Postfire Regeneration in Arizona's Giant Saguaro Shrub Community

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Abstract.---In May 1993, an arsonist set numerous fires in the saguaro shrub vegetation type on the Mesa Ranger District, Tonto National Forest. In January 1994, we began a postfire examination in these burned areas to determine the potential of the shrub species for resprouting after fire. Fire girdled saguaros and charred shrub skeletons covered the burned areas. Shrub skeletons were examined for basal sprouts or branch regrowth, Resprouting from branches of shrubs was evident within islands of partially burned areas and along the edges of the burns. Basal sprouting was observed on plants that had no apparent viable upper branches. This implies that some shrub species in the saguaro shrub association studied have the potential to regenerate after a spring wildfire.

INTRODUCTION

A review of current fire records, 1973 to 1992, from the Tonto National Forest, Arizona, reveals a continuing increase in fire frequency and acreage burned in upland Sonoran desert communities. The number of fires in desert habitats approaches those in timber, but exceeds all other habitats in actual acres burned (Narog et. al. in press). Earlier studies of fire occurrence reported similar increases in desert-shrub and desert-grassland fires (Rogers 1986, Rogers and Vint 1987, Schmid and Rogers 1988). Consequently, internationally renowned scenic vistas, composed of giant saguaros (Carnegiea gigantea) and associated vegetation, are becoming severely degraded by this recent change in fire regime. Modern fire records for this desert habitat do not provide the type of documentation necessary to understand fire dynamics from a historical perspective. However, fire histories from adjacent montane habitats have been reconstructed from dendrological analyses (Baisan and Swetnam 1990) and may be useful.

Sonoran desert communities, with their species rich patches (Silvertown and Wilson 1994), present us with a complex and dynamic mosaic of vegetation. Areas once characterized by small in frequent fires, now support flammable exotic grasses that connect many of these patches and purportedly increase ignitions and acreage burned.

The role of fire and grazing in Arizona desert grassland-shrub communities has been debated and evaluated for over 70 years. Leopold (1924) called for a serious consideration of his perceived problem of shrub encroachment into grasslands. He attributed the shrub encroachment to overgrazing and decreased fire occurrence into the uplands. The majority of research on fire in the desert has focused on conversion of the desert shrubland to grassland (Phillips 1962, Martin and Turner 1977). Others have documented and weighed responses of desert-grassland-shrub species to fire against anthropogenic factors (e.g., Cable 1972, Rogers and Steele 1980, Ahlstrand 1982, McLaughlin and Bowers 1982, Martin 1983, Cave and Patten 1984, Humphrey 1984, Rogers 1985, Goldberg and Turner 1986, Cox, Ibarra and Martin 1988, Davis 1989, and Thomas 1991). All these studies combined suggest more questions than they answer for managing fire in these desert ecosystems. Wright (1988) summed up the problem when he wrote, "The historical role of fire in the semidesert grass-shrub community is somewhat perplexing." Multiple-use management, and changing needs and interests have further confounded fuels and fire management. Therefore today, fire remains problematic for many desert land managers.

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Following recurrent fire problems, the Tonto National Forest, Arizona, requested assistance in developing alternative fire management policies in desert-shrub saguaro habitats. They were concerned that the increasing fire frequency would decimate the dwindling population of highly prized saguaro resource. We, therefore, initiated a study on the effects of fire on this saguaro community. This paper presents preliminary observations and survey results of 1-year post-fire plant growth responses as contrasted with plants on an adjacent unburned plot.

