

2006-2007 Saguaro Cactus Census Saguaro National Park

FINAL REPORT TO:

Friends of Saguaro National Park

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Saguaro National Park
Tucson, AZ

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Executive Summary

In 2006 and 2007, the Friends of Saguaro National Park funded an effort by the park to collect census data from saguaro monitoring plots first established in 1990. Led by park personnel, volunteers revisited ten (10) plots throughout both districts of the park and measured all detected saguaros to the nearest tenth of a meter. Teams also recorded data regarding saguaro health and number of arms. When compared to data from the 1990 survey, the 2006-2007 census efforts yielded encouraging results. In all plots visited, saguaro recruitment (the establishment of seedling saguaros) increased significantly. After many decades of decline, the overall size of the saguaro population at the park appears to be continuing the increase first observed in the late 1970s.

Since its inception as a National Monument in 1933, Saguaro National Park's consistency in monitoring the status of its saguaro population has led to greater knowledge of the ecology and conservation of the park's namesake cactus. This study provided valuable lessons for the park and helped to lay the groundwork for the next major survey of the park's saguaro population in 2010.



Figures 1-2. Volunteers from the Sierra Club measure saguaro cacti directly (left), and indirectly using a tape measure and clinometer (right), during the 2006-2007 saguaro cactus census.



Figures 3-4. Student Conservation interns Jen Oliphant (left) and Cristina Andruk (right) measure saguaros. The SCA team played a major role in 2007 long-term saguaro and plant monitoring at the park.



Figures 5-6. Student Conservation intern Lyndsey Sloat (left photo, left side), Sierra Club volunteers, and park biologist Mark Holden (right photo) measure saguaros. Note light-colored patch of invasive buffelgrass (*Pennisetum ciliare*) in background of right photo.

Introduction

Saguaro National Park was established in 1933 for the purpose of protecting the saguaro cactus (*Carnegie gigantea*) and the associated Sonoran Desert ecological community. Since that time there has been significant ecological change in the park, including the dramatic decline, noticed soon after the park was created, of the large stand of saguaros in the park's signature "cactus forest" at the base of the Rincon Mountains. Although the original landscape character of the cactus forest is largely now gone, a surge in recruitment since the 1970s indicates that the saguaro population is increasing (Turner and Funicelli 2000).

The park has a long history of saguaro monitoring by researchers both within and outside the National Park Service. One series of plots, established in 1941 by L.S. Gill and P.C. Lightle, has been surveyed almost annually through 2006 by researchers Stanley M. Alcorn, Tom Orum, and Nancy Fergusen. Almost twenty years ago, the park began a long-term effort to monitor saguaro cactus populations within Saguaro National Park. In 1990, 45 4-hectare (10 acre) saguaro monitoring plots were established in the park by researchers Dan Duriscoe and Sandra Graban. Of these, 25 plots are located in the Rincon Mountain District (RMD) and the remaining twenty in the Tucson Mountain District (TMD). Researchers recorded physical characteristics related to cactus health, such as the number of arms, presence of spines, physical injuries, and most notably, the extent of epidermal browning. Duriscoe and Graban also mapped perennial vegetation and performed a census of saguaros on all 45 plots. These data were recorded, cataloged and finalized in a report published the following year (Duriscoe and Graban 1991).

In 2000 these plots were re-surveyed, this time by park researchers Dale Turner and Carianne Funicelli. Each plot was revisited and critical data representing a ten-year period of change on saguaro height, recruitment and effects of epidermal browning were recorded and published in their two-part report (Turner and Funicelli 2000, Funicelli and Turner 2000). However, due to time and personnel constraints, Turner and Funicelli only performed a complete saguaro census on eighteen plots. The goal of the 2006-2007 study was to collect census data on some of the remaining 27 plots. This effort was intended to fill in the gaps from 2000, but also to look at recruitment and survival of saguaros since 2000, and to refine methods in advance of the next major saguaro census of all 45 plots scheduled for 2010.

Methods

In 2006 and 2007, we revisited a total of ten plots. Of these ten plots, seven are in TMD (plots 27, 28, 29, 32, 35, 37, and 44) and three (plots 1, 9, and 20) are located in RMD (Figures 7 and 8). The effort was organized by park staff (Mark Holden, Don Swann, and Bethany Hontz) and by three SCA interns (Jen Oliphant, Lyndsey Sloat, and Cristina Andruk). We used volunteers from The Sierra Club, Arizona Native Plant Society, and several University of Arizona students.

Methods for the saguaro census were the same as described by Turner and Funicelli (2000). The plot corner markers were located using GPS, and the sides of the plots were flagged in advance. Volunteer teams of three or four individuals moved on belt transects across the plot, flagging and measuring each saguaro encountered and recording the height, number of arms, and other data. Small saguaros were measured directly using a tape measure or meter stick, and larger saguaros were measured indirectly using a tape measure and clinometer. After all saguaros on a transect had been measured and flagged, the transect was re-walked to find any saguaros that might have been missed, then walked a third time to remove flags. Most plots could be sampled in one six-hour day with a crew of about four staff and twelve volunteers, but plots with large numbers of saguaros or those in very remote or steep areas sometimes required a two-day effort.

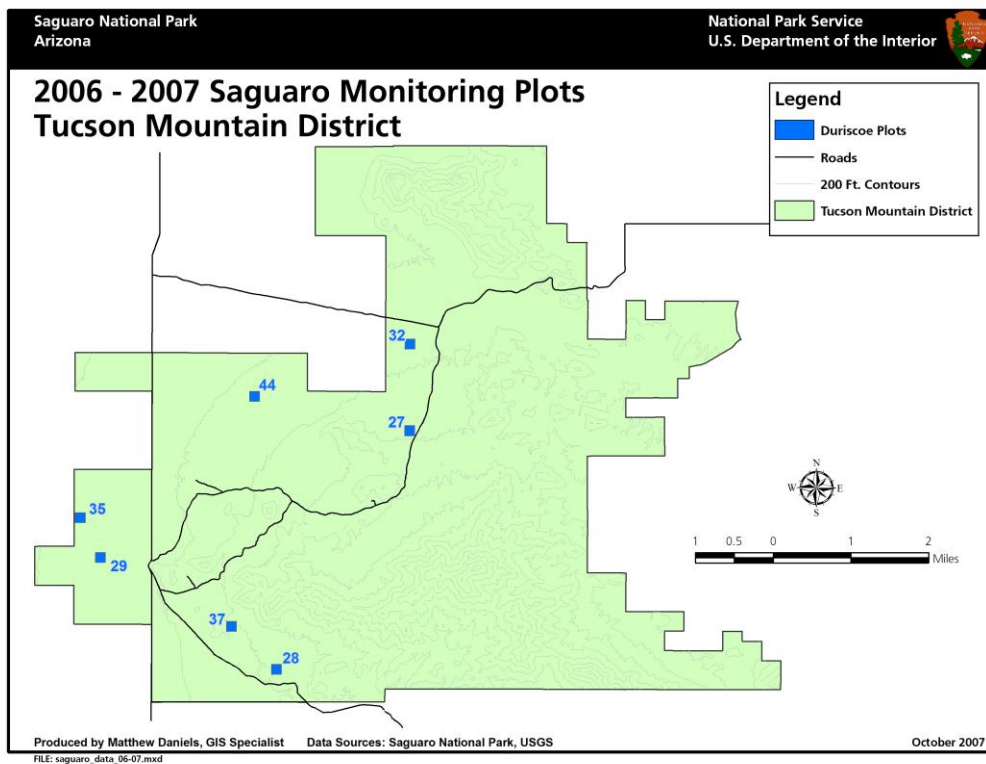


Figure 7: 2006-2007 saguaro census plot locations, TMD (Plot numbers denoted from 1990 Duriscoe and Graban survey)

