Gill and Lightle (1942) also established 6 smaller plots in Saguaro National Monument; two of these are in Section 17. These plots have been re-surveyed 3 times: in the 1970s, 2000, and 2011 (Steenbergh and Lowe 1983; Funicelli and Turner 2002; Saguaro National Park, unpublished data).

Note: Saguaro National Park repeated the Section 17 study during 2011-2012, and results are published in a paper by Conver et al. (2017).

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