METHODS

Study Area

This study is being conducted on the Mesa Ranger District of the Tonto National Forest, Arizona. Our research is confined to approximately a 16-square mile area located about 40 miles northeast of Phoenix along the B-line Highway (Highway 87), southwest of Four Peaks Mountains, and northeast of Adams Mesa (fig. 1). It is in the mid-elevation range, ca. 800 m, of saguaro habitat with generally uniform slope and aspect. This land is heavily used for recreation and as open rangeland for cattle. Data reported here are from two of nine plots identified for this research project. These two plots were placed at the May 4, 1993, Vista View burn site. Both plots were aligned east to west along the same slope contour to minimize geological, elevational and vegetation gradients. The unburned (fig. 2) plot was east of the wildfire in vegetation without prior fire history. The burned (fig. 3) plot was due west of the

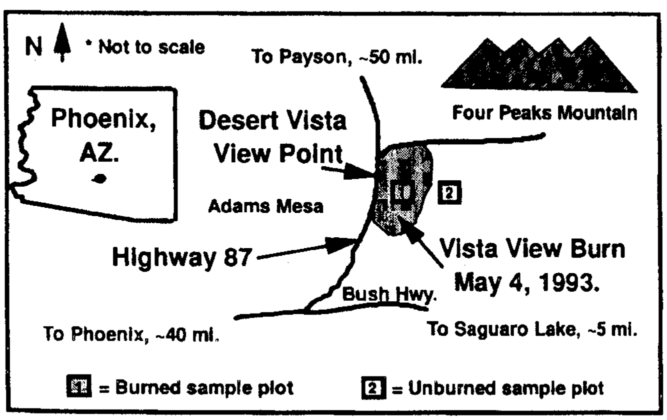

Figure 1.--Study site location on the May 4, 1993 Vista View burn, Mesa District, Tonto National Forest, Arizona. Note: map is not to scale.

Figure 2.--Unburned saguaro community adjacent to the May, 1993 Vista View burn, Tonto National Forest, Arizona.

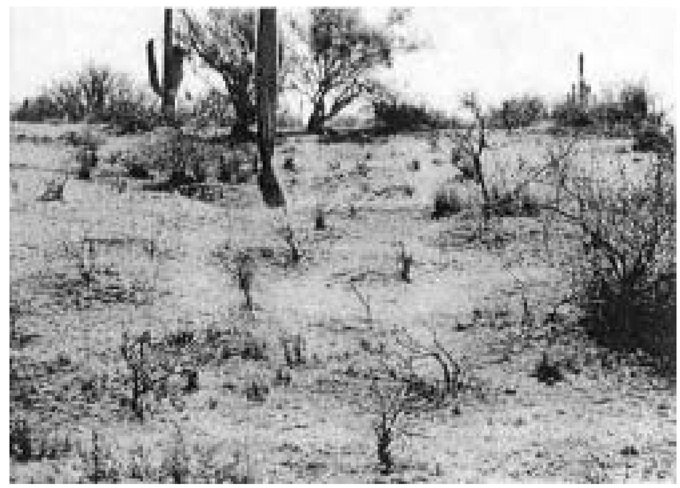

Figure 3.--Burned saguaro community 1 year after the May, 1993 Vista View burn, Tonto National Forest, Arizona.

unburned plot and had been placed 100 m within the burned area perimeter. Both plots established for this study were on adjacent similar terrain and were evaluated during the spring of 1994.

Experimental Design

Standard ecological methods and calculations as outlined by Cox (1990) were modified and adjusted to make their application appropriate in size and scope for this vegetation type. An integrated combination of line intercepts and quadrats was used to survey cover, density and frequency of occurrence for trees and shrubs in adjacent and similar unburned and burned permanent 1ha plots. Information on the herbaceous layer is not addressed in this paper, and future reference to plants will include only trees and shrubs. Each plot was subdivided into five 20m X 100m belt transects. Within each belt transect, a set of 10 contiguous quadrats was sampled adjacent to a randomly placed 100m line (fig. 4). Data for the line were recorded in 10m subunits coincident with the adjacent quadrat. Plants were counted in quadrats and measured on line intercepts. Obvious new growth from basal sprouts or branch regrowth on trees and shrubs were counted as resprouts. Other plant dimensions and community parameters were measured but are not reported here.

