

The Exclosure Plots at Saguaro National Park: A 40-Year Study



Ray Turner (center) at the exclosure plot #3 with park staff in 2005

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Executive Summary

Three mammal-proof exclosures (15m x 15m), each with an adjacent non-fenced control area, were established in the Rincon Mountain District of Saguaro National Park in 1965. The purpose of the plots was to monitor the long-term influence of large and small mammal herbivory and granivory on survival of saguaros. In the 1960s, mammals were believed to be a major factor on survival of small saguaros in the park. All plants on each of the six plots were mapped and measured in 1965 and re-sampled in 1974. In 2005, we digitized the original 1965 maps and repeated the surveys using a total station. This report summarizes the changes in vegetation on treatment and controls plots over the 40-year period.

We found no statistical differences between number of plants and total plant cover on control and treatments during the 40-year period, probably due to the small sample size of 3 paired plots. In addition, one pair of plots was burned over by a fire in 1994, which reduced diversity on both treatments and controls, and one plot appears to have been breached by small mammals. Overall, the data suggest that mammal herbivory may exert an observable influence on plant communities at the park. For example, number and cover of succulents, and cover of grasses, increased in exclosures compared to non-fenced control plots.

In general it appears that factors that change with time (e.g. climate) have a larger impact on these vegetation communities than herbivory. The total number of plants per plot decreased on all plots between 1965 and 2005, while total cover either increased or stayed nearly the same.

We found notable changes in certain families and species. Interestingly, one of the most dramatic examples of a single species change was Englemann's prickly pear, which increased its cover nearly 1200% during the 40 year period. The influx of prickly pear, which appears to be related to climate change, may be an important factor in explaining the apparent decline in saguaro herbivory since the 1960s, as this species is a preferred food source for white-throated woodrats and other rodent herbivores.

Acknowledgements

We thank the three cohorts of surveyors responsible for carrying this project over the past 40 years. The 1965-66 survey was conducted by USGS staff S.B. Bingham and D.K. Warren and data was compiled by F. Wiseman and O. Grosz. The 1974 survey was also conducted by USGS staff. Contributors to the 2005 survey included National Park Service staff Cheryl McIntyre, Jeff Balmat, Dana Backer, Kate O'Connor, Melissa Spandl, David Walker, Matt Daniels, and Mark Holden. Funding for the creation of this report was provided by the Desert Southwest Cooperative Ecosystem Studies Unit and the National Park Service's Youth Internship Program. The Southwest Monuments Association (now Western National Parks Association) provided funding for enclosure construction.

Introduction

Herbivory from livestock, rodents, and other species have exerted an observable influence on vegetation communities in Saguaro National Park. The influence of livestock grazing on saguaro populations in the park was examined as early as 1939. The impact of rodent herbivores were identified as a potential problem for saguaros going back to 1944 (Steenbergh and Lowe 1977) and was the subject of several studies in the 1960s and 1970s (Turner et al. 1969, Steenbergh and Lowe 1977). In addition to directly impacting the saguaro, herbivory can indirectly influence the species by affecting other plant species such as the saguaro's most common nurse plant, *Parkinsonia microphylla* (Fig 1; McAuliffe 1986).

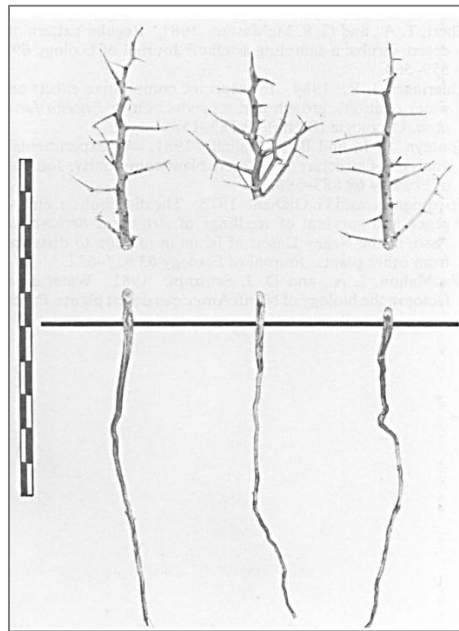


Figure 1. *Cercidium microphyllum* [now *Parkinsonia microphylla*] seedlings from the Saguaro National Monument West site on 21 January 1984 showing the effects of herbivory. At left is a 10 cm scale with 1-cm graduations. The horizontal line represents the soil level; basal portions of stems with roots are positioned to show the height above the soil surface at which seedlings were cut. The gap between the basal and apical portions is the actual amount of each seedling apparently consumed. Image and caption from McAuliffe (1986).

To isolate the impact of herbivory on the vegetation community at what was then called Saguaro National Monument, Dr. Ray Turner and his colleagues at the US Geological Survey, University of Arizona, and NPS established six paired study plots in 1965 in the Rincon Mountain District (Fig 2). This study was designed to examine the impact of herbivory on perennial vegetation by surveying plants on three control plots exposed to herbivory while excluding herbivory on three adjacent treatment plots. These three treatment plots were intended to exclude herbivorous and granivorous mammal species common to this area. The most common herbivorous and granivorous mammals encountered in this area included deer, javelina, jackrabbits, cottontails, ground squirrels, woodrats, kangaroo rats, pocket mice, cactus mice (Kurzius 1984), and (historically) livestock.

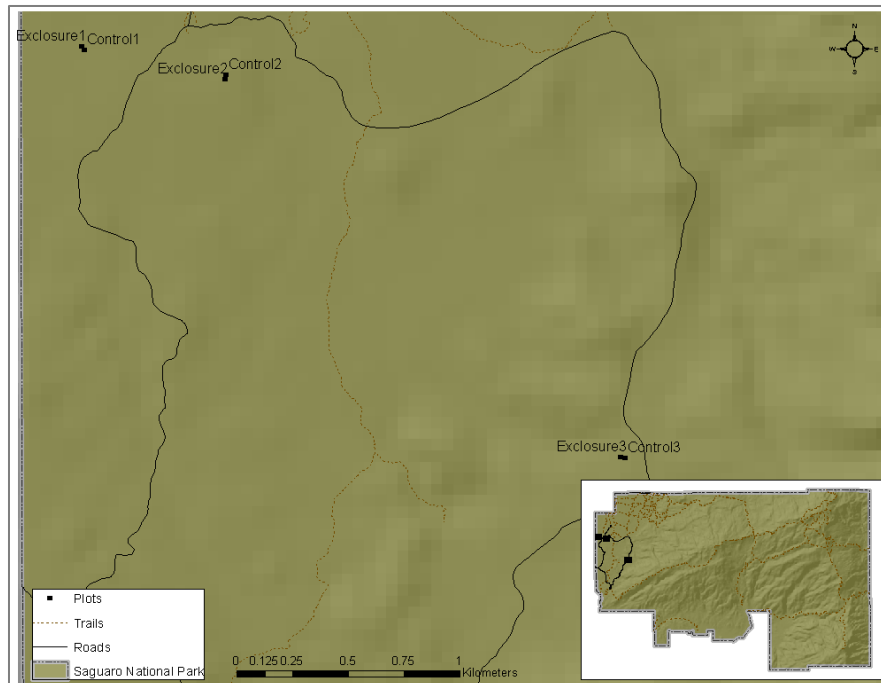


Figure 2. Orientation map for exclosure plots at the Rincon Mountain District of Saguaro National Park.



Figure 3. Survey of control plots in (L) and mammal exclosure treatment plots (R) by National Park Staff in 2005. Pictured from left to right: Jeff Balmat, Mark Holden, and Matt Daniels.

Climatic conditions influence the impacts grazers cause to desert plant communities. Studies indicate that herbivory impacts increase in times of drought (Steenbergh and Lowe, 1977). As Figure 4 indicates, precipitation conditions were substantially different in the years immediately prior to the three surveys. The initial survey followed the fifth highest annual precipitation value (17.99 in) in Tucson's record extending back to 1894. The 1965 and 1974 surveys had similar 5-year and 10-year running averages; however, conditions for the 2005 survey were substantially drier over the same time period. The 20-year and 30-year running averages for all three surveys were more similar.