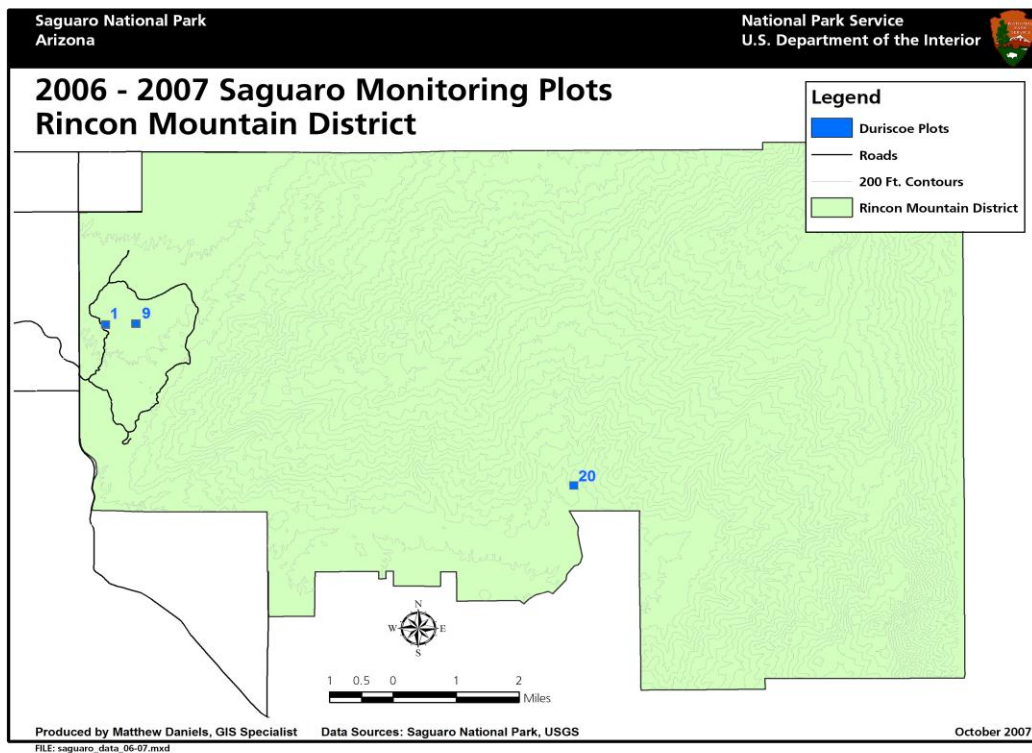


Figure 8: 2006-2007 saguaro census plot locations, RMD (Plot numbers denoted from 1990 Duriscoe and Graban survey)

Results

Population Size. Seven of the twenty plots at TMD that were surveyed in 1990 were re-surveyed during 2006 and 2007. In 1990, the census total was 1,536 saguaros (Duriscoe and Graban 1991). In 2006-2007, the total was 2,970 cacti, an overall increase of 93% (Figure 9, Table 1). Saguaros increased on all plots (Appendix A); four of the plots increased 100% or more over the 16 year period.

At RMD, a total of 278 saguaros were observed on plots 1, 9, and 20 during the 1990 census. In 2006-2007, the total was 882 cacti, an overall increase of 217% (Figure 9, Table 1). All three plots increased approximately 200% during the sixteen years since they were last monitored.

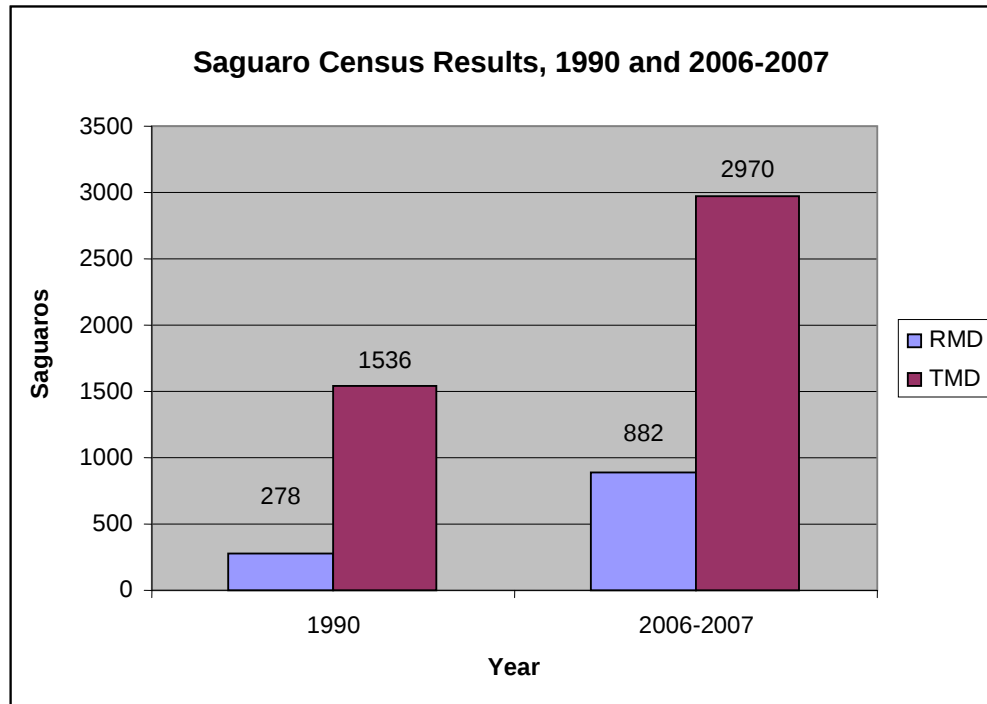


Figure 9: Total saguaros observed, 1990 and 2006-2007 on seven monitoring plots in TMD (27, 28, 29, 32, 35, 37, and 44) and three RMD plots (1, 9 and 20). 1990 data from Duriscoe and Graban (1991).

Size Distribution. In both districts of the park, the number of young saguaros increased from 1990 to 2006-2007 (Figures 10 and 11). In 1990, Duriscoe and Graban observed 365 saguaros ≤ 0.5 m on the seven TMD plots. In 2006-2007, those same plots yielded 937 saguaros of the same height class, an increase of 157%. On the three plots at RMD, Duriscoe and Graban recorded 36 saguaros ≤ 0.5 m. The 2006-2007 census recorded 231 individuals on these same plots, an increase of 542%.

District	Plot #	1990	2006-2007	Increase	Percent Increase
TMD	27	119	290	171	144%
	28	386	528	135	35%
	29	84	244	160	190%
	32	95	247	152	160%
	35	194	388	194	100%
	37	525	908	383	73%
	44	133	365	232	64%
	TOTAL	1,536	2,970	1,434	93%
RMD	1	40	117	77	193%
	9	55	183	128	233%
	20	183	582	399	218%
	TOTAL	278	882	604	217%

Table 1: Number of saguaros observed and percent increase on saguaro monitoring plots at TMD (7) and RMD (3), 1990 and 2006-2007.

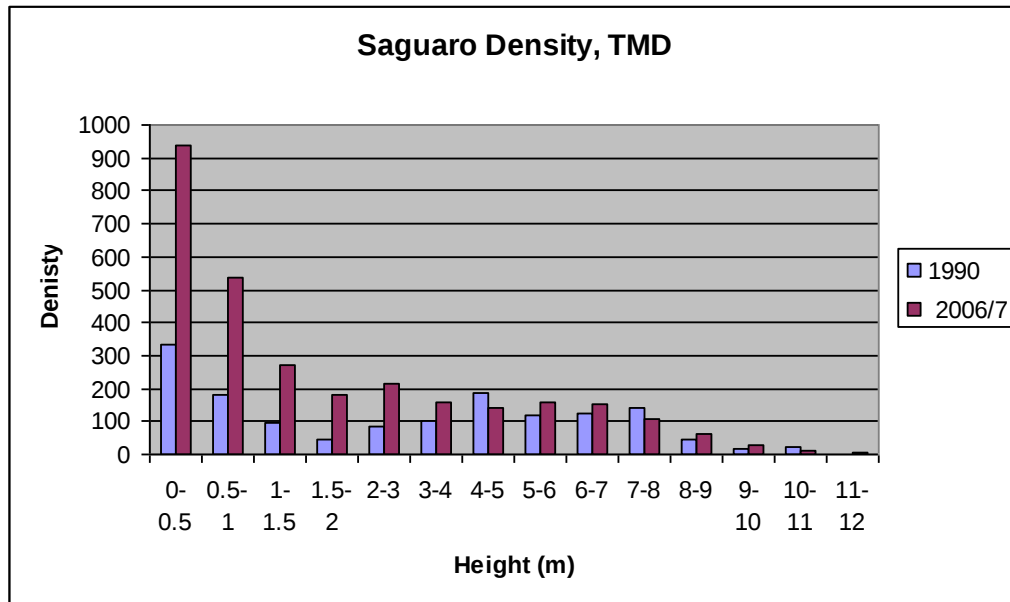


Figure 10: Saguaro density by size class in the seven plots resurveyed in TMD, 1990 and 2006-2007 [see Duriscoe and Graban (1991) and Appendix B for data].

