Postfire Saguaro Injury in Arizona's Sonoran Desert

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Abstract.--In May 1993, arson wildfires burned along Hwy 87 in saguaro-shrub vegetation on the Mesa Ranger District, Tonto National Forest, Arizona. Preliminary findings on the extent of saguaro injury caused by these wildfires are presented here-Height class distribution was similar for saguaros from unburned and burned areas. Saguaro mortality was about 2 percent on unburned sites compared to an initial 19 percent on burned sites. Over 90 percent of saguaros exhibited fire injury, and more than 60 percent were girdled. Long-term mortality may increase to over 80 percent of the saguaros on burned sites. Six woody small-tree or large-shrub species composed 88 percent of nearest neighbors associated with saguaro. An evaluation of the fuel potential of these nearest neighbors is needed.

INTRODUCTION

Wildfire frequency and acreage burned have increased over the past 40 years in upland Sonoran Desert communities (Rogers 1986, Schmid and Rogers 1988, Narog et al.1995). Superior giant saguaros, *Carnegiea gigantea (Engelm.)* Britt. & Rose, are being degraded or lost by this apparent change in fire occurrence (Rogers 1985, Wilson et al. 1995 a,b). Cave and Patten (1984), McLaughlin and Bowers (1982), and Thomas (1991) document similar effects of fire on desert vegetation. Although associated woody plants (e.g., foothill paloverde, *Cercidium microphyllum* (Torn) Rose & Johnst.) are considered nurse plants by some (e.g., McAuliffe 1984, Turner et al. 1995), they may contribute to saguaro injury or death by providing fuel for fire (Wilson et al. 1995a).

Freezing temperatures delimit the range of saguaro, and may unpredictably damage large numbers of them in a short period of time (Steenbergh and Lowe 1976, 1983). Fire may also destroy large numbers of saguaros (Cave and Patten 1984) when thousands of hectares of desert are burned (Narog et a1.1995).

Programs addressing multiple use concerns and fire management in these desert ecosystems are difficult to develop (Wright 1988). In response to the need for an evaluation of wildfire effects on saguaro and its associated vegetation, a cooperative effort between the Tonto National Forest and the Pacific Southwest Research Station was initiated. In January of 1994, we began a project to study fire effects on saguaro-shrub vegetation, and investigate fire management options (Narog et a1.1995). This paper compares preliminary findings on saguaro injury and mortality at unburned sites with fire-caused injury and mortality at burned sites on the Tonto National Forest, Arizona.

METHODS

Study Area

On May 4, 1993, arson fires were set between the Vista View Desert Observation Point along Hwy. 87 and Bush Hwy., Arizona. The extent of these fires and existence of adjacent unburned saguaro-shrub vegetation lead to the selection of this area for our permanent plots.

Study plots were located at an elevation of about 800 m, within a 25-square-km area known as "The Rolls" (R8E: T3-Sec. 2, 4, 5, and T4-Sec. 26, 27, 35 of the Four Peaks Quad), Mesa Ranger District, Tonto National Forest, Arizona. The heavily vegetated unburned areas have no record of recent fires. This open rangeland area

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is subject to heavy recreational use and intermittent livestock grazing.

Experimental Design

Sampling methods (Cox 1990) were modified to fit the characteristics of this saguaro-shrub vegetation. To minimize geologic, elevational, and vegetational gradients, plots were placed in and around the Vista View Burn (Narog et al. 1995, Wilson et al. 1995a) along similar aspect and slope contours. We used plotless point-quarter and nearest neighbor techniques to collect data from five point-quarter transects associated with five of our nine[1]-hectare plots: two in unburned and three in adjacent burned areas.

