

**Golden Gate Wildfire
06 June 1994**

**Tucson Mountain District,
Saguaro National Park**

1994 – 2003 Fire Effects and Southwestern Desert Fires



**Saguaro National Park Division of Science and Resource Management
June 2004**

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**Saguaro Nat'l Park
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INTRODUCTION

The Tucson Mountain District was added to Saguaro National Monument in 1961 to protect "...a remarkable display of relatively undisturbed lower Sonoran desert vegetation, including a saguaro stand which equals or surpasses saguaro stands elsewhere in the Nation" (Presidential Proclamation #3439, November 15, 1961). As a national park close to a growing urban center, Saguaro National Park often experiences incidents of resource damage caused by accidental and deliberate human action.

An arsonist started a fire at the edge of Golden Gate Road within the Tucson Mountain District (TMD) on 06 June 1994. The weather was hot and dry, typical for Sonoran desert summer – the TMD Visitor Center recorded a high temperature of 40°C (103° F) for that day. Winds fanned the fire, which grew and spotted to the opposite side of Golden Gate Road. Picture Rocks Fire Department responded to suppress the fire; natural fuel breaks (a wide arroyo on the south side of the fire and generally sparse vegetation) helped keep the fire relatively small, to about 1 hectare (2.5 acres) total (see Map 1). Park biologists responded to document the effects of the fire on vegetation within the fire area, and to record long-term changes in vegetation composition and visual appearance in the area.

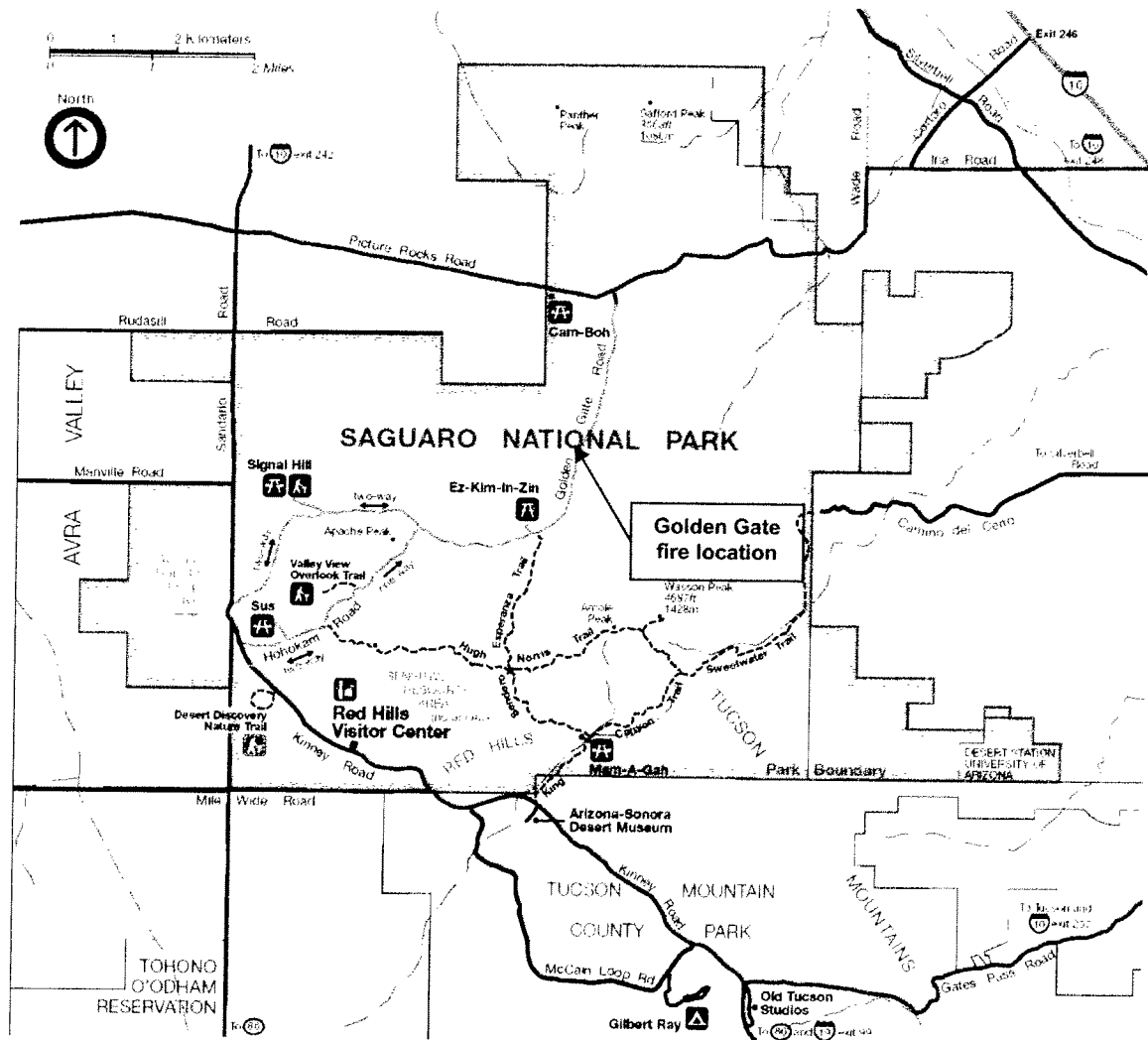
The fire burned at an elevation of about 850 m (2800 ft) in Sonoran Desertscrub (Turner and Brown 1994, Rondeau et al. 1996); the plant community was typical for TMD, with saguaro (*Carnegiea gigantea*), mesquite (*Prosopis velutina*), foothill palo verde (*Cercidium microphyllum*), and desert ironwood (*Olneya tesota*). Shrubs included acacias (*Acacia constricta*, *A. greggii*), creosote bush (*Larrea tridentata*), triangle-leaf bursage (*Ambrosia deltoidea*), cheesebush (*Hymenoclea salsola*), limberbush (*Jatropha cardiophylla*), and other cactus included barrel cactus (*Ferocactus wislizenii*), and various species of cholla (*Opuntia acanthocarpa*, *O. fulgida*, *O. phaeacantha*, *O. versicolor*).