Analysis

Taxonomic determinations were made using available keys (Kearney and Peebles 1960, Elmore 1976, Earle 1980, Fisher 1989, Parker 1990, Bowers 1993, Hickman 1993). And voucher specimens were collected. For this preliminary examination of plant differences between unburned and burned plots, we arranged the species in a series of seven growth-form classes: trees, shrubs-large, shrubs-medium, shrubs-small, yucca, cactus and perennials. These were based on plant height, growth form, apparent woodiness and succulence. Numerical analyses were based on individual totals divided by 50 sample units for each plot studied. Each sample unit included a 10m line segment adjacent to a 10m X 10m quadrat. Means are presented as the average cover per 10m segment or mean density per 10m X 10m quadrat.

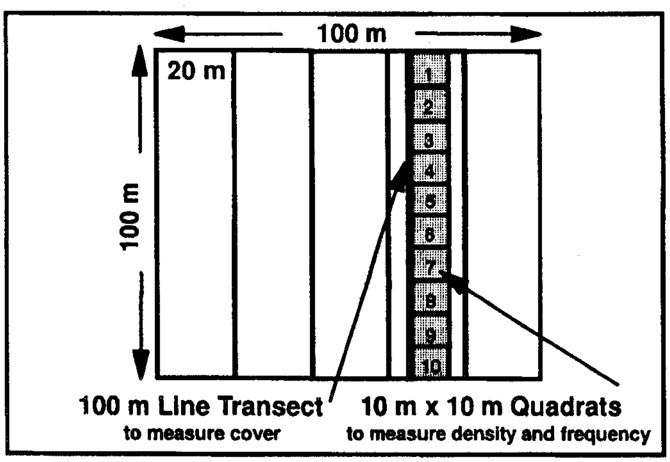

Figure 4.--Within each of the five 20m x 100m belt transects, a randomly placed 100 m line transact and ten 10m x 10m quadrats were placed for vegetation sampling in each hectare surveyed 1 year after the May, 1883 Vista View burn, Tonto National Forest, Arizona.

Relative percent cover was calculated from line data. Percent and relative percent frequency and relative percent density were calculated from quadrat data. Importance values as presented are the sum of relative percent cover, density and frequency, divided by 3.

RESULTS

Thirty-five plant species were counted and grouped into the growth-form classes: 2 trees, 5 shrubs-large, 13 shrubs-medium, 3 shrubs-small, 1 yucca, 7 cacti, and 4 perennials (Table 1). Of the 30 species found on the burned plot, 28 were observed resprouting. Species also noted to resprout by Rogers and Steele (1980) are identified in Table 1.

Both cover and density (Table 2) were less in the burned than in the unburned plot. In the unburned plot, the overlapping plants and clustered pattern of diverse species was reflected by the amount of cover on the line. The portion of the line that had living plants had a mean of about 109 percent cover. The rank order of plant frequency was similar in both the burned and unburned plots (Table 2), with the exception of a lower frequency of cactus in the burned plot. Even though absolute cover, density and frequency values may be lower in the burned plot, their calculated importance values show vegetation type composition and patterns similar to those of unburned sample units (fig. 5).

Total cover for live plants (fig. 6) in the burned plot was 15 percent as compared to 41 percent in the unburned plot. After only 1 year, resprouting plants accounted for the majority of the 15 percent cover in the burned plot (fig. 7).

Among the growth-form classes, cactus showed the greatest difference in density between the unburned and the burned plots (Table 3). Notably, 88 percent of all plants counted in the burned plot were resprouting at this time. Compared with the 3,126 individuals counted in the unburned plot, the 1,741 individuals in the burned sample represent a possible 55 percent survival.

In the unburned plot, many saguaros were observed growing in close proximity to shrubs and trees (fig. 8). Saguaros were often severely injured when their associated plant complex was burned (fig. 9). The ultimate impact of the fire on the standing saguaros cannot be estimated from the data collected at this 1-year post-fire sampling. A

Table 1. Saguaro community species presence and resprouting densities on unburned[1] and burned plots 1 year after the May, 1993 Vista View burn, Tonto National Forest, Arizona.