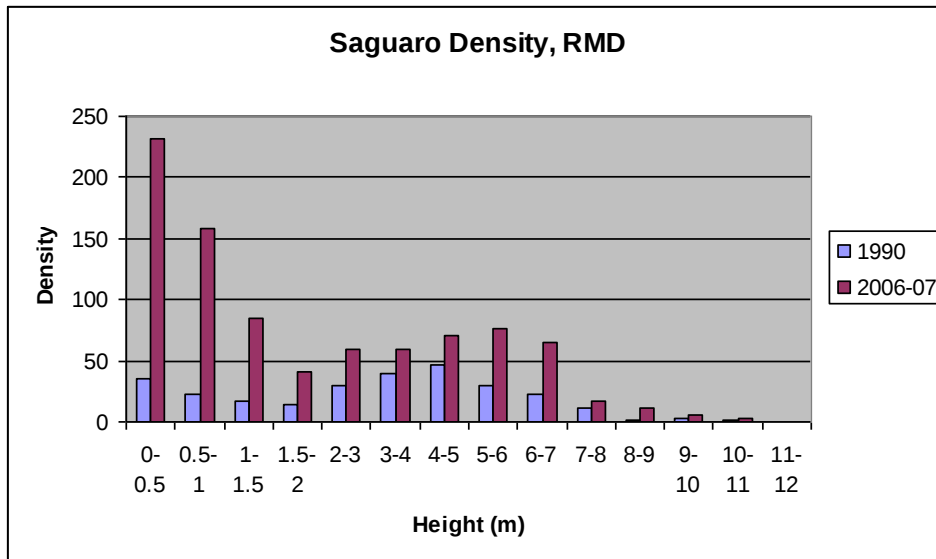


Figure 11: Saguaro density by size class in three RMD monitoring plots, 1990 to 2006-2007 [see Duriscoe and Graban (1991) and Appendix B for data].

Average Seedlings Per-plot. It is not possible to determine directly whether there has been a more recent (since 2000) increase or decrease in the number of young saguaros, since none of the plots sampled in 2006-2007 were sampled in 2000. However, we can compare the mean number of saguaros in small size classes per plot in 2000 and 2006-2007. For size classes ≤ 0.5 m between 2000 and 2006-2007 (Figure 12), recruitment at RMD appears to show a very slight increasing trend. In TMD, results from 2006-2007 showed there to be fewer saguaros in all small size classes, and particularly in the 0.1 to 0.2 m size class, compared to 2000.

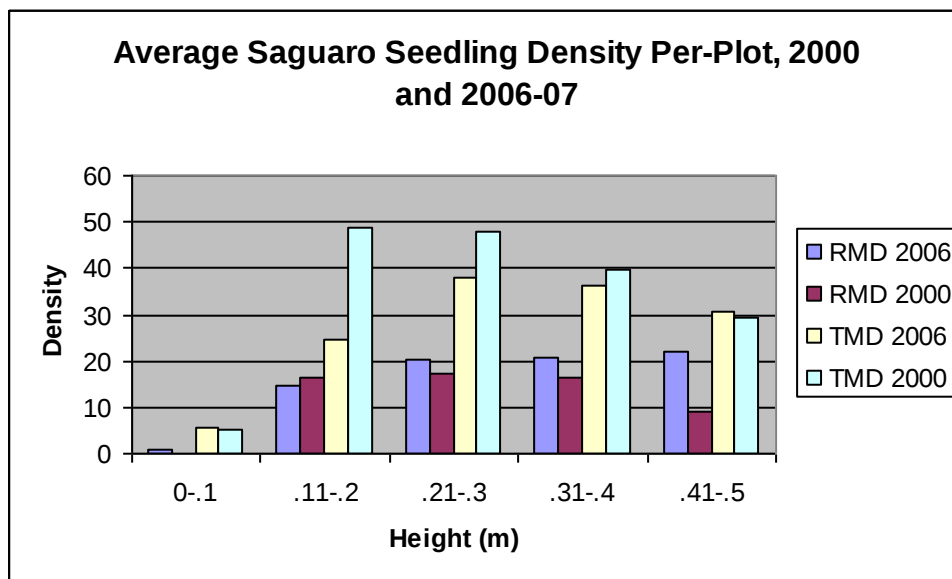


Figure 12: Mean density of young saguaros per plot, 2000 and 2006-2007. 2000 data from Turner and Funicelli (2000) for 18 plots (9 in each district). 2006-2007 data is for 10 plots (3 at RMD and 7 at TMD).

Discussion

For nearly four decades after the establishment of Saguaro National Park, the park's greatest management concerns were the alarming increase in the mortality of mature saguaros and the lack in recruitment of young saguaros to replace the falling giants. In fact, in the early 1960s, two researchers stated that it was likely that saguaros would be extirpated from the park by the year 2000 (Alcorn and May 1962). The Tucson Mountain District was established in 1961 in part because of concerns that saguaros were dying off in and around the Rincon Mountains. By the 1970s many scientists working on the problem believed that the lack in recruitment of young saguaros was caused largely by land use practices stemming from Tucson's mining boom in the 1800s, specifically cattle grazing and wood-cutting that had removed the protective "nurse plant" canopy. Repeat photographs by Ray Turner and other data indicated that as these impacts were reduced and eliminated, habitat conditions for the establishment of saguaro seedlings improved. By the 1970s, evidence from long-term plots suggested that saguaros were beginning to rebound (Orum 1991, Turner 1992). The Duriscoe and Graban census in 1990 confirmed these changes, as did a repeat of their census by Turner and Funicelli in 2000.

Although our 2006-2007 census draws from a relatively small subset of Duriscoe and Graban's plots, the results are consistent with previous findings that a great increase in recruitment of young saguaros has occurred in both districts of the park. Indeed, in a direct comparison of plots between 1990 and 2006-2007, the number of saguaros ≤ 0.5 m in height increased a dramatic 157% at TMD and 542% at RMD. Every plot sampled in 2006-2007 showed an increase in the number of saguaros, and saguaros on some plots more than doubled. If survival of these young saguaros remains high, we can expect that during the next few decades visitors will begin to see a landscape with many large saguaros at RMD that looks increasingly similar to the view that existed when the park was created in the 1930s.

It is worth noting, however, that recent data from one long-term (since 1942) monitoring study at RMD indicates that recruitment of very young saguaros may again be in decline (T. Orum, pers. comm.). The three plots we sampled at RMD did not confirm this trend. Indeed there were more saguaros found on average in small size classes in 2006-2007 than were found in 2000. However, our results do suggest that recruitment of the smallest size classes may be slowing at TMD. It is important to point out that our data are based on small sample sizes, and could be confounded by differences in the ability to locate small saguaros during the two sample periods due to differences in ground cover. In general, conditions in 2006-2007 were dryer than in 1990 or 2000, which might have made it easier for observers to find smaller saguaros.

While individual saguaros likely become established whenever conditions are favorable, saguaros are thought to establish episodically in relatively large, even-aged groups called 'cohorts.' These incidents of establishment are supported by consecutive years of favorable climatic conditions, with above-average precipitation and moderate temperatures, that may occur only a few times each century. Young saguaros have highly variable growth rates, but they are very slow growers by any calculation; individuals between 0.2 and 0.4 m are typically between 15 and 25 years in age (Steenberg and Lowe 1983). This suggests that if recruitment has slowed at TMD it may have begun with the drought conditions that have prevailed in southern Arizona since the early 1990s. The possible decrease in recruitment of saguaros is of negligible concern for the immediate fate of TMD's saguaro population, but its occurrence could become important in the future. Nevertheless it is safe to say that the current population of saguaros at Saguaro National Park appears to be quite healthy and has continued to increase.

Recommendations

Saguaros are the signature species of Saguaro National Park, and long-term monitoring of their health and population size has been, and should continue to be, the most important research and monitoring priority at the park. The 1990 study by Duriscoe and Graban is a model study for any national park in that it established a well-designed, well-documented monitoring program of both health and demographics that can be easily repeated at regular intervals. In 2000, a similar dedicated effort by Pam Anning, Dale Turner, Carianne Funicelli, Mark Holden, and other biologists repeated much of Duriscoe and Graban's efforts and improved upon their documentation through the creation of a GIS database. The 2000 study estimated the number of saguaros in each district of the park, added some additional plant monitoring components, and documented the continuing surge in the saguaro population.

The 2000 study occurred during the same time as the decadal US national census. The coincidence of the two events provided a great deal of valuable publicity for Saguaro National Park and its namesake cactus. It is the park's intention that the saguaro census be repeated along with the US census in 2010, and it is strongly suggested that this should occur. It is beyond the scope of this paper to make specific recommendations as to what activities are most important in 2010, but we do feel that monitoring of saguaro population size and recruitment should be emphasized. The great value of this census, in addition to the scientific benefit, is that it provides welcome publicity for Saguaro National Park and a wealth of public education on the saguaro and the Sonoran Desert.

The participation of so many volunteers is an added benefit. In 2006 and 2007, as in 2000, the active engagement of a large number of citizen scientists made conducting the census activities enjoyable and educational. With proper training and safety procedures that have been established and tested, the saguaro census is an excellent example of citizen participation in NPS resource management activities. We enjoyed working with volunteer groups and felt confident in the quality of the data that they gathered.