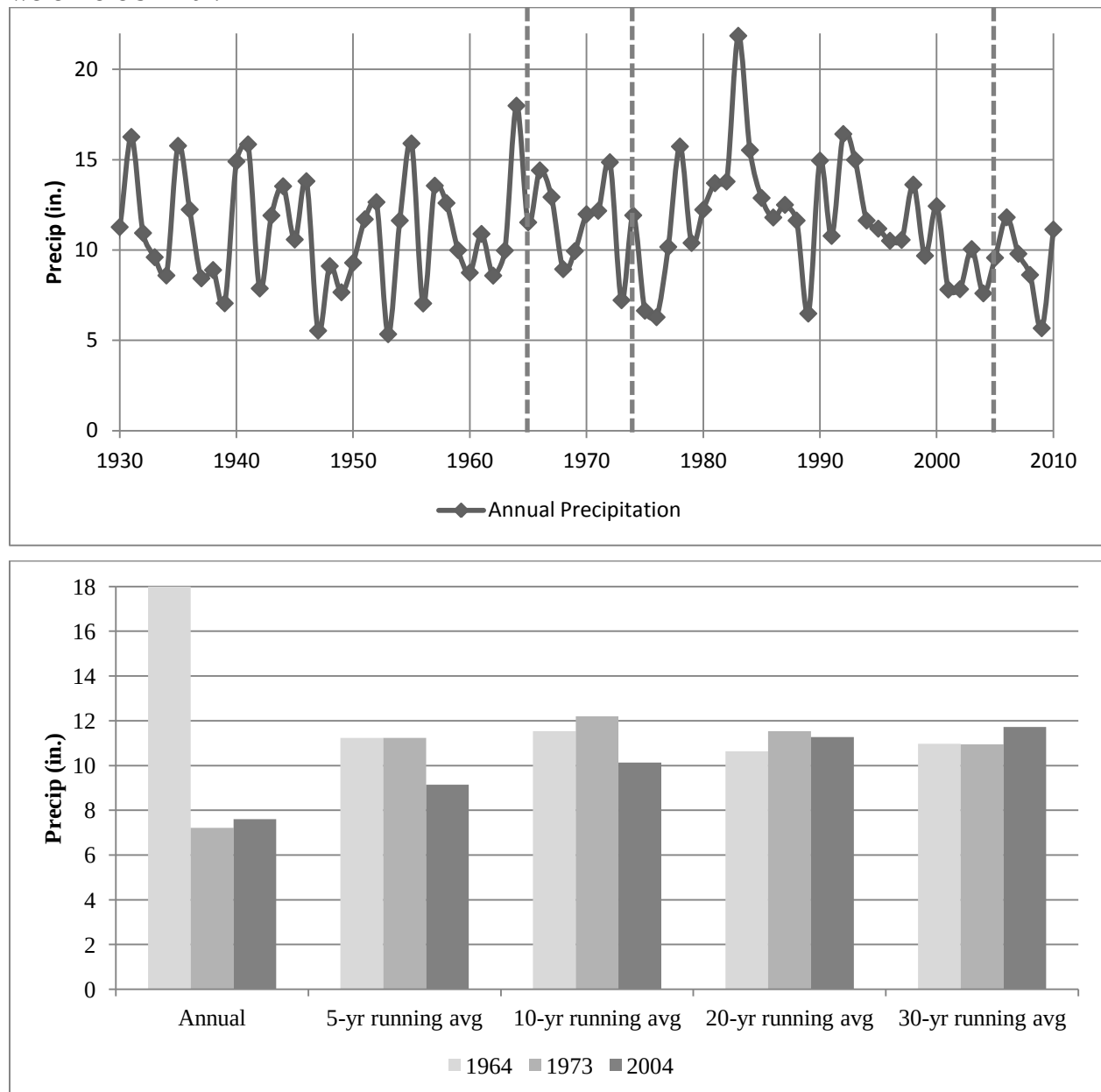


Figure 4. Annual precipitation record from the Tucson International Airport (top), with the three years of enclosure plot surveys at the Rincon Mountain District of Saguaro National Park indicated by dashed vertical lines. Precipitation conditions in the year preceding the three surveys are shown in the bottom figure.

The plots and surveys have also differed in their exposure to fire. Plot pair #3 was burned in the 1994 Mother's Day Fire, while the other plots were not (Fig 5). These fires not only impact the vegetative community, but they also impact rodent communities (Simons 1991).

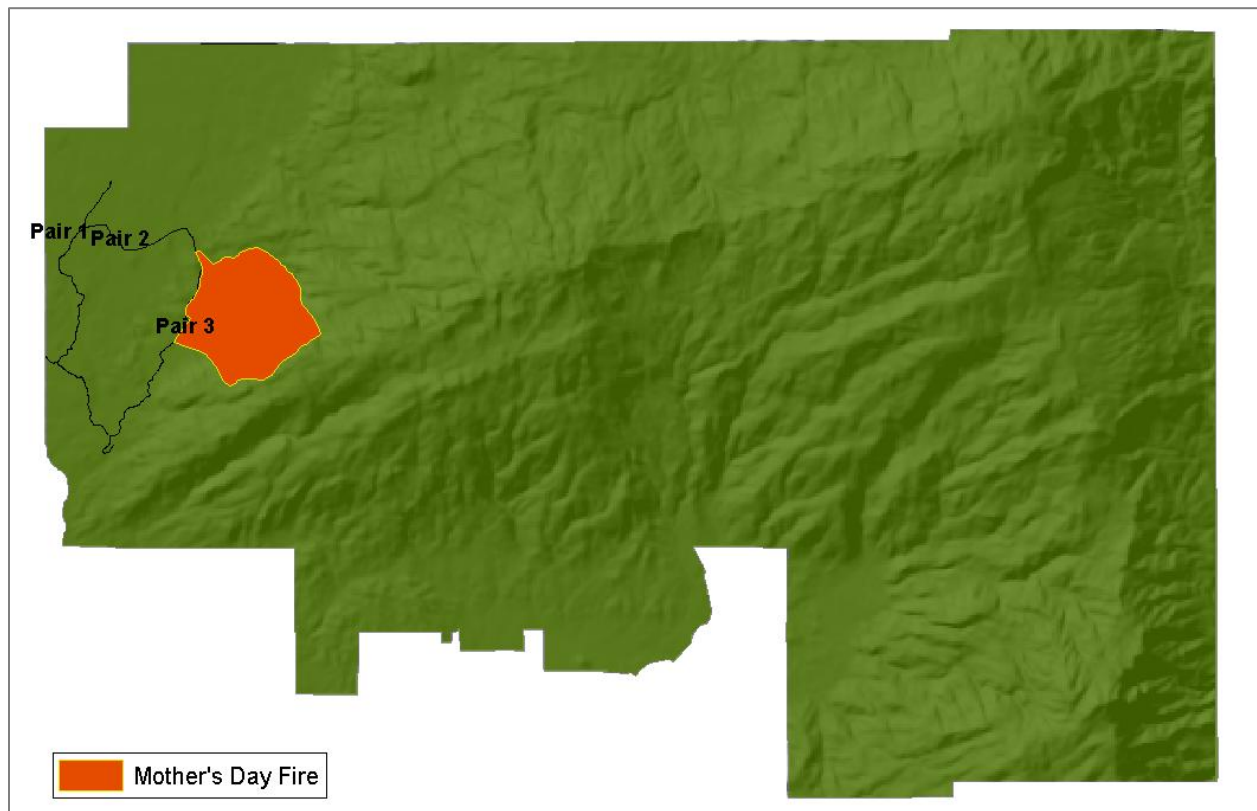


Figure 5. Exclosure plot fire history at the Rincon Mountain District of Saguaro National Park. The 1994 Mother's Day Fire burned plot pair #3. The burned area is indicated in orange.

Methods

Establishment of the plots

Six plots were established in 1965. Each plot measures 15 meters (50 ft) on a side with a total area of 0.02 ha (0.05 acres). Exclosures on the treatment plots were constructed with ¼ inch hardware cloth 1.8 m (6 ft) high. The base of the exclosure material was buried to prevent burrowing beneath and metal flashing was installed to prevent rodents from breaching the top of the fence. The elevation of the plots range from 882 to 971 m (2,894 to 3,186 ft) and slope ranges from 1% to 13%. All mammals were removed from the plots directly following completion of the exclosure construction by trapping.

Survey methods

A baseline survey was conducted in 1965 and 1966 following the construction of exclosures. The 1965 and 1974 surveys used a plane table and alidade to map the individual plants. In 2005, the survey methodology changed to the use of a Nikon DTM-330 Total Station Transit. This survey methodology has the advantage of increased speed and spatial accuracy compared to the previous method. Paper maps were produced from the 1965-66 and 1974 surveys. In 2005, paper maps from the 1965-66 survey were digitized and combined with the 2005 survey data into a

single spatial dataset. Unfortunately, the maps from the 1974 survey have been lost, although summary statistics are available and included in this report.