Growth form Scientific name	Common name	Unburned density (.5 ha)	Burned density (.5 ha)	Post-fire resprouts[2] (.5 ha)	
Trees					
Canotia holacantha	Crucifixion thorn	39[1]	43	36	S
Cercidium microphyllum	Foothill palo verde	46	16	12	S
Shrubs-large					
Acacia constricta	Whitethorn	76	72	72	S
Acacia greggii	Catclaw	44	42	42	S
Jatropha cuneata	Wedgeleaf limberberry	1	5	5	
Lycium californicum	Desert thorn	5	4	4	
Lyclum parishii	Wolfberry	52	33	33	G
Shrubs-medium					
Ambrosia deltoidea	Triangle leaf bur sage	183	113	10	S
Callandra eriophylla	Fairy duster	168	196	195	S
Encelia farinosa	Brittle bush	30	27	25	S
Encelia frutescens	Green brittle bush	0	17	17	
Ephedra asperca	Mormon tea	61	63	55	
Ephedra trifurca	Mormon tea	81	117	110	
Ericameria cooped	Cooper golden bush	594	1	1	
Ericameria larcifolia	Turpentine bush	116[1]	25	27	
Edogonum fasciculatum	Wild buckwheat	157	0	0	
Helianthus annuus	Sunflower	15	0	0	
Krameria grayi	White ratany	137	153	147	S
Psilostrophe cooped	Paper flower	97	12	12	
Thamnosma montana	Turpentine broom	100	41	3 9	
Shrubs-small					
Palafoxia linearis	Spanish needle	82	9	9	
Senna covesii	Cassia	86	0	0	S
Sphaeralcea ambigua	Globe mallow	85	153	144	
Yucca					
Yucca torreyi	Yucca	107	105	95	
Cacti					
Camegiea gigantea	Saguaro	5	14	0	
Echinocereus engelmannii	Strawberry hedgehog	35[1]	3	2	
Mammillaria tetrancistra	Corky-seed fishhook	18	4	2	
Opuntia bigelovii	Teddy bear cholla	1	0	0	
Opunda engelmannii	Prickly pear	12	2	1	
Opuntia leptocaulis	Desert christmas cactus	37	9	4	S
Opuntia versicolor	Staghorn cholla	228	28	19	
Perennials					
Baileya multiradiata	Desert marigold	374	332	322	
Cersium neomexicana	Thistle	21	99	0	
Haplopappus spinulosus	Yellow aster	15	1	1	
Stipa sp.	Bunch grass	18	0	0	

[1] Unburned area resprouts include: 1 Canotia, 2 Ericameria laricifolia, and 1 *Echinocereus engelmannii.*
[2] Plants also identified as resprouting by Rogers 8 Steele (1980):
S = identified to species level and G =only Identified to genus level.

high proportion of each fire-damaged saguaro still maintained photosynthetically active tissue. Numerous saguaros were observed flowering and producing fruit even though their bases had been severely girdled or charred.

DISCUSSION

The natural range of saguaro is limited by cold intolerance (Steenbergh and Lowe 1971 1983). Successful recruitment and establishment of saguaro seedlings requires protection from unpredictable, extreme fluctuations in temperature and rainfall, as well as from biotic factors such as herbivory. This subtropical cactus is often found shielded from these hazards by association with a nurse plant (Nobel 1980, Vandermeer 1980, McAuliffe 1984, Gibson arid Nobel 1986). However, when fire becomes a frequent component of this ecosystem, the nurse plants may become a liability. They may supply adequate fuel in close proximity so that the cactus is destroyed. Our observations suggest this may be more likely to occur where this habitat has been degraded by continuous grazing and invaded after wet winters by fine-fueled exotic grasses.

Table 2. Mean[1] plant cover per 10m segments and total number of hits for five 100m line intercepts in a saguaro community on unburned and burned plots one year after the May, 1993 Vista View burn, Tonto National Forest, AZ.