When the 2010 census is conducted, it is imperative that emphasis be placed on access to electronic and printed copies of 1990 and 2000 data. The amount of data accrued in this long-term study is already somewhat daunting, but it has been relatively well managed and archived at the park thanks to Pam Anning and Matt Daniels. It was relatively easy to retrieve and use data from 1990 and 2000 to design this study and complete this report. Thus, it is important that data gathered during 2010 be similarly organized and made accessible in both hard and electronic formats.

Finally, we are convinced that our census effort in 2006-2007 emphasizes the importance of conducting surveys of a smaller subset of saguaro plots at less than ten year intervals. While a ten-year interval is certainly adequate for gathering long-term data on this slow-growing and long-lived species, intermittent surveys of a few plots can provide valuable insight on recruitment tendencies between the decadal surveys. Additionally, reading saguaro plots at shorter intervals provides the opportunity for new staff to dust off and test old monitoring protocols and prepare for the next ten-year census. It is rare that the individual employees in a national park who organize one census will still be employed at the park a decade later – a fact that has doomed many long-term monitoring programs. Conducting saguaro surveys at more frequent intervals can hopefully provide the familiarity needed to ensure the continuation and improvement of this effort in future decades.

Electronic copies of this report and field data sheets can be found on the park's server under < N:\GPS\Long-term Plant Monitoring\Saguaro_Perennial Veg Monitoring Plots\2006-2007 Saguaro Census>.

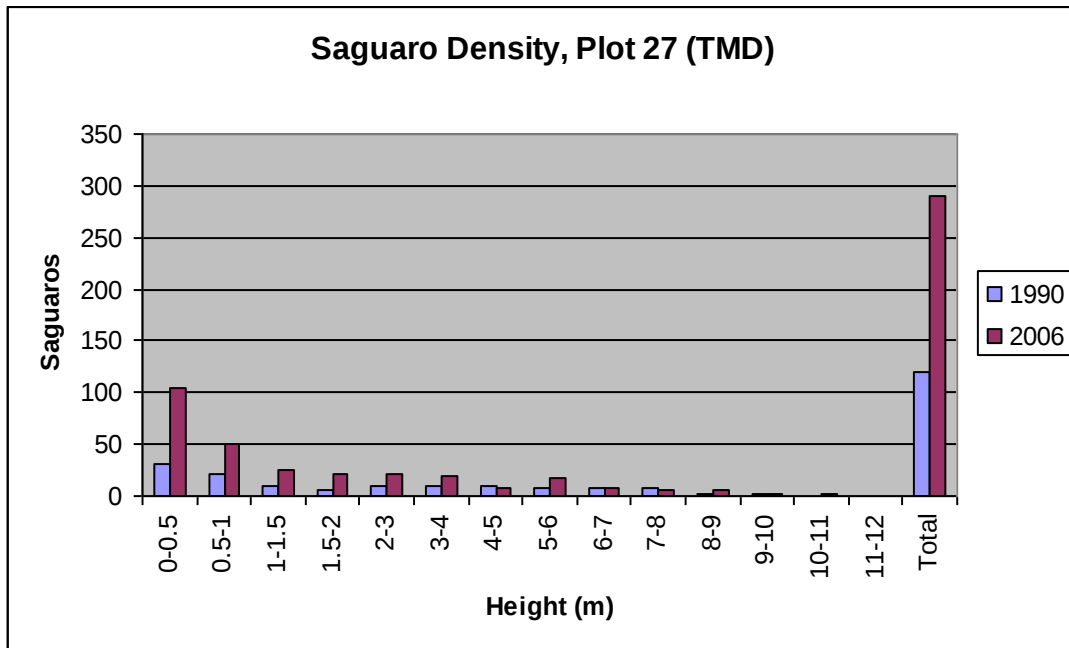
Literature Cited

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- Turner, R.M. 1992. Long-term saguaro population studies at Saguaro National Monument. In Stone, C. P., and E. S. Bellantoni, eds. Proceedings of the symposium on research in Saguaro National Monument. National Park Service, 1992.



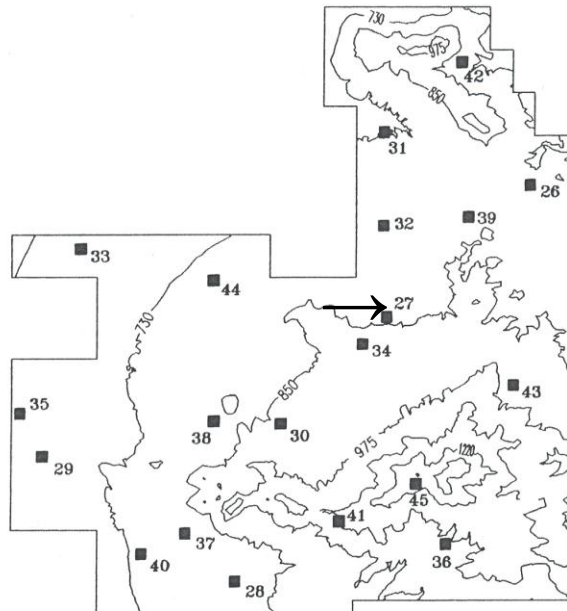
Appendix A

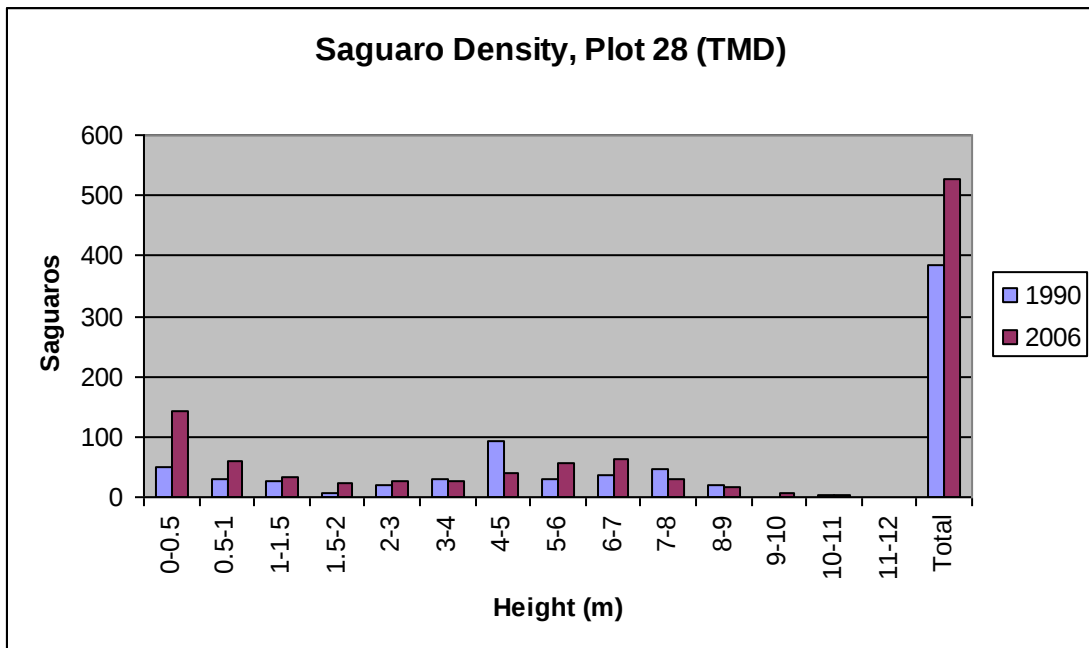
Included within this appendix are population data and figures for each plot visited during the 2006-2007 census.