Analysis

We used descriptive statistics to calculate the numbers of plants and cover (m²) for each species as well as the changes in these values across survey years. We then used the Wilcoxin Signed-Rank Test, a non-parametric version of the paired t-test, to examine the statistical significance of changes between 1965 and 2005. We conducted these tests for both the number of plants and cover area by species, family, and lifeform. Finally, we calculated species diversity using Simpson's diversity index as well as species richness.

Results

The total number of species was 53, 38, and 61 respectively for the 1965, 1974, and 2005 surveys. As Table 1 indicates the total number of plants per plot decreased on all plots between 1965 and 2005; however, total cover either increased or stayed nearly the same over the four decades.

Table 1. Summary data from exclosure plots surveyed in 1965-66 and 2005 at the Rincon Mountain District of Saguaro National Park.

	No. of Plants			Cover (m ²)		
	1965	1974	2005	1965	1974	2005
Plot 1 Exclosure	802	855	449	59.40	61.52	155.90
Plot 2 Exclosure	379	361	167	57.00	44.15	95.22
Plot 3 Exclosure	942	1000	860	103.69	102.27	102.26
Plot 1 Control	599	681	181	43.00	50.49	78.74
Plot 2 Control	360	419	199	38.46	40.03	118.39
Plot 3 Control	1073	1189	642	93.05	101.74	86.27

The Wilcoxin Signed-Rank Test indicated no significant change in either the number of plants or cover for species at the plot level, likely due to having only three replications. Significant changes were detected by conducting this test on species when pooling all observations together irrespective of treatment. The results of this analysis are provided in Appendix D. Although statistical significance cannot be established for treatments, trends in the data are informative and provide insight into the effects of herbivory on these plant communities. The following figures indicate change at the plot level (Fig. 6), lifeform level (Fig. 7), and family level (Figs. 8 and 9). Descriptive data is provided by lifeform (Appendix A), family (Appendix B) and plot (Appendix C).

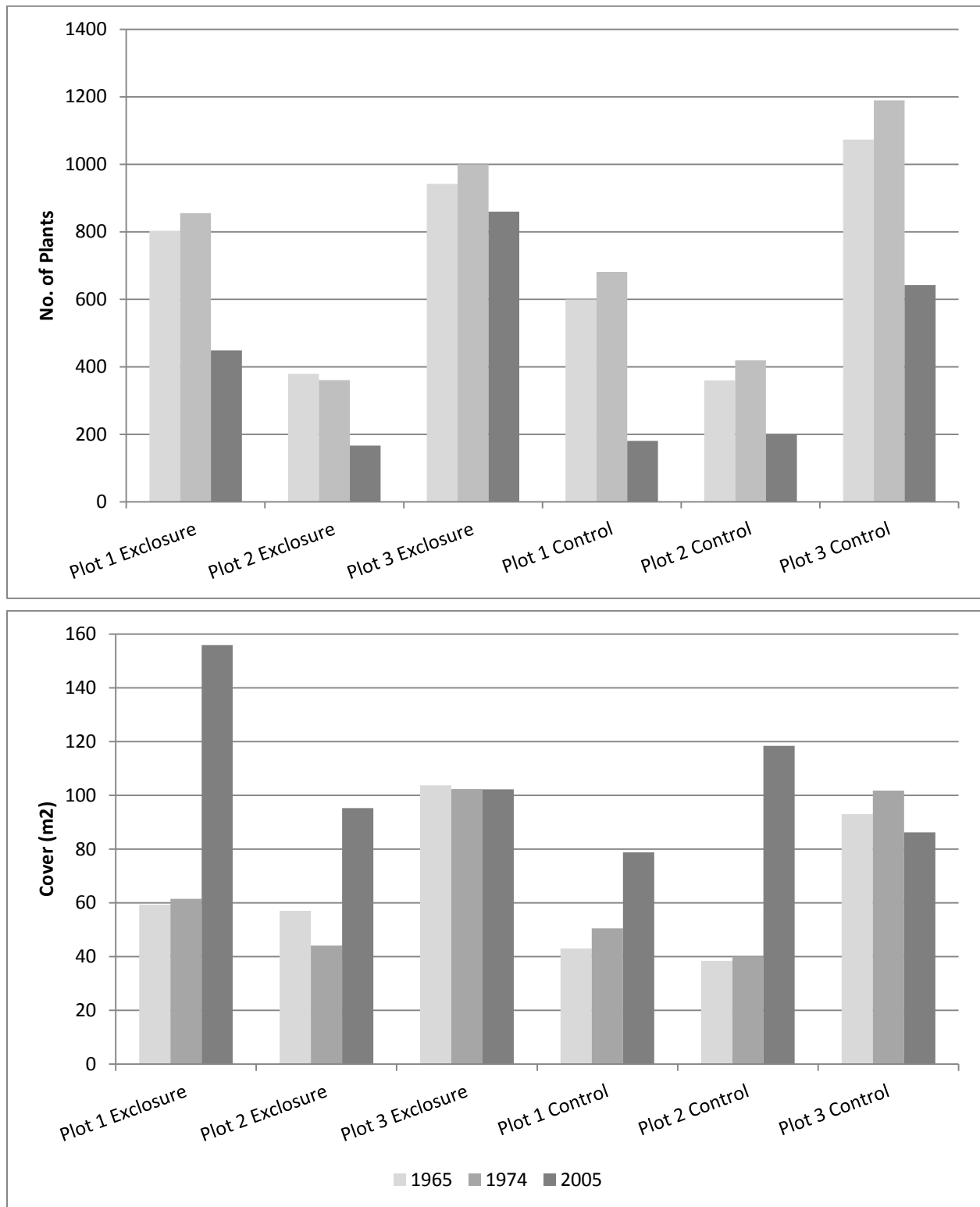


Figure 6. Change in the number of plants (top) and cover (m2) (bottom) on three paired rodent exclosure plots by plot.