POST-FIRE MONITORING

Park biologists were interested in documenting the changes that occurred in the vegetation within the Golden Gate fire area, and specifically the long-term survival of saguaro cacti affected by the fire. We tried to find every saguaro within the fire area, determined the amount of fire damage on each saguaro, and measured its height and number of arms. We also photographed individual fire-damaged plants and panoramas of the site in general to see how they changed over time. We first began collecting data on 07 June 1994, the day after the fire and continued into September 1994. We returned to the fire area at irregular intervals to re-collect data (June 1996, June 1997, January 2003).

SAGUARO MONITORING RESULTS

How bad was the Golden Gate fire for saguaro cacti? We first must look at the number and size distribution of saguaros on the site. We found a total of 33 saguaros within the Golden Gate fire area, 24 saguaros (73%) were less than 1.0 m tall (considered "juvenile"), and 9 saguaros (27%) were 1.0 m tall or greater ("adult"). Of the adult saguaros, 5 had arms. The tallest saguaro recorded in the fire area was 11 m tall with 7 arms.

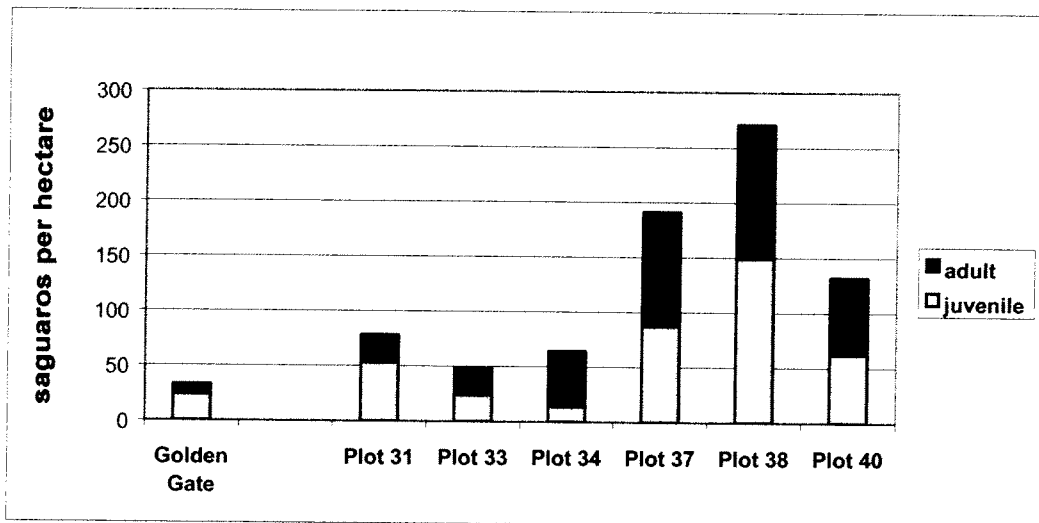


Map 1: Golden Gate Fire location, Tucson Mountain District, Saguaro National Park

Because the burn area was roughly one hectare (10,000 square meters, or 2.5 acres), the estimate of saguaro density in the burn area before the wildfire was about 33 cacti per hectare. Of course, the density may have been higher if we failed to find smaller saguaros completely consumed by fire. For a density comparison, we conducted other saguaro monitoring at TMD in 2000. Six of these saguaro monitoring plots have somewhat similar terrain features as the burn site (Plots 31, 33, 34, 37, 38 and 40); one (Plot 34) is within one km (0.6 mi.) of the Golden Gate fire. The average saguaro density surveyed on these 6 plots was 130 saguaros per hectare, but density ranged from 48 to 271 saguaros per hectare (Turner and Funicelli 2000).

Juvenile saguaros made up 73% of the all saguaros found on the Golden Gate burn. This was a greater percentage of juvenile saguaros than on the same six monitoring plots. Juvenile saguaros averaged 48% of the total saguaros on monitoring plots, and ranged between 22% and 69% of total on individual plots (Turner and Funicelli 2000). See Table 1 (below) for saguaro density comparisons. In general, the Golden Gate fire area had fewer saguaros overall compared to other TMD saguaro monitoring plots, but a greater proportion of juvenile to adult saguaros.

Table 1: Saguaro density on Golden Gate before fire (1994) and 6 saguaro monitoring plots (2000) in TMD



POST-FIRE MONITORING

What effect did the fire have on saguaros? In our first 1994 survey, we determined 22 saguaros (67%) died immediately from fire. Of these, 20 saguaros (91%) were juvenile, and the amount of scorched surface on each cactus was estimated to be 98% or greater. By 1996 mortality for juvenile saguaros reached 100%. Mortality for all saguaros within the fire area was 85% in 1996 and 1997, and 88% by 2003. The four remaining saguaros in the fire area are between 5.5 m and 7.4 m tall.

A similar study on a desert fire near Florence, AZ found 31% mortality in saguaro cactus at 19 months after the fire (McLaughlin and Bowers 1982). Follow-up survey on the same fire found saguaro mortality increased to 68% at 54 months, and the author thought mortality could increase to as high as 85% (Rogers 1985). Similar to the Golden Gate fire, these researchers found higher mortality in juvenile saguaros, with 94% mortality in saguaros less than 1.0 m high, mainly found under the canopies of palo verde trees.

The greater number of smaller juvenile saguaros accounts for the high mortality of saguaros on the Golden Gate fire (currently 88% total). Besides being more easily scorched by relatively shorter flame lengths, saguaro seedlings establish under a “nurse” plant or tree that protects the seedling from environmental extremes. Nurse plants that ignited in the fire subjected smaller saguaros to more concentrated heat (Figure 1, below).