Saguaro Density by Height Class, Plot 27 (TMD)

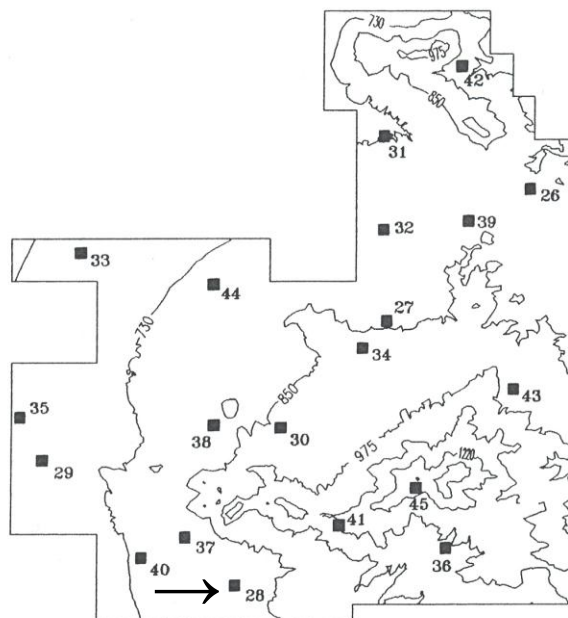
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27	1990	30	21	10	6	9	10	9	7	7	7	2	2	0	0	119
27	2006	104	51	25	22	22	20	8	18	7	5	6	1	1	0	290

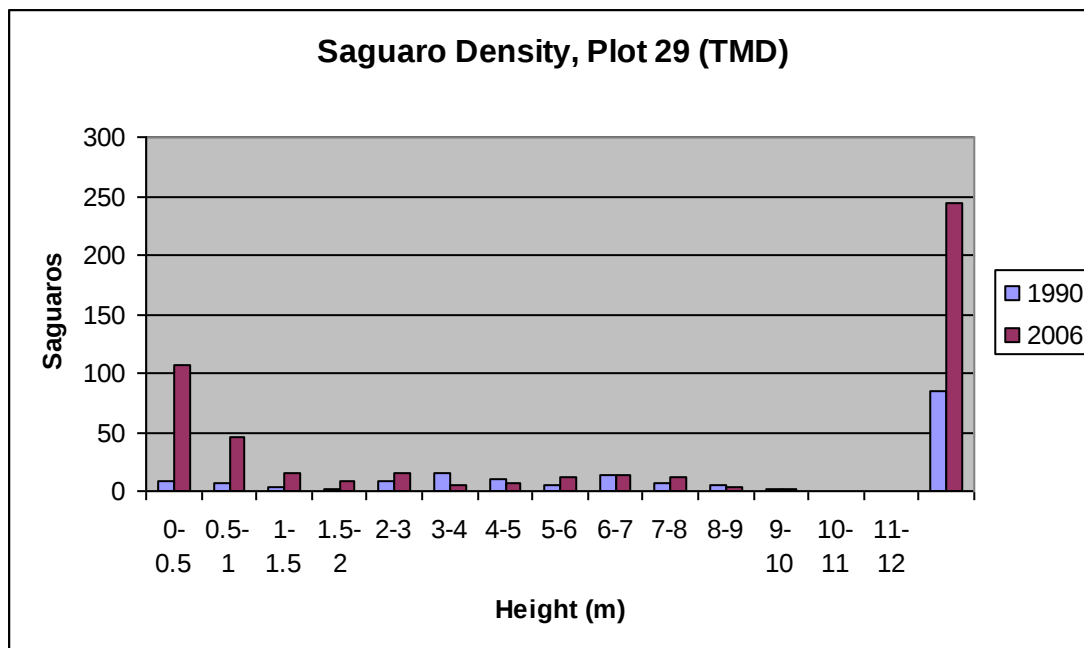




Saguaro Density by Height Class, Plot 28 (TMD)

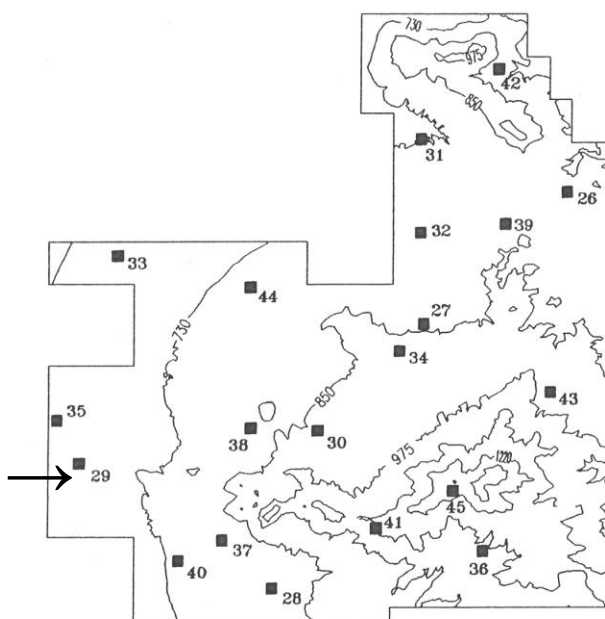
Plot	Year	0-0.5	0.5-1	1-1.5	1.5-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	Total
28	1990	49	29	25	8	19	28	94	28	38	47	19	0	2	0	386
28	2006	143	59	34	23	28	27	39	56	63	30	16	7	3	0	528

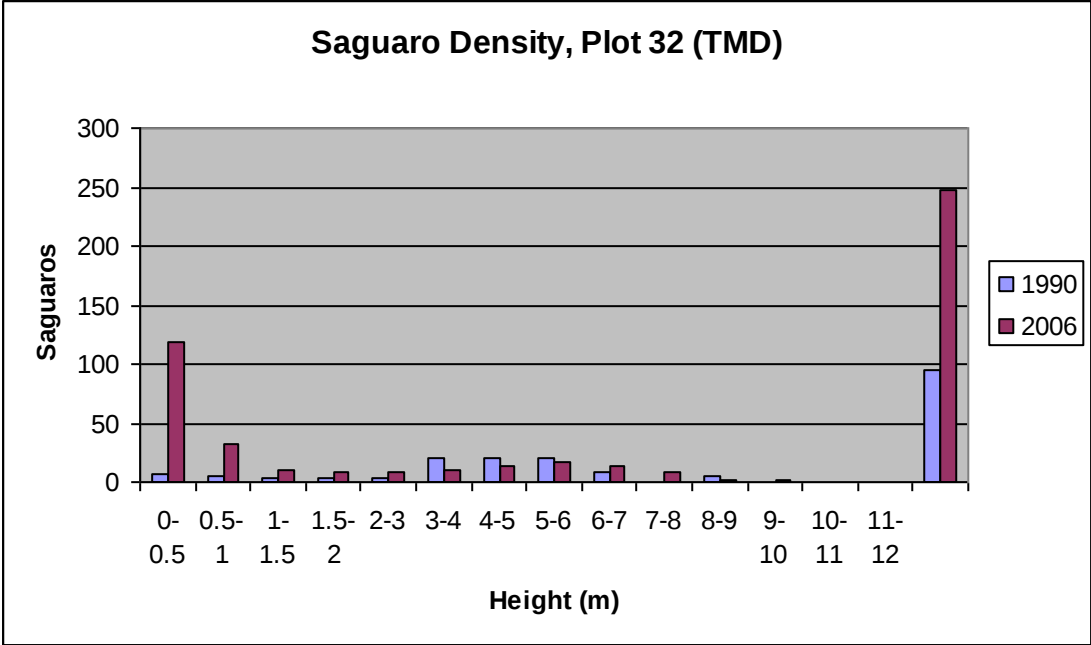




Saguaro Density by Height Class, Plot 29 (TMD)

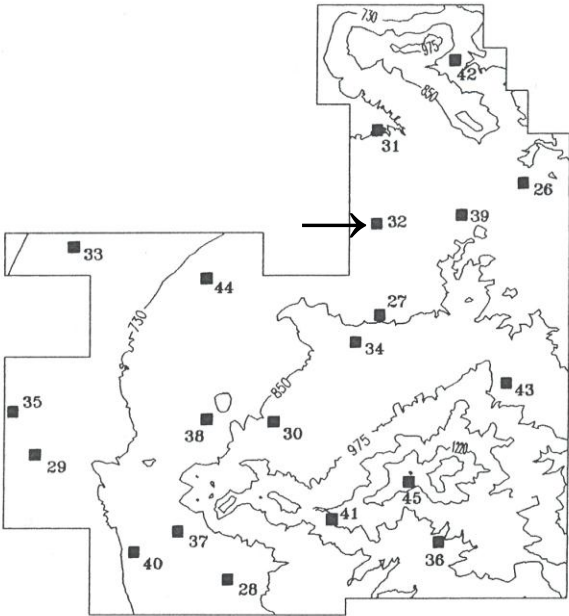
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29	1990	8	6	4	1	9	15	11	4	13	7	4	2	0	0	84
29	2006	107	45	15	9	15	5	7	12	13	12	3	1	0	0	244