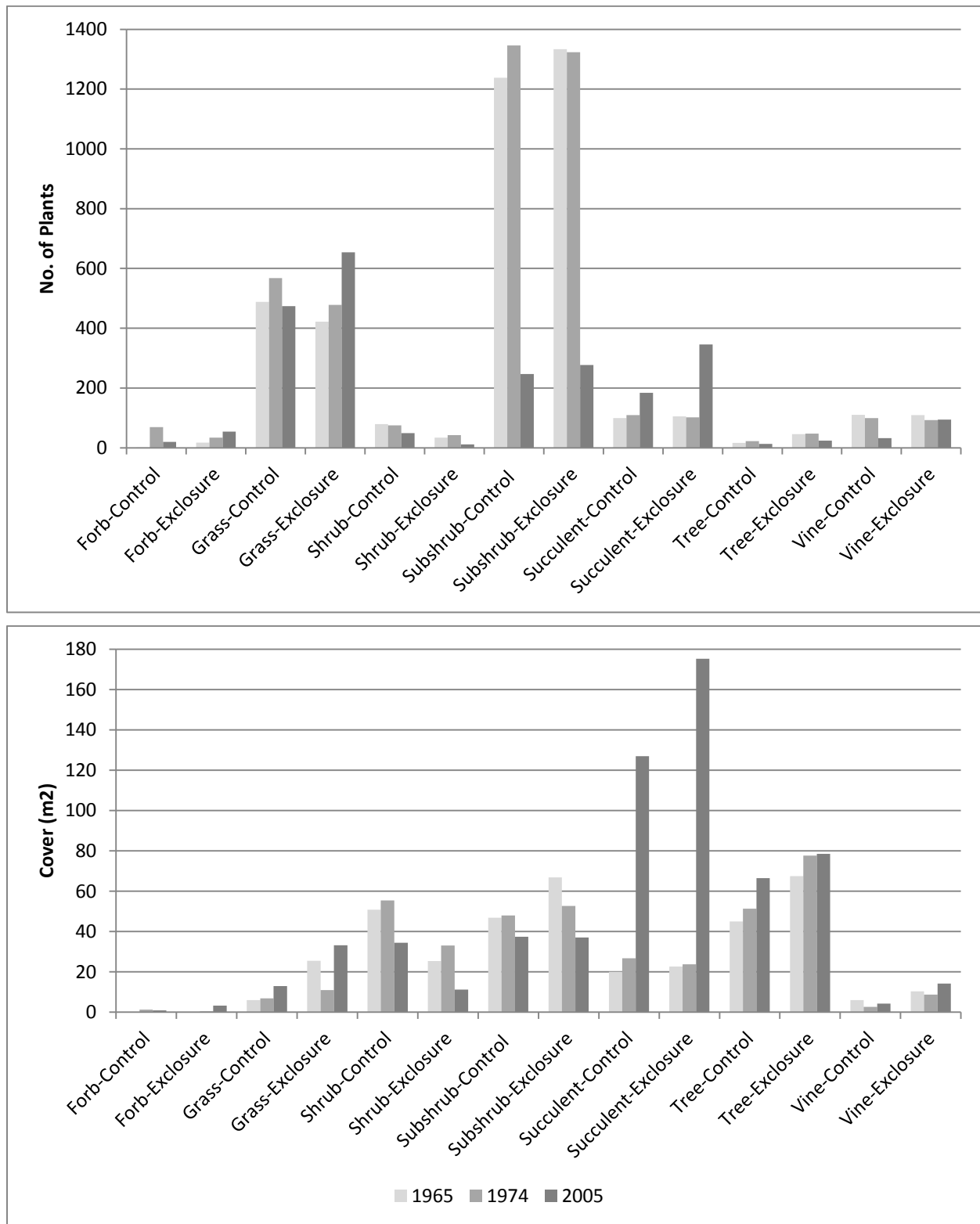


Figure 7. Change in the number of plants (top) and cover (m²) (bottom) on three paired rodent exclusion plots by lifeform.

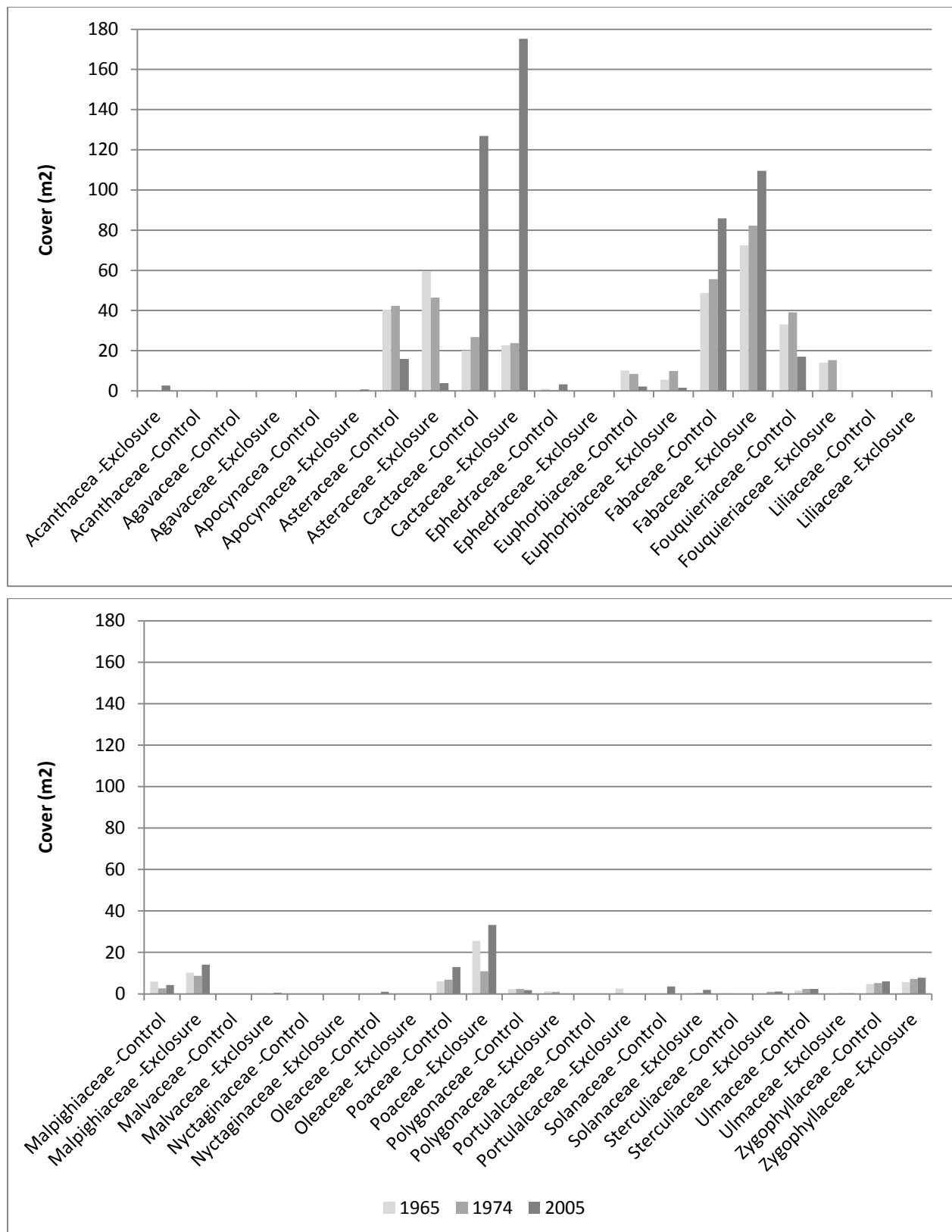


Figure 8. Change in cover (m²) on three paired rodent exclosure plots by family.