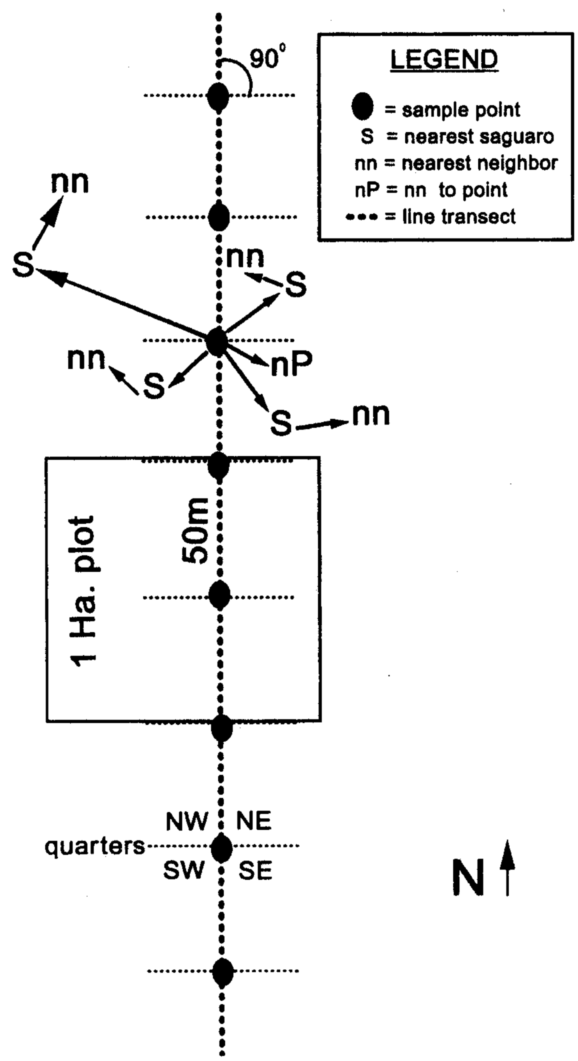

Figure 1. Point-quarter transect and nearest neighbor techniques used to locate saguaros and nearest neighbor plants on unburned and burned sites, Tonto National Forest, Arizona.

Transects started at a randomly selected point along the northern perimeter of each plot and extended 150 m to the north, south through the plot, and 100 m south of the plot (fig. 1). At each of eight points (50 m apart), data were taken for: 1) the nearest saguaro (within 200 m) and its nearest neighbor shrub in each of four quarters, and 2) the shrub nearest each point. When a saguaro occurred as the nearest saguaro to two adjacent transect points, the overlap was recorded and duplicate data were not taken.

Fire-caused saguaro injury was measured by: 1) degree of stem circumference affected, and scar height and aspect, and 2) whether the saguaro was alive or dead (See Analysis). Each saguaro sampled was photographed.

Analysis

Relative percent frequency ((saguaro parameter frequency / total frequency) X 100 = relative percent) was used to plot saguaro height data from unburned and burned sites, and to correlate fire scar data with aspect. We used Quatro Pro for windows statistics and t-test programs to compare height data. Saguaros from burned sites were grouped into four injury categories:

1. Dead-burned with no apparent signs of live green tissue or recently fallen,

2. Girdled-living, but burned 360 degrees around its circumference,

3. Scarred-not girdled but with at least some apparent fire damage, and

4. No scars-no discernible fire-caused injury.

Saguaro heights were sorted into 0.5 m height class intervals. Age estimates are based on height-to-age correlations for Saguaros from Tucson populations (Steenbergh and Lowe 1983).

RESULTS

Saguaro

A total of 137 saguaros were evaluated along the five transects. Individual overlap accounted for a loss of 22 of the 160 possible saguaros: ll in unburned and 11 in burned areas. No saguaro occurred within 200 m in one quarter on a burned site.

Average saguaro heights from unburned (4.39∂2.1 m) and burned (4.73∂2.6 m) samples were similar (t = 0.5>P>0.1). Based on height-to-age correlations, the ages of the 137 saguaros are roughly estimated to range from about 20 years to 200 years. Of the 137 saguaros, individuals are noticeably absent in the 10 m to 11.5 m height classes, possibly representing a 5060 year time period (fig. 2). The shortest saguaro sampled was 0.22 m. Seedlings were not observed in either unburned or burned areas.

On burned sites, frequency of fire-caused injury and mortality (fig. 3) is relatively even across saguaro height classes. Generally, fire damage was most severe at their bases. About 94 percent were either dead or injured to some degree. Only about 6 percent (5 of 84) had no obvious fire scars. Of the living fire-injured saguaros, nearly 80 percent (54 of 68) were completely girdled. This girdling typically occurred within 1 m above the soil surface (fig. 4). In addition, scorched, yellow-brown scars reached heights to 6 m on one or more sides of individual saguaros. These prominent scars (91 total scars on 54 saguaros), appear correlated with aspect: east (44 percent), north (36 percent), south (12 percent) and west (8 percent). Nearly half of these severely burned saguaros bloomed 1 year postfire (fig. 4) and provided a limited seed source.