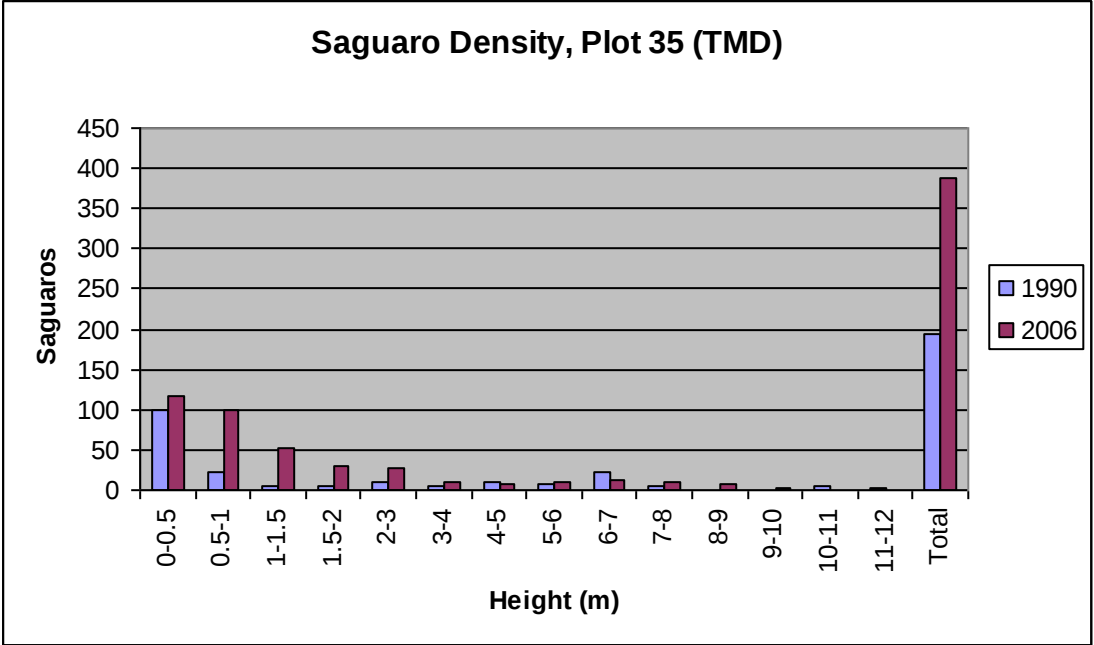




Saguaro Density by Height Class, Plot 32 (TMD)

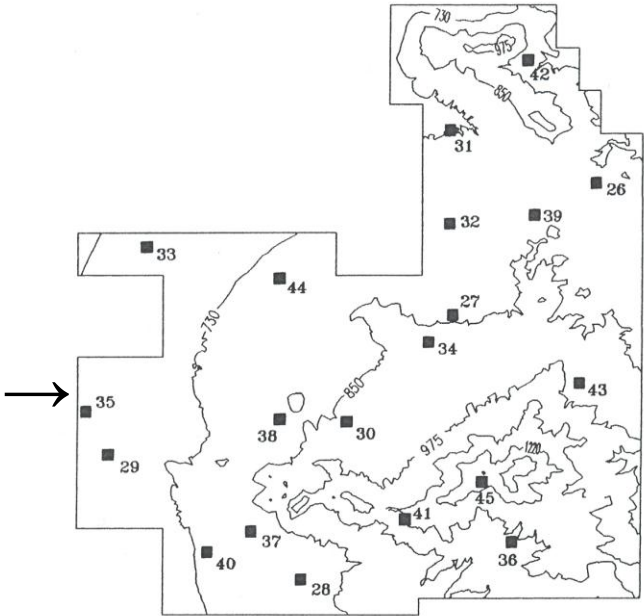
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32	1990	7	5	3	3	3	21	20	20	8	0	5	0	0	0	95
32	2006	119	33	11	8	9	11	13	17	14	8	2	2	0	0	247

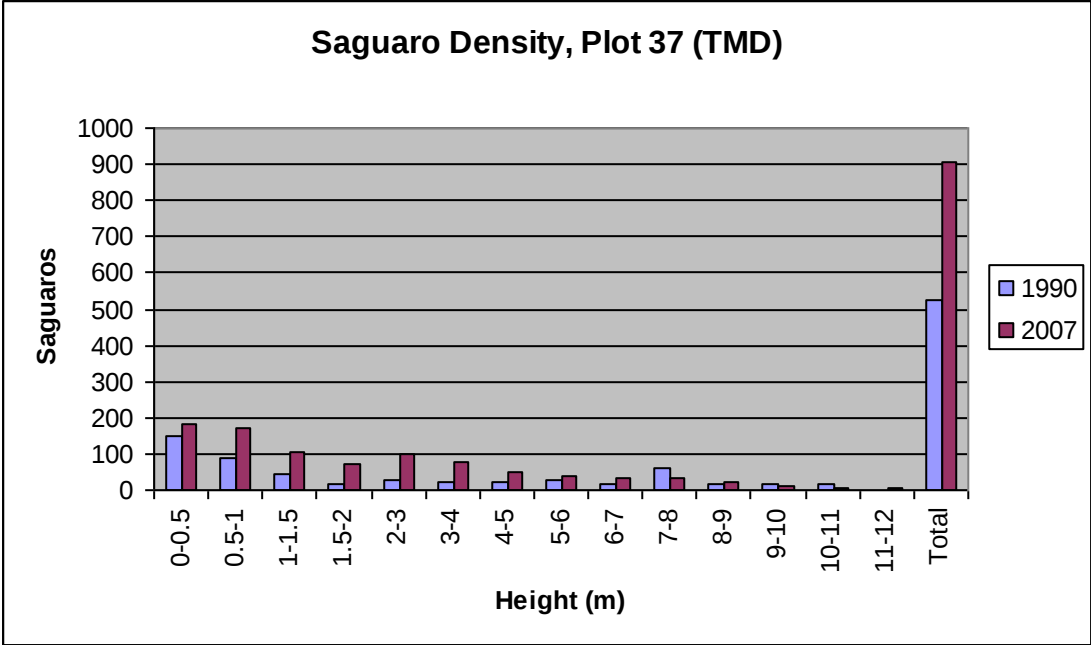




Saguaro Density by Height Class, Plot 35 (TMD)

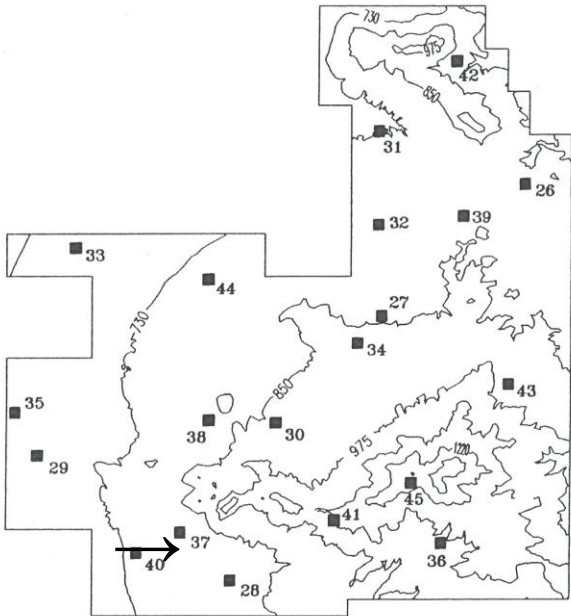
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35	1990	100	22	4	4	9	4	11	7	23	4	0	0	4	2	194
35	2006	118	99	53	31	27	9	7	9	13	11	7	3	0	1	388

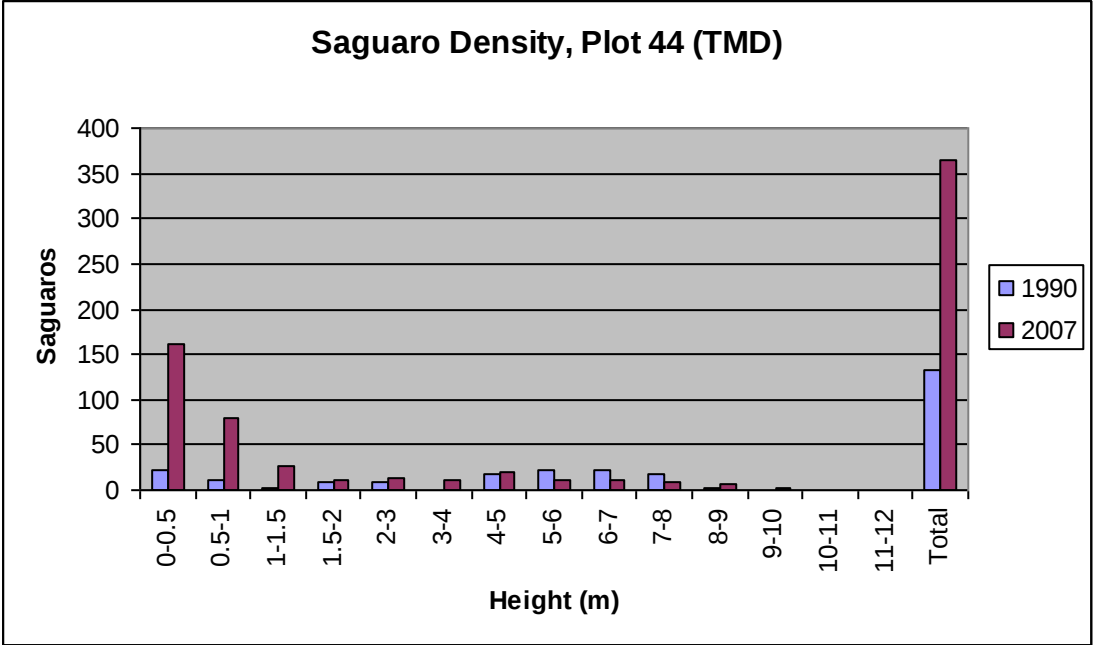




Saguaro Density by Height Class, Plot 37 (TMD)