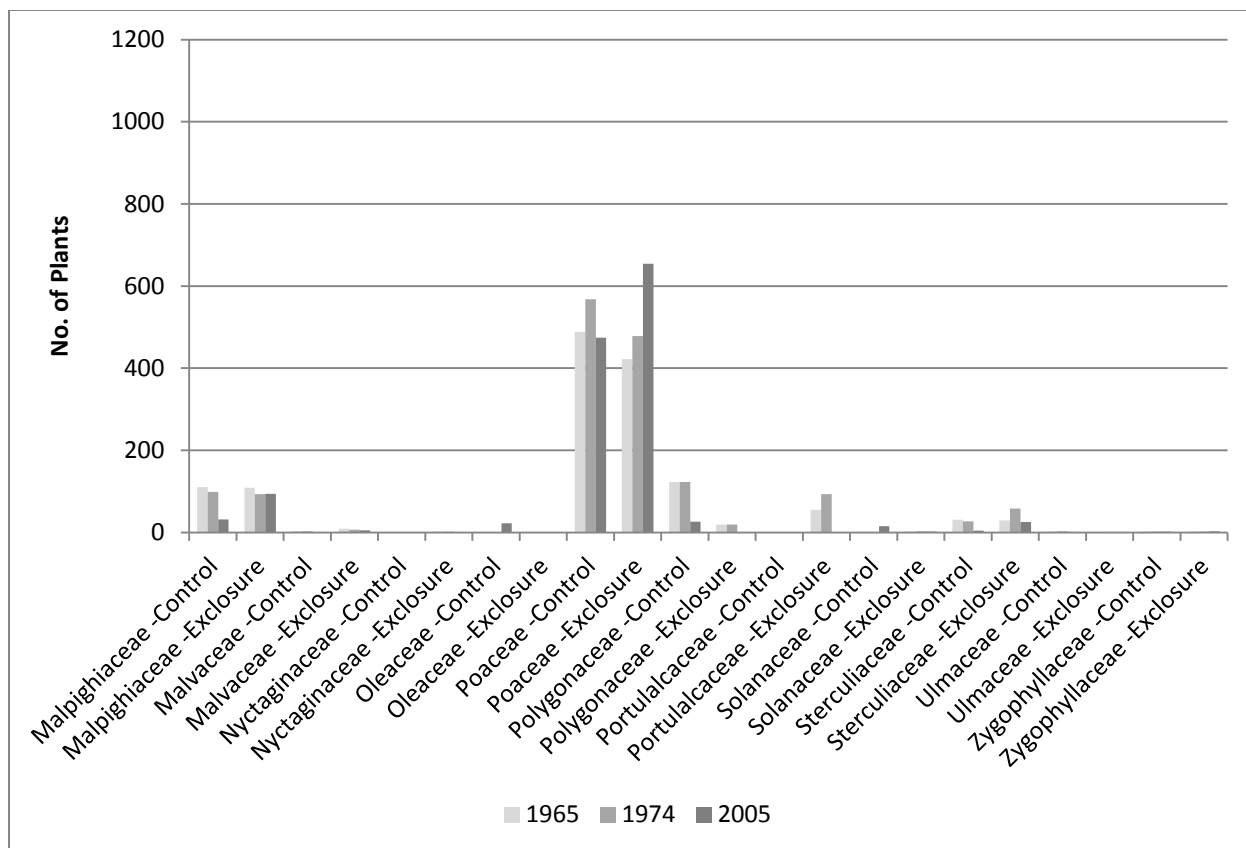
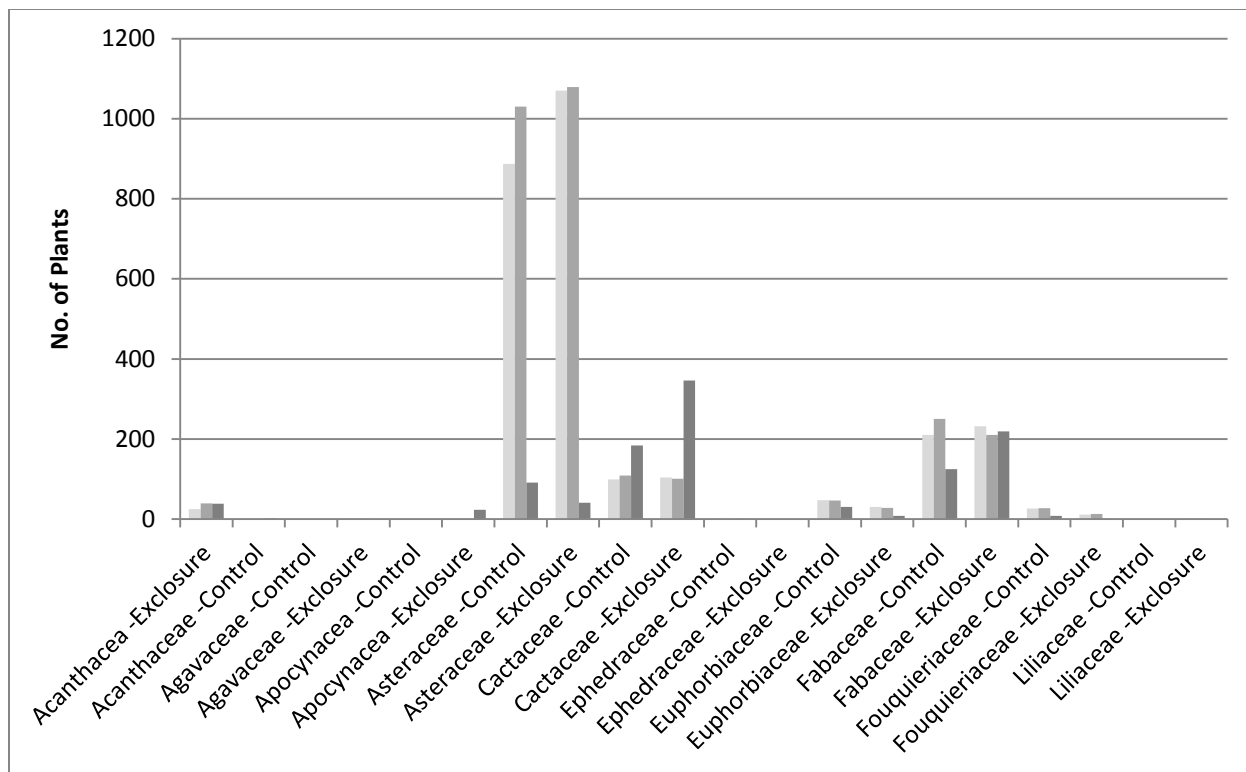


Figure 9 Change in the number of plants on three paired rodent exclosure plots by family.

Discussion

The descriptive statistics from this study show that, in general, changes in the plant community during this study were more pronounced with time than with the exclosure treatment. For example, Figure 7 shows that the difference in succulent cover is much greater over the four decades than between treatment and control plots. The data indicate that those factors which change with time (e.g. climatic factors) had a larger impact on vegetation than the abundance of herbivores on the landscape. However, this study does provide evidence (Fig. 7) that herbivory and granivory exert an observable influence on plant communities at Saguaro National Park.

Plot level changes

Trends in total plant counts and cover are unclear at the plot level. Besides exposure to herbivory and granivory, the plots vary substantially in two obvious ways (slope and fire exposure history). Both the exclosure and control plots of pair #3 were burned in the 1994 Mother's Day Fire. As Appendix C indicates, the number of species on plot pair three dropped markedly following the 1994 Mother's Day Fire. Additionally, Simpson's Diversity Index values increased on plot pair #3 following the fire whereas values decreased on the other paired plots. Because a Simpson's Diversity Index value of 0 indicates infinite diversity and 1 indicates no diversity, these metrics show that plant diversity was lower on the burned plots compared to the unburned plots during the 2005 survey (11 years after the fire occurred). The exclosure in pair #2 appears to have been breached by rodents, at least at some point in the past; we observed a packrat midden in this exclosure. Indeed, differences between treatment and control plots in this pair are not readily discernible.

Lifeform level changes

Changes in lifeforms across the four decades are congruous with what would be expected by removing grazers from an area (Steenbergh and Lowe 1977). Succulents and grasses performed substantially better in the exclosures than when exposed to herbivory. Total grass cover increased across the four decades for treatments and controls; however, the number of plants decreased on the control plots while they increased on the exclosure plots. Subshrubs also declined substantially across the four decades, but given the relatively small difference between control and treatment plots this change is more likely attributable to climatic conditions.

Family level changes

A notable change over time at the family level is the precipitous decline of the Asteraceae family from 1974 to 2005 across treatments. This decrease may be due in large part to the conditions preceding the 1965 survey which may have elevated their population. The anomalous annual rainfall in 1964 of 17.99 inches may have created conditions favorable for species within this family. *Encelia farinosa*, *Isocoma tenuisecta*, and *Machaeranthera pinnatifida* accounted for 91% of the 1957 individuals from the Asteraceae family found on the plots in 1965. This change may not have been as pronounced had the 2005 survey been conducted a year later. In the year 2006, 16.99 inches of rain were received at the RMD visitor center, after which a proliferation of the Asteraceae family members *Encelia farinosa* and *Zinnia acerosa* were observed (Springer et al. 2011). These associations with climatic events further illustrate the impact that changing conditions over time, including conditions that create episodic recruitment or declines, may have greater impact on species composition relative to the influence of herbivory presence or absence.

Species level changes

Many individual species stand out for dramatic increases or losses across the period of analysis. In addition to the Asteraceae family members that respond to short-term precipitation conditions, two succulents demonstrated notable changes. *Mammillaria grahamii* increased its population by 191(589%) individuals over the four decades and prickly pear cactus increased its cover by 1186%. The proliferation of prickly pear cactus is noteworthy because herbivores preferentially graze it over the saguaro. Observations from repeat surveys on perennial vegetation in a related study of 25 plots at the RMD showed prickly pear cactus increased in cover 218% from 1990 to 2010 (Springer et al. 2011). By combining results from these two studies, we can be more confident that the bulk of the dramatic change in prickly pear cactus cover occurred between 1965 and 1990. These changes are consistent with other regional observations showing remarkable increases in the species (Bowers 2005; Turner et al. 2003).

Conclusion

Results from this project are consistent with the hypothesis that eliminating herbivores and granivores from Sonoran Desert habitat will result in observable differences between grazed and ungrazed plant communities. We find that exclosures most noticeably favored succulents and grasses. However, we find that the effects of time are greater than the effects of herbivory on the overall plant communities. Our analysis of this dataset supports the consensus from other long-term vegetation monitoring efforts at Saguaro National Park that access to climate data at a finer spatial resolution is needed to better understand vegetation change and management implications at the park.

Recommendations

This analysis was conducted, in part, to evaluate the value of the long-term exclosures at Saguaro National Park. Exclosure #2, in particular, is highly visible to visitors driving on the park's Cactus Forest Loop Road. The park wanted to know if the visual impact of this and the other two exclosures (which are seldom noticed by visitors) was offset by its scientific and management value.

Exclosure studies, especially to evaluate the influence of cattle grazing, were quite common on public lands in the past. Many of these studies did not receive consistent follow-up surveys, but those that have been well-studied have provided valuable data on ecological processes. The present study clearly shows that areas in Saguaro National Park protected from herbivores and granivores differ substantially from unprotected adjacent areas.

The case for removing the exclosures is that they have been present since 1965 and have served their original purpose. Additionally, the exclosures have created artificial micro-environments which are different from the surrounding "natural" habitat; two plots have been exposed to fire while four plots have not; and one of the exclosures appears to have been breached by rodents.