GROWTH FORM	UNBURNED Mean(cm)	Hits	BURNED May, 1993 Mean(cm)	Hits
Tree	102.7	34	36.8	26
Shrub-large	94.6	53	55.9	33
Shrub-medium	156.2	156	31.4	53
Shrub-small	11.1	27	2.4	4
Yucca	44.8	19	15.1	19
Cacti	10.9	34	3.0	9
Perennial	3.6	19	12.1	22
SUBTOTALS				
All plants	423.9	342	156.8	166
Dead plants	9.1	7	44.3	22
Ground	613.2	225	812.1	248
TOTAL	1,046.2	674	1,013.2	436

[1] N=5, m=10, sample units=50.

Table 3. Density[1] comparisons of plants and their resprouts[2] in unburned and burned plots of a saguaro community 1 year after the May, 1993 Vista View burn, Tonto National Forest, Arizona.

GROWTH FORM	UNBURNED Number of Plants observed	resprouting	BURNED Number of Plants observed	resprouting
Tree	85	1	59	48
Shrub-large	178		156	156
Shrub-medium	1,739	2	765	731
Shrub-small	253		163	154
Yucca	107		105	95
Cacti	336	1	61	30
Perennial	428		432	323
TOTAL	3,126	4	1,741	1,537

[1] Number per 0.5 ha.
[2] New growth emerging from basal sprouts or branch regrowth.

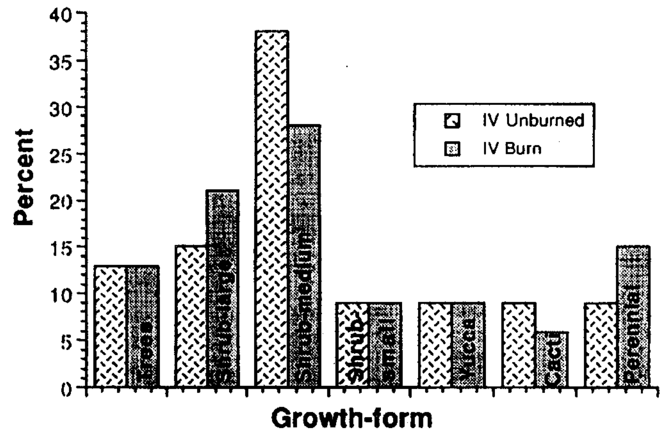

Figure 5.--Relative importance values (IV) among growth forms on unburned and burned plots in a saguaro community 1 year after the May, 1993 Vista View burn, Tonto National Forest, Arizona.

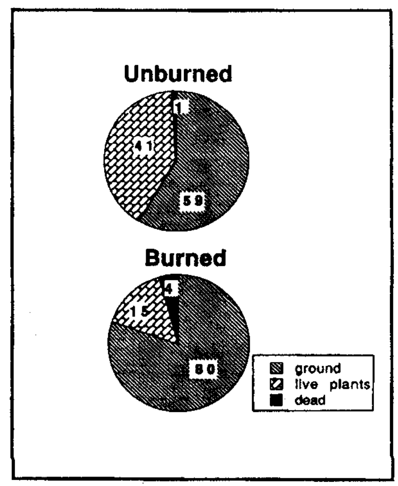

Figure 6.--Relative percent cover observed on an unburned and burned site in a saguaro community on the Tonto National Forest, Arizona. Note: Percentages are rounded to nearest one percent.

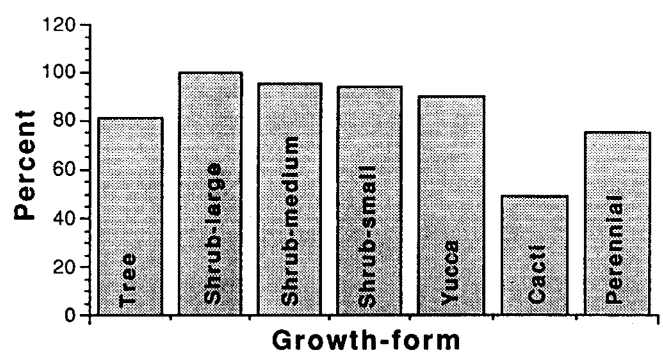

Figure 7.--Percent of plants resprouting In .5 ha of a saguaro community 1 year after the May, 1993 Vista View burn, Tonto National Forest, Arizona.