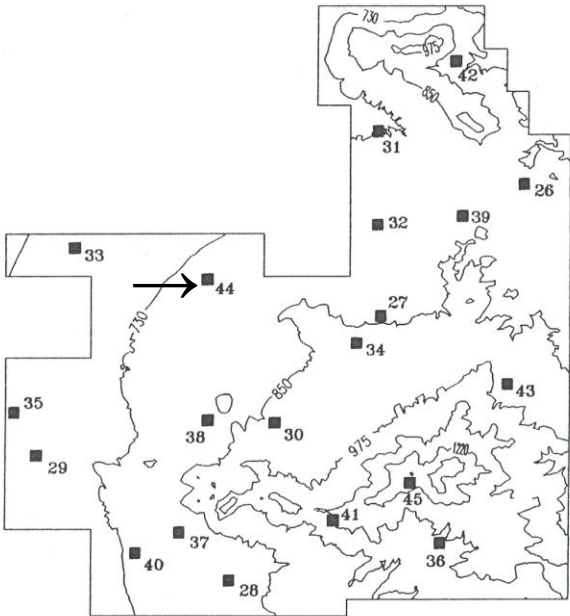
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37	1990	149	89	45	15	30	23	23	30	15	61	15	15	15	0	525
37	2007	184	172	107	73	98	75	48	36	33	34	22	12	8	6	908

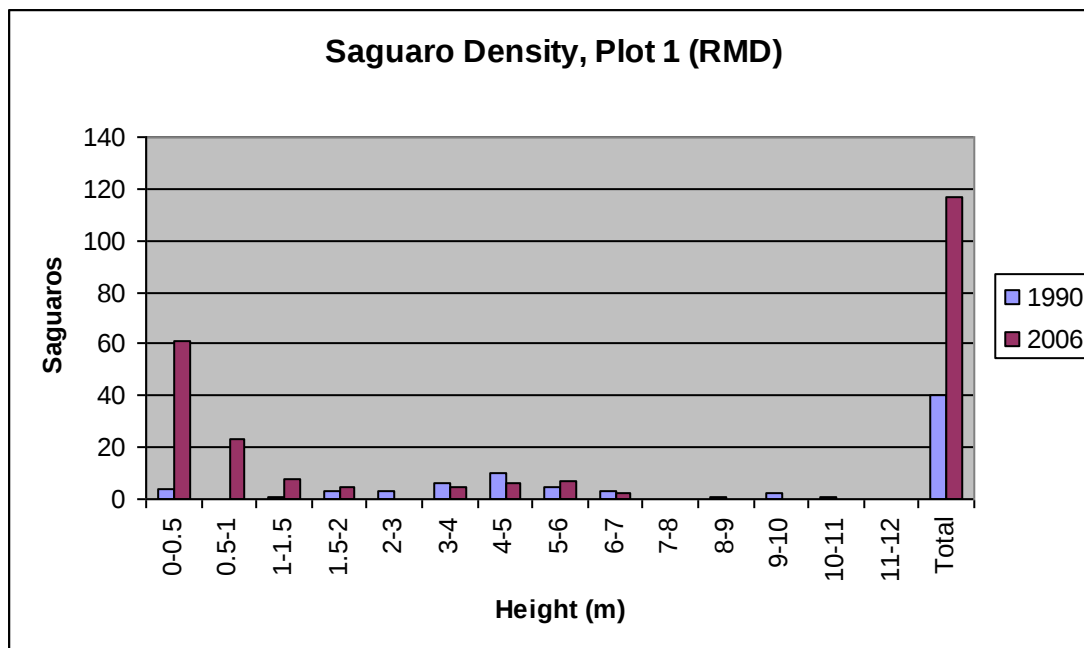




Saguaro Density by Height Class, Plot 44 (TMD)

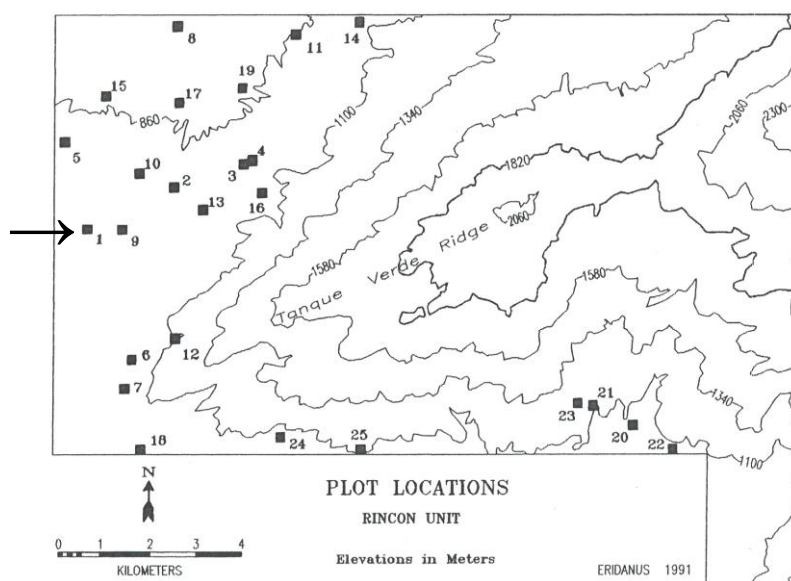
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44	1990	22	11	3	8	9	0	18	21	21	18	3	0	0	0	133
44	2007	162	80	27	12	14	10	19	12	12	9	6	2	0	0	365

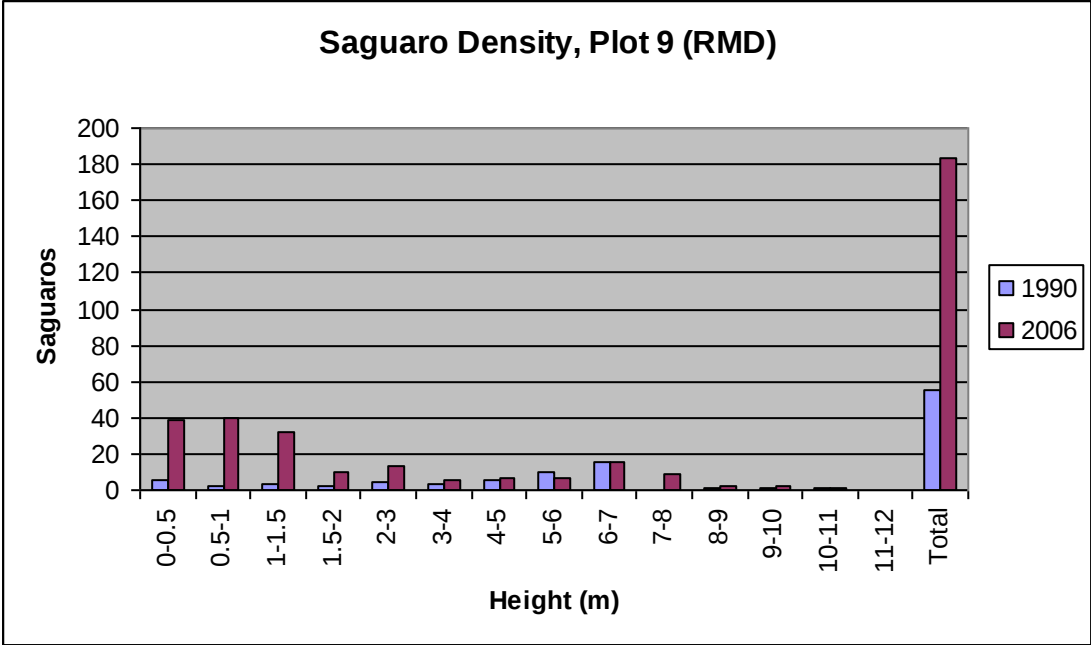




Saguaro Density by Height Class, Plot 1 (RMD)