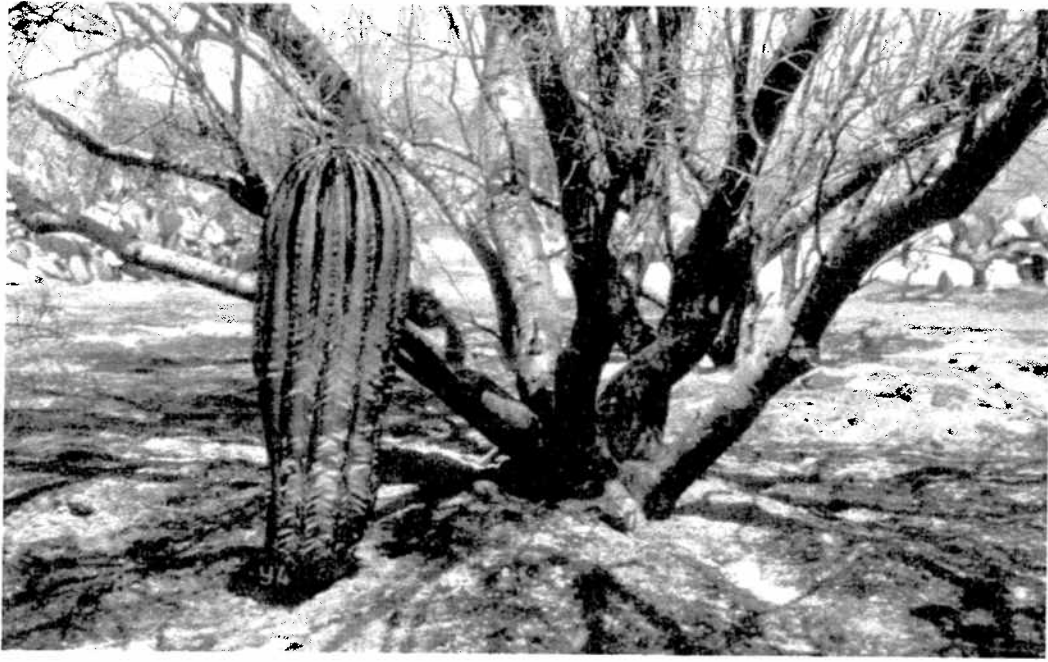


Figure 1: Juvenile saguaro beneath a burned “nurse plant” palo verde tree.

On adult saguaros in the Golden Gate fire, charred epidermis peeled over time, and these cacti survived a few years before dying (Figure 2). When fire scorches a saguaro’s green cells on the stem surface, it destroys its photosynthetic food-producing capability. However, if surface damage is not extreme, stored reserves seem to keep the saguaro alive, sometimes 5 years or more, before it finally succumbs to fire mortality.



Figure 2: Charred and peeling epidermis on saguaro cactus after fire. This cactus lived (and even flowered) for about 2 years before finally succumbing to fire mortality.

What about fire effects on other plants? Of the 11 individual plants we chose for long-term photographing, one saguaro is still alive (although it is leaning badly), and a creosote bush and prickly pear both burned to the base have but re-sprouted and grown back to full size. The remaining plants – three saguaros, one palo verde, one mesquite, one cholla cactus, one desert ironwood, and one barrel cactus (Figures 3 and 4, below) – have died.



Figures 3 and 4: Barrel cactus chosen for long-term monitoring in 1994 (above), and remains in 1996 (below). Note scorched surface of cactus in photo above.



Other plants were top-killed, but have since re-sprouted. Of interest, most of the desert ironwood in the fire area have re-sprouted and regained their original size. Desert ironwood is considered a very slow-growing species, yet these trees have re-grown to full size in just under a decade. There is little available information of the effects of fire on desert ironwood: the Nitrogen Fixing Tree Association (1992) states ironwood is not fire-resistant, and the City of Santa Barbara (2001) lists ironwood as undesirable in fire-resistant landscaping, suggesting high flammability. Besides ironwood, cheesebush and prickly pear cactus have also re-sprouted within the fire area, but have not increased appreciably into new open areas in the burn.

Almost a decade after the Golden Gate fire, the effects of the fire are still clearly evident, and repeat photography shows these changes. The Golden Gate fire area is much more open, less dense, and has lower plant diversity than the surrounding undisturbed desert (Figures 5 and 6).



Figures 5 and 6: The same vantage point on the burn, looking south, immediately post-fire in 1994 (above), and in 2003 (below).



Reduced plant cover affects recovery of saguaro cacti. With fewer nurse plants on site, saguaro establishment and long-term survival could be impacted. In a similar situation, over-grazing by cattle in the Rincon Mountain District (RMD) reduced saguaro establishment for close to a century. The loss of plant cover from over-grazing (combined with trampling and catastrophic freezes) impacted the establishment of seedling saguaros in the district through the 20th century. The Park phased out grazing leases at RMD by the 1980s, and saguaro seedlings showed signs of recovery when we monitored long-term saguaro plots in 2000.