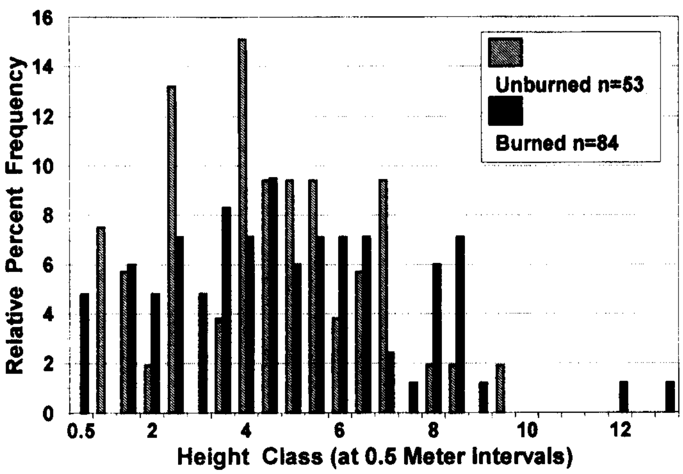

Figure 2. Relative percent frequency of saguaros, distributed by height class, from unburned and burned sample transects (total n=137) in and near the May 1993 Vista View Burn.

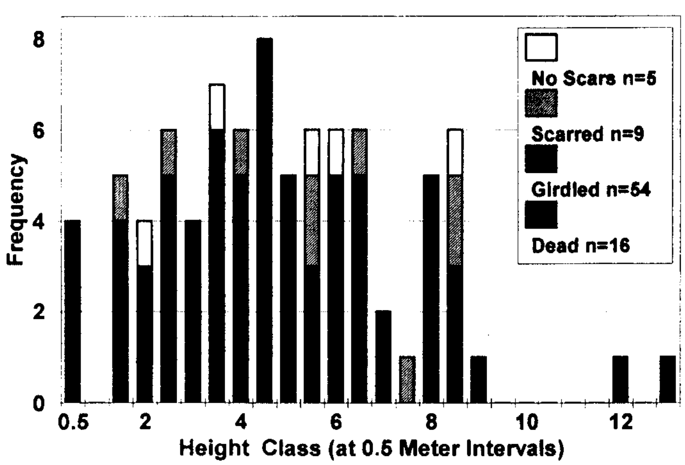

Figure 3. Frequency of wildfire injury to saguaros, distributed by height class, from sample transects (n = 84) in the May 1993 Vista View Burn.