The case against removing the exclosures is that they may not have finished yielding insights into the role that herbivores and granivores play in the Sonoran Desert. For example, the plots could be used for a study of annual plants and, perhaps most compelling, to provide future insight into the effects of climate change. Drought affects vegetation species directly through decreased water availability and increased evapotranspiration and additionally through altering

herbivore behavior. Finally, while the small number of plots can be problematic for establishing statistical significance, these plots could provide statistical power to analyses conducted at larger spatial scales.

Should we continue to keep the exclosures at Saguaro, and if so should we continue to maintain and monitor them? And, if so, what resources are available to do so? Our recommendation going forward is that this report should be circulated widely with a request for comments on this question, and then the comments should be compiled and reviewed by park managers. Given that Saguaro National Park has (in a sense) invested in this study for more than 40 years it makes sense to have complete information before making a final decision. However, if there are no obvious and compelling reasons to keep the exclosures, we recommend that they be removed. It may also make sense for a hybrid approach – for example, to remove exclosure #2 while repairing and establishing a more regular monitoring schedule for exclosures #1 and #3.

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Appendix A. Summary data for plant lifeforms from exclosure plots surveyed in 1965, 1974, and 2005 at the Rincon Mountain District of Saguaro National Park.

	No. of Plants			Cover (m2)		
	1965	1974	2005	1965	1974	2005
Forb-Control	1	69	20	0.01	1.31	0.95
Forb-Exclosure	17	34	54	0.19	0.45	3.3
Grass-Control	488	568	474	6.04	6.89	12.96
Grass-Exclosure	422	478	654	25.53	10.93	33.22
Shrub-Control	79	75	49	50.76	55.39	34.47
Shrub-Exclosure	34	42	11	25.31	33.07	11.23
Subshrub-Control	1238	1346	247	46.78	47.91	37.38
Subshrub-Exclosure	1333	1323	277	66.82	52.65	37.03
Succulent-Control	99	109	184	19.98	26.76	126.89
Succulent-Exclosure	105	102	346	22.64	23.78	175.2
Tree-Control	16	22	13	44.98	51.36	66.46
Tree-Exclosure	46	47	24	67.44	77.6	78.45
Vine-Control	110	99	32	5.95	2.64	4.28
Vine-Exclosure	109	93	94	10.29	8.76	14.13

Appendix B. Summary data for plant families from exclosure plots surveyed in 1965, 1974, and 2005 at the Rincon Mountain District of Saguaro National Park.

Family	No. of Plants			Cover (m ²)		
	1965	1974	2005	1965	1974	2005
Acanthaceae	25	25	40	0.52	0	2.74
Agavaceae	1	1	23	0.01	0	0.78
Apocynaceae	0	0	23	0	0	0.78
Asteraceae	1957	2111	132	99.84	99.86	19.75
Cactaceae	203	210	530	42.61	48.86	302.09
Ephedraceae	1	0	1	0.93	0.32	3.27
Euphorbiaceae	77	74	38	15.65	18.31	3.80
Fabaceae	442	460	346	121.23	137.85	195.34
Fouquieriaceae	37	40	9	47.05	101.96	16.97
Liliaceae	1	1	0	0	0	0
Malpighiaceae	219	192	126	16.24	11.40	18.41
Malvaceae	12	10	5	0.34	0.17	0.56
Nyctaginaceae	2	2	0	0.09	0	0
Oleaceae	0	0	22	0	0	1.03
Poaceae	910	1046	1128	31.57	17.82	46.18
Polygonaceae	142	142	26	3.58	3.38	1.77
Portulacaceae	55	93	0	1.78	0	0
Solanaceae	3	3	17	0.56	0.42	5.48
Sterculiaceae	60	85	29	0.55	1.07	1.23
Ulmaceae	2	4	2	1.53	2.70	2.68
Zygophyllaceae	4	4	5	10.37	12.41	13.87

Appendix C. Plot level characteristics for perennial species.

Plot	No. of Plants			Cover (m²)			No. of Species			Simpson's Diversity Index		
	1965	1974	2005	1965	1974	2005	1965	1974	2005	1965	1974	2005
Plot 1 Exclosure	802	855	449	59.40	61.52	155.90	18	21	30	0.46	0.44	0.13
Plot 2 Exclosure	379	361	167	57.00	44.15	95.22	16	19	11	0.64	0.59	0.50
Plot 3 Exclosure	942	1000	860	103.69	102.27	102.26	33	32	25	0.14	0.19	0.21
Plot 1 Control	599	681	181	43.00	50.49	78.74	20	24	27	0.40	0.39	0.10
Plot 2 Control	360	419	199	38.46	40.03	118.39	16	19	21	0.47	0.42	0.15
Plot 3 Control	1073	1189	642	93.05	101.74	86.27	26	29	25	0.19	0.18	0.30

Appendix D. Change in the number of plants and cover on three paired plots from 1965 to 2005. Change is indicated for plants on all six plots. Significance is indicated from the Wilcoxin Signed-Rank test and percent change is shown in parentheses.

Species	Stem Change (%)	Cover Change (%)
<i>Abutilon pringlei</i>	-4 (-44)	0.25 (180)
<i>Acacia constricta</i>	-1 (-20)	16.69 (575)
<i>Acacia greggii</i>	-13 (-43)‡	21.27 (286)
<i>Adenophyllum porophylla</i>	-13*	-0.43*
<i>Adenophyllum</i> species	-1	-0.03
<i>Agave</i> species	-1	-0.01
<i>Andropogon</i> species	-36 (-94)	-0.6 (-74)
<i>Aristida purpurea</i>	8	0.3
<i>Aristida</i> species	140*	6.81*
<i>Aristida ternipes</i>	45	2.53
<i>Ayenia filiformis</i>	29	1.23
<i>Ayenia pusilla</i>	-60‡	-0.55‡
<i>Bahia absinthifolia</i>	-6	-0.04
<i>Bouteloua rothrockii</i>	-16 (-2)	6.25 (154)
<i>Brickellia</i> species	12 (700)	1.06 (2220)
<i>Calliandra eriophylla</i>	-11 (-3)	41.91 (632)*
<i>Carlowrightia arizonica</i>	-25	-0.52
<i>Carnegiea gigantea</i>	-32 (-64)	0.03 (102)
<i>Celtis pallida</i>	0 (0)	1.15 (175)
<i>Cylindropuntia arbuscula</i>	7 (200)	1.1 (139)
<i>Cylindropuntia bigelovii</i>	-3	-0.02
<i>Cylindropuntia fulgida</i>	0 (0)	-0.02 (-9)
<i>Cylindropuntia leptocaulis</i>	7 (275) ‡	-4.56 (-80)
<i>Cylindropuntia versicolor</i>	21 (165)	19.9 (305)
<i>Dalea formosa</i>	-2	-0.02
<i>Dalea</i> species	-2	-0.07
<i>Dasyochloa pulchellum</i>	8	0.06
<i>Dicanthelium saccharoides</i>	1	0.07
<i>Digitaria californica</i>	158	15.21
<i>Ditaxis neomexicana</i>	-12	-0.16
<i>Echinocereus fasciculatus</i>	1	0.12
<i>Echinocereus fendleri</i>	-12 (-85)	0 (0)
<i>Encelia farinosa</i>	-496 (-88)	-29.9 (-68)
<i>Ephedera trifurca</i>	0 (0)	2.34 (351)
<i>Ericameria laricifolia</i>	-83 (-92)	-22.23 (-93)
<i>Erigeron modestus</i>	1	0.03
<i>Erigeron</i> species	6	0.57