Researchers suggest that widespread saguaro establishment occurs only a few times each century, probably in consecutive years of plentiful precipitation and moderate temperature. Recovery of saguaro cacti on burned sites could be further delayed until the return of adequate tree and shrub cover to the site first.

WILDFIRE in the SOUTHWEST, FOREST and DESERT

Fire is no stranger to the Southwest. The region experiences a summer “monsoon” weather pattern with almost daily thunderstorms, and lightning that causes frequent wildfires. At higher elevations, older ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*) withstand numerous fires in their lifetimes. Prior to 20th century forest fire suppression, fire histories re-constructed from fire scars in annual growth rings in these old higher-elevation conifers suggest a frequent fire interval, as short as every 5 to 7 years. However, frequent fires were of low intensity, because they regularly consumed dead and downed material, killed back dense seedling growth, and maintained forests in an open “park-like” state (Figure 7, below).



Figure 7: A ponderosa pine forest, circa 1909. Before forest fire suppression, regular fires kept western forests open, but fires were of low intensity. (Photos courtesy of USDA Forest Service)

Lightning strikes frequently in the desert, but there are no long-lived plant species like ponderosa pine and Douglas-fir to help us determine historic fire frequency. Widely spaced plants and high fire mortality of key plant species suggest that the Sonoran desert is generally not a fire-adapted environment. McLaughlin and Bowers (1982) point out that lightning, high temperatures and low humidity in deserts can create favorable conditions for fire, perhaps after consecutive years of above average rainfall that increased annual plant production, providing enough fine fuel to carry fire between otherwise widely-spaced desert plants. In other years, fires would be limited to isolated trees or small patches.

A number of modern-day issues aggravate the problem of wildfires in the Sonoran desert. Non-native plants invading or introduced into the southwest are spreading into deserts. Annual grasses such as red brome (*Bromus rubens*) and cheat grass (*Bromus tectorum*) and perennial grasses such as buffelgrass (*Pennisetum ciliare*) fuel fires in desert systems (McAuliffe 1995). Also, increasing human populations in the southwest have increased accidental and intentional fire starts. Fire records show an increasing frequency of human-caused fires through the 20th century at Saguaro National Park (Swantek et al. 1999) and on the Tonto National Forest (Alford and Brock 2002), close to Tucson and Phoenix.

The Golden Gate fire came on the heels of the Mothers' Day fire on 08 May 1994. A vehicle fire on the Cactus Forest Loop Road ignited the Mothers' Day fire that burned about 500 hectares (1250 acres) in the lower elevation of RMD. This fire was fanned by high winds from a passing weather front and is thought to have been carried by the ground cover Resurrection Plant (*Selaginella arizonica*), and build-up of dried annual grass (specifically, red brome) from a number of consecutive wet springs (Figure 8, below). However, saguaro mortality may have been reduced due to the fire's speed and patchiness.