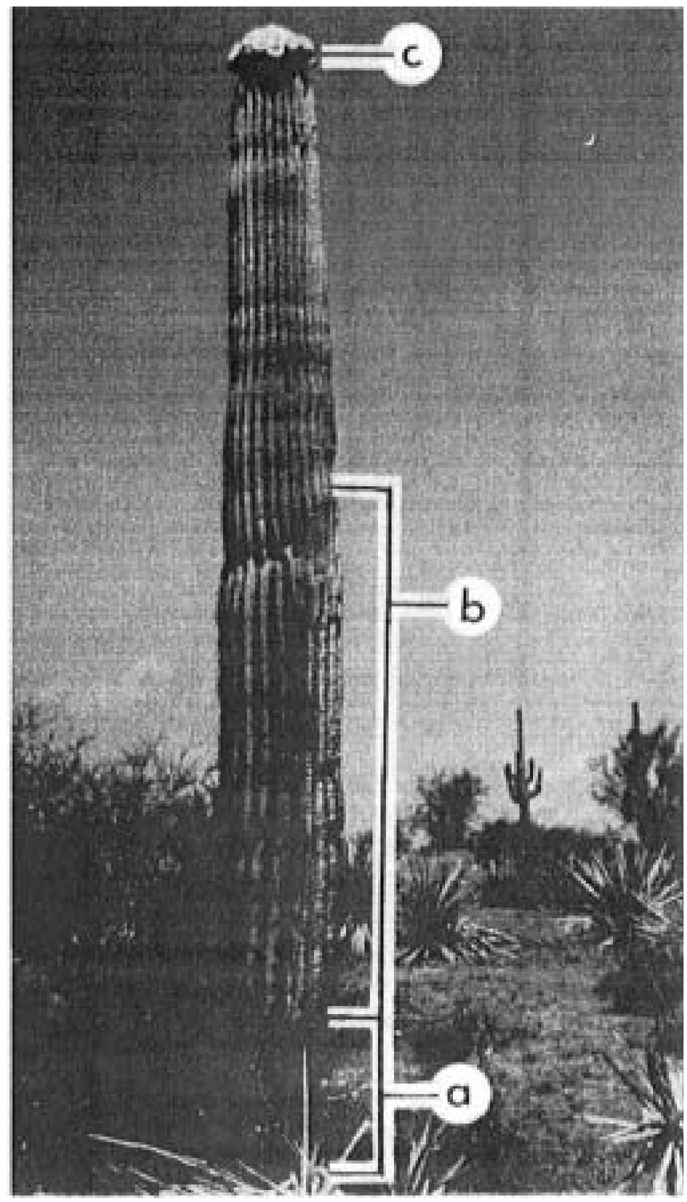

Figure 4. Fire girdled (a) and scarred (b) saguaro blooming (c) 1 year after the May 1993 Vista View Burn.

In unburned areas 2 percent (1 of 53) of the saguaros were dead compared to 19 percent (16 of 84) in burned areas.

Injury, unrelated to fire, was observed on saguaros in unburned and burned sites. This injury was seen most often in the upper portions of the saguaros (e.g., bird cavities in the arms and upper trunk) and was clearly distinguishable from fire damage. Scars on saguaros in burned areas were obviously fire-caused and not the effects of epidermal browning.

Associated Vegetation

Six woody small-tree or large-shrub species, common to both unburned and burned areas, composed about 88 percent of the nearest neighbors to the 137 saguaros sampled. They included: foothill paloverde, *Cercidium microphyllum* (31 percent), white thorn, *Acacia constricta* Benth. (17 percent), wolfberry, Lycium spp. (17 percent), creosote bush, Larrea *tridentata* (DC.) Cov. (12 percent), catclaw, *Acacia gregii A.* Gray (6 percent), and crucifixion thorn, *Canotia holacantha* Torr. (5 percent). Other nearest neighbor shrubs, each with less than 3 percent frequency, included: mormon tea, *Ephedra trifurca* Torn, white ratany, *Krameria grayi* Rose & Painter, jojoba, *Simmondisa chinesis* (Link) C. Schneid, and *Yucca sp.* Of these, all except *L. tridentata* were resprouting in burned areas (Wilson et al. 1995a). *Carnegiea gigantia* occurred as a nearest neighbor twice in each of the unburned and burned areas.

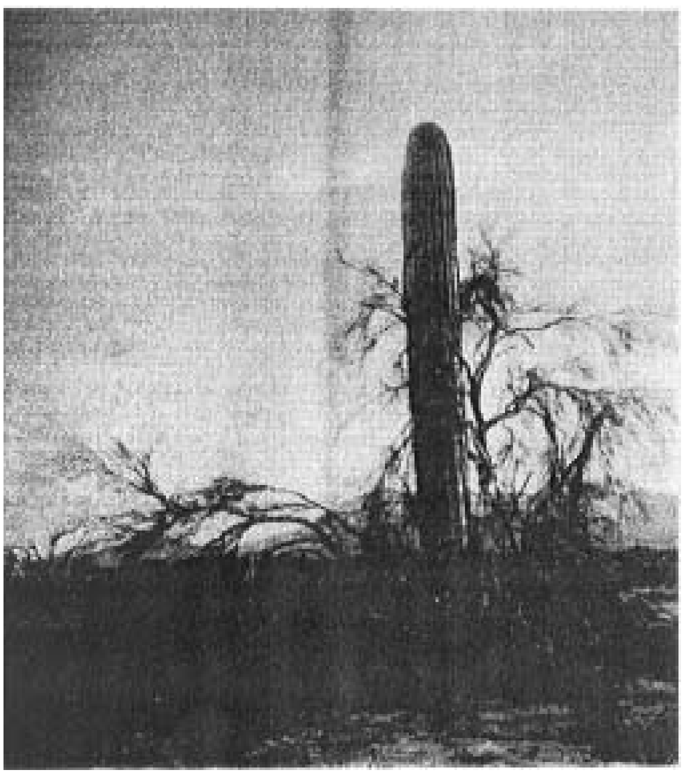

Figure 5. Saguaro, Camegiea gigantea, and its common nearest neighbor, foothill paloverde, *Cercidium microphyllum,* on the May 1993 Vista View Burn.