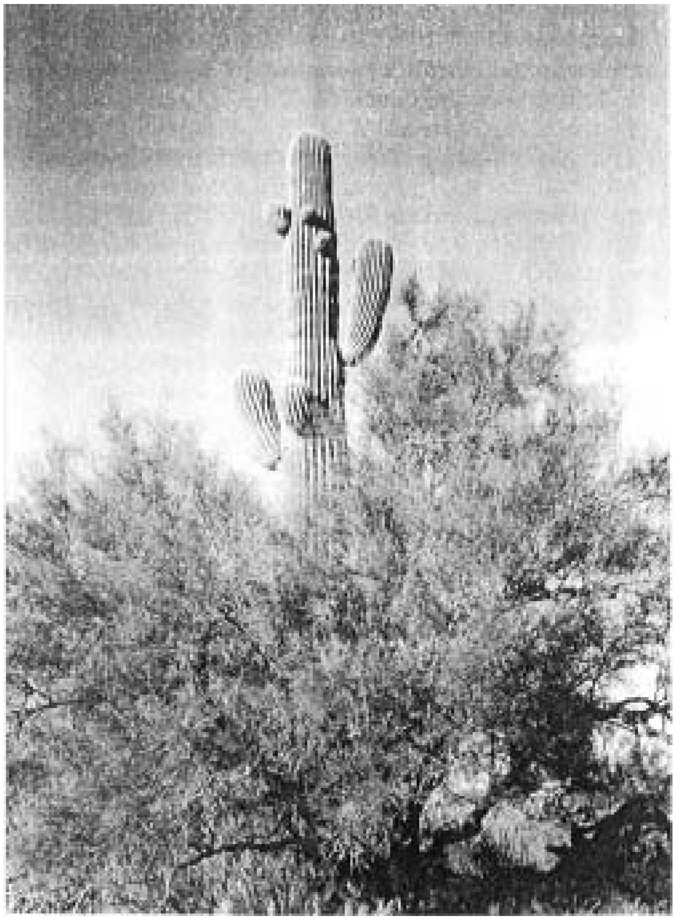

Figure 8.--Unburned saguaro and palo verde adjacent to May, 1993 Vista View burn, Tonto National Forest, Arizona.