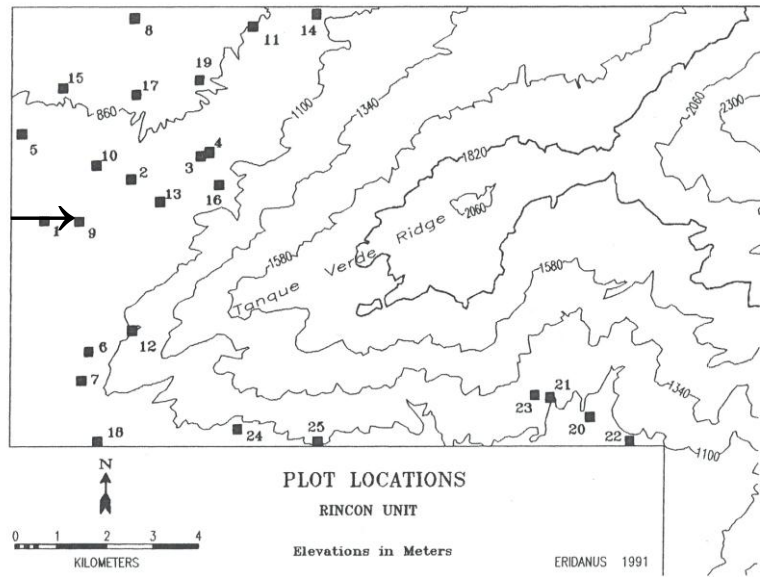
Plot	Year	Height (m)														Total
		0-0.5	0.5-1	1-1.5	1.5-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	
1	1990	4	0	1	3	3	6	10	5	3	0	1	2	1	0	40
1	2006	61	23	8	5	0	5	6	7	2	0	0	0	0	0	117

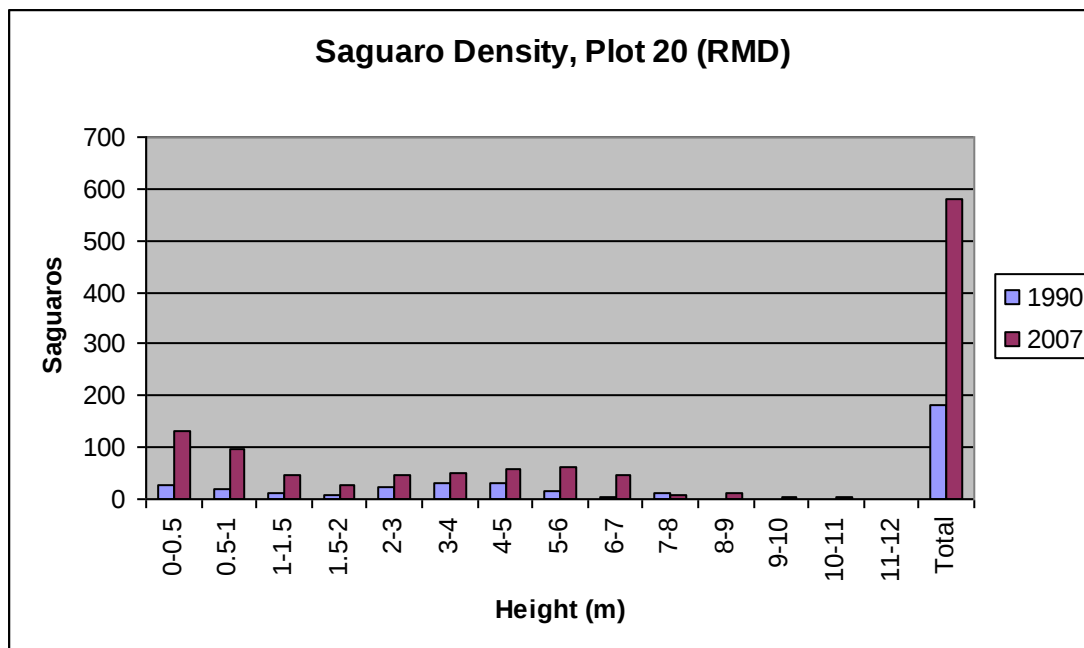




Saguaro Density by Height Class, Plot 9 (RMD)

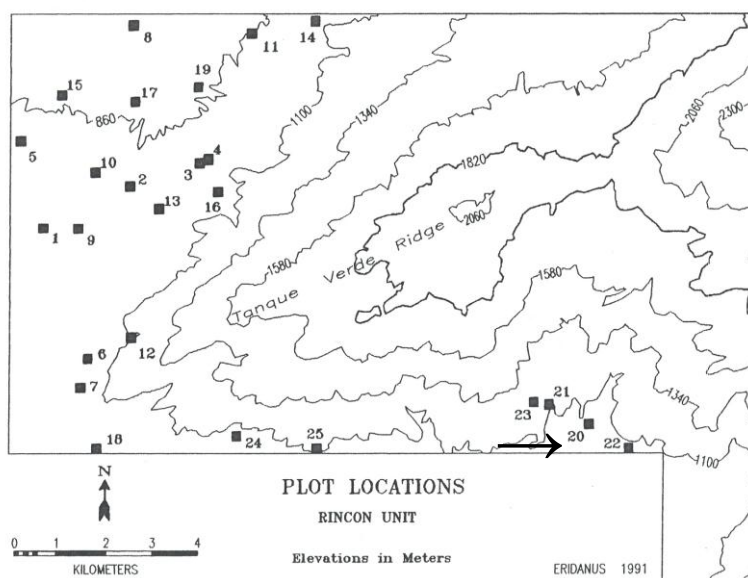
Plot	Year	Height (m)														Total
		0-0.5	0.5-1	1-1.5	1.5-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	
9	1990	5	2	3	2	4	3	6	10	16	0	1	1	1	0	55
9	2006	39	40	32	10	13	5	7	7	16	9	2	2	1	0	183





Saguaro Density by Height Class, Plot 20 (RMD)

Plot	Year	Height (m)														Total
		0-0.5	0.5-1	1-1.5	1.5-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	
20	1990	27	21	13	9	23	30	30	15	4	11	0	0	0	0	183
20	2007	131	95	45	26	46	49	57	62	47	8	10	4	2	0	582



Appendix B: Saguaro density by height class

Plot	Year							Height (m)								Total
		0-0.5	0.5-1	1-1.5	1.5-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	
27	1990	30	21	10	6	9	10	9	7	7	7	2	2	0	0	119
28	1990	49	29	25	8	19	28	94	28	38	47	19	0	2	0	386
29	1990	8	6	4	1	9	15	11	4	13	7	4	2	0	0	84
32	1990	7	5	3	3	3	21	20	20	8	0	5	0	0	0	95
35	1990	100	22	4	4	9	4	11	7	23	4	0	0	4	2	194
37	1990	149	89	45	15	30	23	23	30	15	61	15	15	15	0	525
44	1990	22	11	3	8	8.9	0	18	21	21	18	3	0	0	0	133
Totals		365	183	94	45	88	101	186	117	125	144	48	19	21	2	1536

1990 Saguaro Density by Height Class, TMD Plots

Plot	Year							Height (m)								Total
		0-0.5	0.5-1	1-1.5	1.5-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	
27	2006	104	51	25	22	22	20	8	18	7	5	6	1	1	0	290
28	2006	143	59	34	23	28	27	39	56	63	30	16	7	3	0	528
29	2006	107	45	15	9	15	5	7	12	13	12	3	1	0	0	244
32	2006	119	33	11	8	9	11	13	17	14	8	2	2	0	0	247
35	2006	118	99	53	31	27	9	7	9	13	11	7	3	0	1	388
37	2007	184	172	107	73	98	75	48	36	33	34	22	12	8	6	908
44	2007	162	80	27	12	14	10	19	12	12	9	6	2	0	0	365
Totals		937	539	272	178	213	157	141	160	155	109	62	28	12	7	2970

2006-2007 Saguaro Density by Height Class, TMD Plots

Plot	Year							Height (m)								Total
		0-0.5	0.5-1	1-1.5	1.5-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	
1	1990	4	0	1	3	3	6	10	5	3	0	1	2	1	0	40
9	1990	5	2	3	2	4	3	6	10	16	0	1	1	1	0	55
20	1990	27	21	13	9	23	30	30	15	4	11	0	0	0	0	183
Totals		36	23	17	14	30	39	46	30	23	11	2	3	2	0	278

1990 Saguaro Density by Height Class, RMD Plots

Plot	Year							Height (m)								Total
		0-0.5	0.5-1	1-1.5	1.5-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	
1	2006	61	23	8	5	0	5	6	7	2	0	0	0	0	0	117
9	2006	39	40	32	10	13	5	7	7	16	9	2	2	1	0	183
20	2007	131	95	45	26	46	49	57	62	47	8	10	4	2	0	582
Totals		231	158	85	41	59	59	70	76	65	17	12	6	3	0	882

2006-2007 Saguaro Density by Height Class, RMD Plots