Cercidium microphyllum (fig.5) was the most frequent nearest neighbor to saguaros in both unburned (36 percent) and burned (27 percent) areas. Interestingly, it was also the most common nearest neighbor to the transect points (37 percent) in two burned areas.

About 9 percent of nearest neighbor plants were dead in both unburned and burned areas. Dead plants in unburned areas included: C. *microphyllum* and *Lycium spp.* Charred dead, non-sprouting plants in burned areas included: C. *microphyllum, Acacia spp., Ephedra spp.*, and *Krameria spp.*

DISCUSSION

The succulent nature of saguaros makes them an unlikely fuel plant. Few, especially large individuals, appear to be consumed by fire. Yet, the fact that fire kills saguaros is documented here. Our findings corroborate those of Rogers (1985) and Thomas (1991) who both note the increased impact of fire in Sonoran Desert regions and high fire-caused cactus mortality, specifically for saguaro. Cave and Patten (1984) report a 100 percent fire-caused mortality for saguaro. Rogers (1985) reports 85 percent postfire saguaro mortality. Because these giant cacti hold large stores of both water and products from photosynthate, it may take several years before an individual dies from either frost or fire damage. Delayed mortality after fire may take over 6 years (Rogers 1985, Thomas 1991). We observed an initial postfire mortality of 19 percent, and expect most of the severely girdled saguaros to die prematurely. Based on this expected additional loss, our projection of over 80 percent eventual saguaro mortality from the Vista View Burn is substantial.

Regeneration of this saguaro population may depend on a diminished seed pool from the few surviving saguaros. Injured saguaros often continue to produce seeds (fig. 4) for several years (Rogers 1985). However, seedling success is linked to precipitation and temperature fluctuations, animal foraging, and available suitable plant cover (Steenbergh and Lowe 1983). Postfire resprouts of associated vegetation (Wilson et al. 1995a) and reproduction by moribund saguaros may provide the potential for this saguaro shrub community to recover after fire. However, intermittent livestock grazing may reduce seedling survival. Numbers of saguaros under 20 years of age are markedly greater in populations where livestock are excluded (Abouhaidar 1992).

Cyclic fire events may now influence the dynamics of major components in this saguaro-shrub ecosystem. Introduced grasses now supply a carpet of contiguous fuels that may contribute to larger conflagrations. Increased use of this National Forest increases the chance for more ignitions. Therefore, extra fire suppression efforts may be required to protect the saguaro resource, especially after seasons with high precipitation. Studies are needed to determine how fuels relate to fire-caused injury or survival. These studies should include analysis of:

1. Fuel loading,

2. Size, distance from, and aspect of nearest neighbors,

3. Aspect of greatest fire injury and

4. Weather conditions relating to fire behavior.

Postfire evaluations of saguaro injury and death should take into account any possible prefire damage from other factors. Evans et al. (1992) describe epidermal discoloration and spine loss on saguaros that could be mistaken for fire-caused injury.

More questions than answers remain. Can temporal burning reduce seed set of exotic herbaceous fuels and disrupt fuel contiguity without damaging saguaros? Prescribed burning as an alternative may increase biomass at the expense of desirable species such as the saguaro (Cave and Patten 1984). In high fire risk areas, can selective removal of flashy fuels save valuable individual cacti? Using grazing to reduce fuel buildup further reduces the chances that young saguaros may survive (Abouhaidar 1992). How can we reduce fire risks without losing the benefits of protection from frost and insolation provided to saguaro by its associated plants? Clearly, fire management alternatives are needed to reduce further degradation of this Sonoran Desert "keystone" species. Will the public support an unseen resource? Once lost, several human generations may pass before the giant saguaro regains its visible majestic status.

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