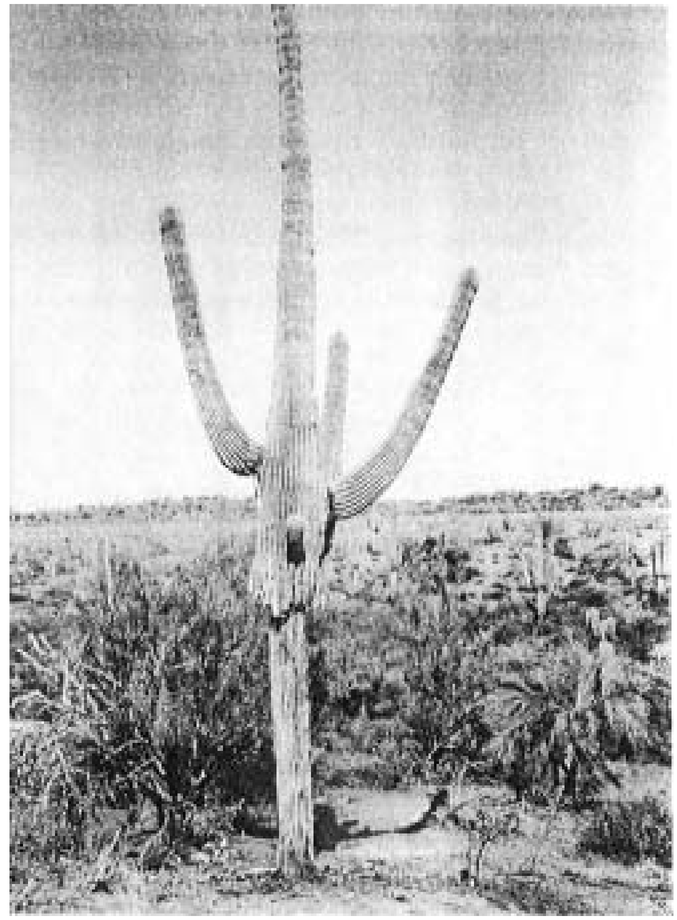

Figure 9.--Fire-girdled saguaro 1 year after the May, 1993 Vista Viewburn, Tonto National Forest, Arizona.

Saguaro individuals may continue to stand and even reproduce seeds for several years after being mortally injured. Saguaro seeds reportedly must germinate and establish seedlings within their first season because the seeds are not viable beyond 1-year (Steenbergh and Lowe 1977). This paper focuses on the resprout response of plants associated with saguaro and whether they can survive fire. If saguaro is to remain an important component in this plant communitiy, then the significance of resprouting becomes apparent when we consider the immediate need for the quick post-fire re-establishment of the associated 'shelter' shrub species.

Palo verde is most often identified as the typical nurse plant for saguaros, however, other species may serve as potential shelter. Saguaro individuals may benefit from various degrees of shelter during their development and life history. Differences in biodiversity of associated vegetation may impact saguaro success. We found 35 associated species of potential shelter plants in our plots. Saguaros were often observed surrounded by trees and large shrubs, e.g., Canotia, Cercidium, Acacia spp. and Lycium spp. The potential role of other species is of interest, but undocumented. Further investigations are required to make that determination.

The saguaro community we studied is not unlike desert-shrub communities described by Silverton and Wilson (1994). Islands of species diversity are scattered throughout the area, separated by bands of bare ground. Our comparison of unburned with adjacent burned saguaro habitat showed five fewer species encountered in the unburned compared to the burned plot. In our unburned plot, live tree/shrub "islands" accounted for 41 percent of the cover on the line transect. Within that 41 percent we observed, 109 percent tree/shrub overlap. Live plant cover for the burned plot was only 27 percent of the unburned, while the average plant density in the burned plot was 59 percent of the unburned. When we consider this information with the fact that 88 percent of the plants encountered in our burned study plot were resprouting 1 year after the wildfire, it becomes apparent that a high percentage of plants in this saguaro community have the capacity to rapidly recover after fire. Shrubs that resprout may thus provide immediately needed post-fire shelter for saguaro seedling establishment, yet may ultimately contribute to a potential fire hazard. However, long-term monitoring of these associated plants is required to determine whether they will recover, or like the saguaro, eventually die.

Clear documentation of the detrimental impact of cattle grazing on saguaro seedlings is presented by Abouhaidar (1992) for fenced plots on the Saguaro National Monument, Tucson. Our observations on the Tonto National Forest of the complex community structure and interplay of both biotic and abiotic natural and introduced factors, parallel those identified by Turner (1992) for the Saguaro National Monument, Rincon Mountain District, Tucson.

Post-fire mortality has been clearly documented for the giant saguaro cactus (Steenbergh and Lowe 1977, 1983, McLaughlin and Bowers 1982, Rogers 1985). Rogers (1986) noted that the mortality of saguaros has been underestimated because of the long lag between injury and death of individual saguaros. In his reevaluation of the area studied by McLaughlin and Bowers (1982), Rogers (1985) suggests "... that saguaro could be virtually eliminated by a sequence of fires that occur at intervals of less than 30 years, because saguaro requires 30 years to reach reproductive maturity ...".

Declines in these giant cactus forests have been precipitated by the combined assaults of urban encroachment, grazing, fire and natural climatic factors. Few saguaros will remain in many parts of its range if this trend is not reversed. Therefore, integrated efforts of scientists, managers and politicians, dedicated to programs of detailed studies, holistic management and political commitment, are needed to preserve the biodiversity of this unique ecosystem.

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