Table continued from previous page

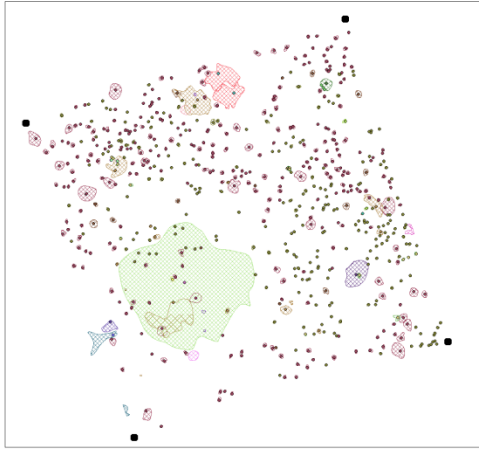
<i>Eriogonum wrightii</i>	-116 (-81)	-1.81 (-50)
<i>Euphorbia</i> species	10	0.07
<i>Euphorbia supina</i>	2	0.3
<i>Ferocactus wislizenii</i>	14 (333)	0.25 (144)
<i>Fouquieria splendens</i>	-28 (-75)‡	-30.08 (-63)‡
<i>Gossypium</i> species	-3	-0.03
Grass species	-85	-1.06
<i>Haplophyton crooksii</i>	23	0.78
<i>Heterpogon contortus</i>	10 (242)	0.82 (456)
<i>Isocoma tenuisecta</i>	-811	-26.25
<i>Janusia gracilis</i>	-93 (-42)	2.17 (113)
<i>Jatropha cardiophylla</i>	-39 (-60)	-12.06 (-77)
<i>Justicia longii</i>	40	2.74
<i>Larrea tridentata</i>	1 (125)	3.5 (133)
<i>Lycium berlandieri</i>	12 (500)	3.57 (737)
<i>Lycium brevipes</i>	1	0.62
<i>Lycium</i> species	1	0.73
<i>Machaeranthera canescens</i>	1	0.07
<i>Machaeranthera pinnatifida</i>	-395 (-96)‡	-3.73 (-85)‡
<i>Mammillaria grahamii</i>	191 (589)‡	2.73 (1192) ‡
<i>Menodora scabra</i>	22	1.03
<i>Muhlenbergia porteri</i>	-12 (-19)	-1.56 (-42)
<i>Nolina microcarpa</i>	-1	0
Nyctaginaceae species	-2	-0.09
<i>Opuntia engelmannii</i>	132 (386)*	240.02 (1186)*
<i>Opuntia phaeacantha</i>	0	-0.07
<i>Opuntia</i> species	1	0
<i>Parkinsonia microphylla</i>	-16 (-61)	-61.42 (-63)*
<i>Pediomelum trinervatum</i>	14	0.47 (0)
Perennial grass	1	0
<i>Porophyllum gracile</i>	18 ‡	1.78‡
<i>Prosopis juliflora</i>	-1	-1.48
<i>Prosopis velutina</i>	6 ‡	57.43‡
<i>Senna covesii</i>	-70 (-97)‡	-0.67 (-78)‡
<i>Tridens mutica</i>	-1	-0.01
unknown perennial grass	-13	-14.28
<i>Vulpia microstachys</i>	10	0.07
<i>Zinnia acerosa</i>	4	0.07
<i>Zinnia pumila</i>	-62 (-96)‡	-1.06 (-94)‡
‡ p<0.10; *p<0.05		

Appendix E. Plot coordinates (coordinate system: UTM; datum: NAD 83).

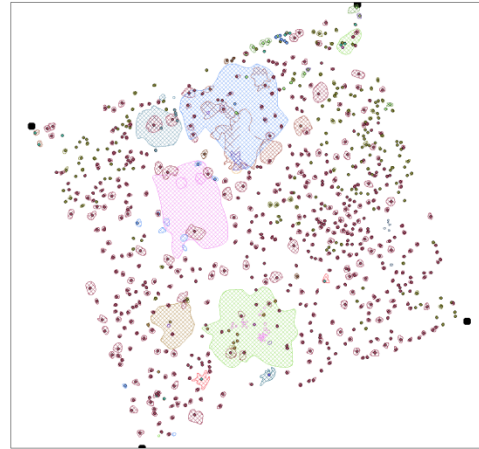
Pair	Treatment	Corner	Easting	Northing
1	Control	NE	524991	3562938
		NW	524976	3562933
		SE	524995	3562923
		SW	524981	3562919
	Exclosure	NE	524981	3562954
		NW	524966	3562949
		SE	524985	3562940
		SW	524971	3562934
2	Control	NE	525628	3562824
		NW	525613	3562822
		SE	525629	3562809
		SW	525614	3562807
	Exclosure	NE	525624	3562804
		NW	525609	3562801
		SE	525627	3562789
		SW	525612	3562787
3	Control	NE	527422	3561105
		NW	527407	3561109
		SE	527417	3561091
		SW	527403	3561094
	Exclosure	NE	527400	3561111
		NW	527386	3561115
		SE	527397	3561096
		SW	527383	3561100

Appendix F. Plot maps from 1965 and 2005.

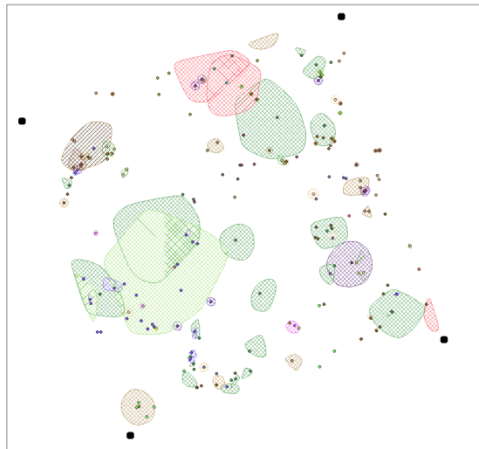
Turner Mammal Exclosure Plot #1



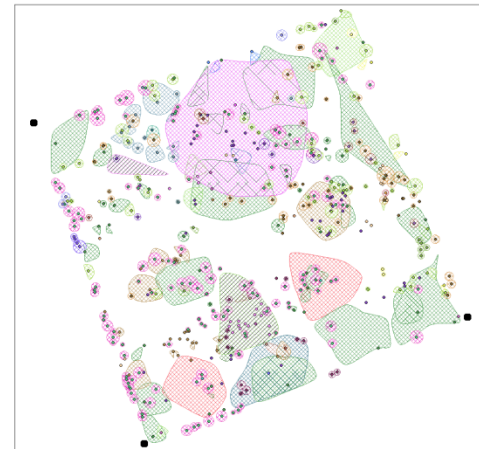
Control Plot - 1965



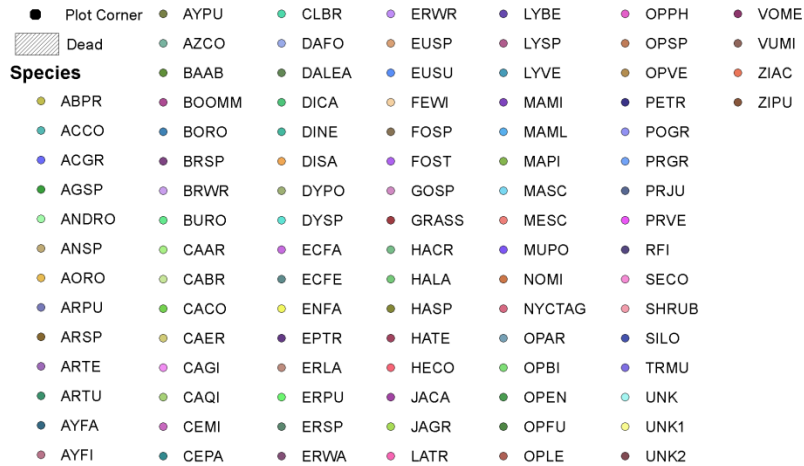
Exclosure Plot - 1965



Control Plot - 2005



Exclosure Plot - 2005



Number of Stems per Plot		
	1965	2005
Control	595	183
Exclosure	751	468

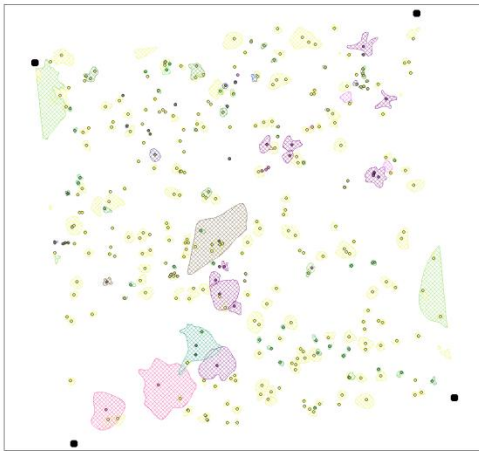
Total Aerial Cover per Plot (m ²)		
	1965	2005
Control	44	87
Exclosure	69	85



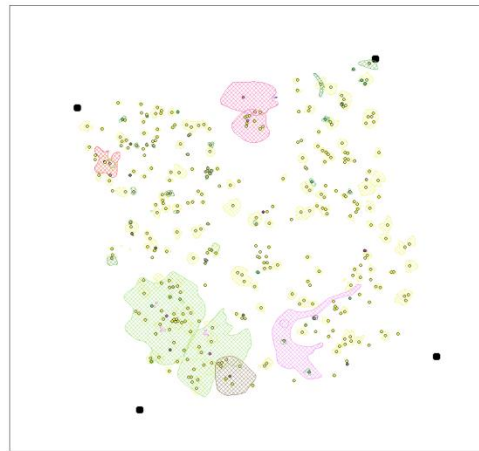
0 1.5 3 6 Meters

Plots were surveyed by hand in August 1965 and re-surveyed using a Transit Total Station in December 2005.

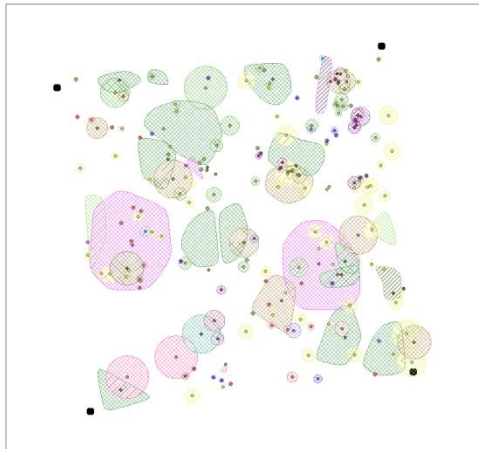
Turner Mammal Exclosure Plot #2



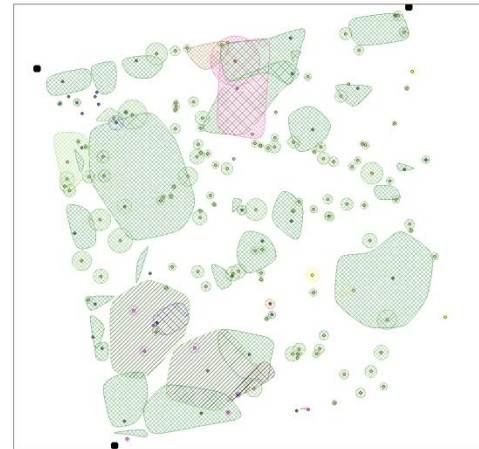
Control Plot - 1965



Exclosure Plot - 1965



Control Plot - 2005



Exclosure Plot - 2005

● Plot Corner	● AYPV	● CLBR	● ERWR	● LYBE	● OPPH	● VOME
■ Dead	● AZCO	● DAFO	● EUSP	● LYSP	● OPSP	● VUMI
Species	● BAAB	● DALEA	● EUSU	● LYVE	● OPVE	● ZIAC
● ABPR	● BOOMM	● DICA	● FEWI	● MAMI	● PETR	● ZIPU
● ACCO	● BORO	● DINE	● FOSP	● MAML	● POGR	
● ACGR	● BRSP	● DISA	● FOST	● MAPI	● PRGR	
● AGSP	● BRWR	● DYPO	● GOSP	● MASC	● PRJU	
● ANDRO	● BURO	● DYSP	● GRASS	● MESC	● PRVE	
● ANSP	● CAAR	● ECFA	● HACR	● MUPO	● RFI	
● AORO	● CABR	● ECFE	● HALA	● NOMI	● SECO	
● ARPU	● CACO	● ENFA	● HASP	● NYCTAG	● SHRUB	
● ARSP	● CAER	● EPTR	● HATE	● OPAR	● SILO	
● ARTE	● CAGI	● ERLA	● HECO	● OPBI	● TRMU	
● ARTU	● CAQI	● ERPU	● JACA	● OPEN	● UNK	
● AYFA	● CEMI	● ERSP	● JAGR	● OPFU	● UNK1	
● AYFI	● CEPA	● ERWA	● LATR	● OPLE	● UNK2	

Number of Stems per Plot		
	1965	2005
Control	349	199
Exclosure	360	165

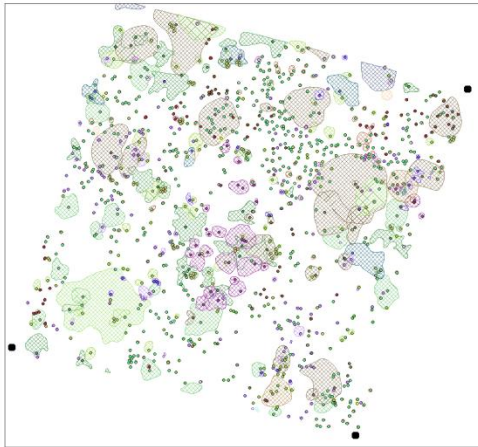
Total Aerial Cover per Plot (m ²)		
	1965	2005
Control	39	132
Exclosure	62	121



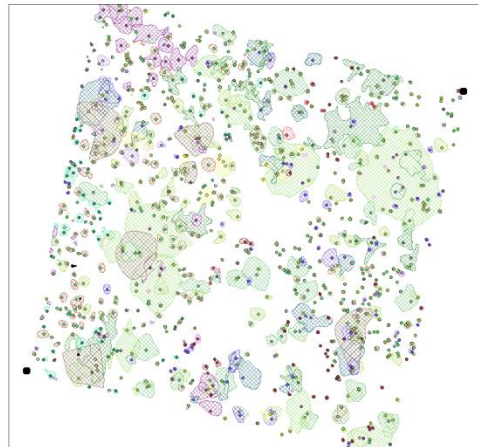
0 1.5 3 6 Meters

Plots were surveyed by hand in August 1965 and re-surveyed using a Transit Total Station in December 2005.

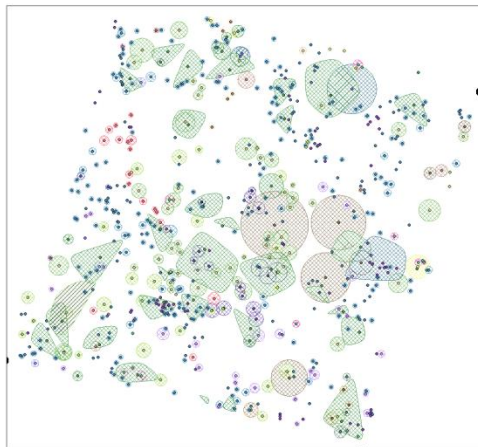
Turner Mammal Exclosure Plot #3



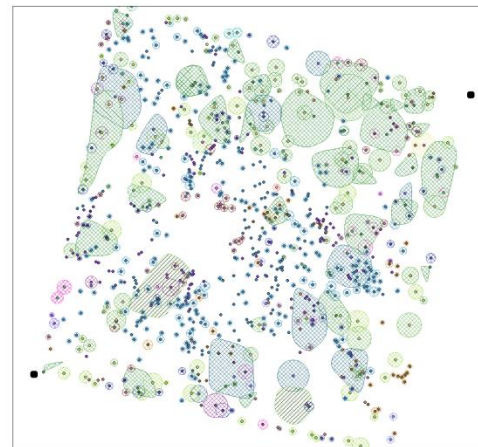
Control Plot - 1965



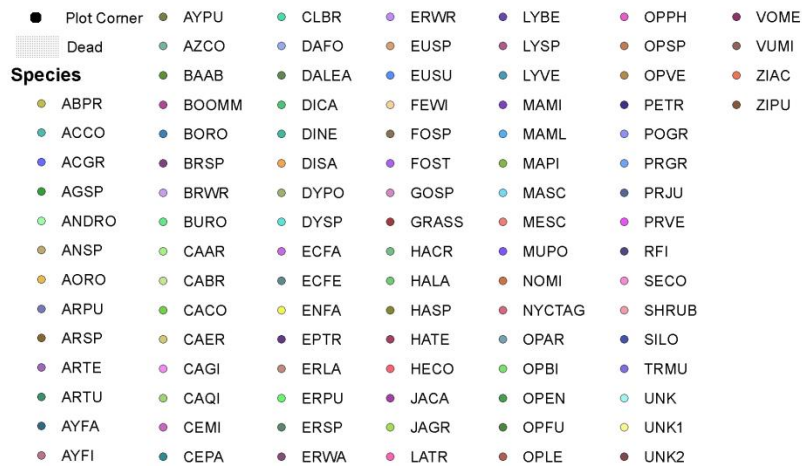
Exclosure Plot - 1965



Control Plot - 2005



Exclosure Plot - 2005



Number of Stems per Plot		
	1965	2005
Control	1035	654
Exclosure	893	865

Total Aerial Cover per Plot (m ²)		
	1965	2005
Control	96	95
Exclosure	109	116



0 1.5 3 6 Meters

Plots were surveyed by hand in August 1965 and re-surveyed using a Transit Total Station in December 2005.