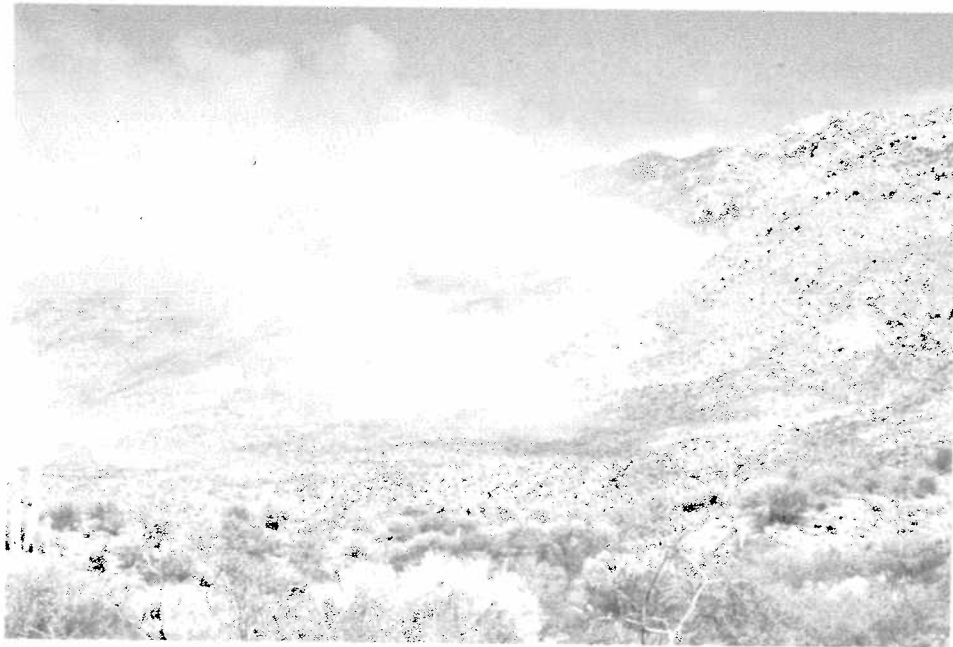


Figure 8: The Mothers' Day fire, May 1994, on the north slope of Tanque Verde Ridge, Rincon Mountain District. (Photo by Don Swann)

Given the effects of these fires, larger and more frequent fires could change the appearance of the Sonoran Desert, and Saguaro National Park specifically. As invasive non-native grasses move into deserts, the threat of wildfire size and frequency increases, since fire tends to stimulate grass establishment. Because smaller saguaros are more subject to fire mortality and their growth rate is so slow, fire as infrequently as every 30 years could eliminate most newly established saguaros from an area and cause localized extinction of saguaros (Rogers 1985).

Parks and preserved open space areas in the Sonoran desert should be vigilant about fire prevention, and should also monitor and control non-native plant species that could fuel more devastating wildfires in an ecosystem not adapted to such disturbance. Saguaro National Park currently suppresses fires below 4500' in elevation at RMD, and all TMD wildfires are suppressed. Also, Resource Management staff monitors and eradicates populations of specific non-native plants in the park.

We also need to cooperate with other local land management agencies and park neighbors on these issues to educate others on the potential for change in desert ecosystems, and to protect our Sonoran desert landscapes, and the plants and wildlife found therein.

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GOLDEN GATE BURN PHOTOPPOINT INFORMATION

I. OVERVIEW PHOTOPPOINTS

June 7, 1994 notes (from old files)

All photos taken in 360 degree circle starting at N (moving counter-clockwise); a letterboard ID photo was taken for some photopoints. A mix of prints and slides were shot.

May 09, 1996 notes

Photographers tried to match the above sequence by using horizon features, surviving plants or evidence of burnt vegetation. Some of the 6/7/94 photos could not be matched and were skipped; matching shots for both years at each photopoint were given a number based on their sequence in the series. Letterboard was used to ID each photopoint site.

The logic of using plants only as photopoints, especially burned ones which may fall over and decay, is questionable. Some points had rebar, others didn't. Aluminum tags on rebar stakes will be installed as a more permanent marker for the *overview* photopoints. The tags will be marked with *PP* [#] and the letters *OV* below to denote an overview photopoint.

June 04, 1997 notes

We shot slides to duplicate all shots taken in 1996. Most of the shots look almost alike in terms of vegetation recovery. While we might not need to photograph each photopoint every year, it doesn't take a great effort and might want to for viewing subtle changes over time. All tags were in place; we discussed the idea of generating a GIS map, plotting boundary and photopoints with GPS.

Photopoint 04

Location: NW base of a small ironwood 22M E of PP#19; about 30M directly into the burn from N end of pull out (to NE, about 24M S of saguaro in PP#05)
06/07/94: 5 prints taken from N to SE; letterboard shot after series photographed
05/09/96: Letterboard shot; 4 slides match June 1994 shots (02, 03, 05, 06)
Ironwood is dead & standing
06/04/97: Letterboard + slides taken
Ironwood still present

Photopoint 05

Location: 25M NW of PP#04; used stake at base of burned saguaro to be monitored; to NE are twin saguaros
06/07/94: 9 prints were taken
05/09/96: Letterboard shot; 11 slides match June 1994 shots (01-11)
PP#05 saguaro is dead and fallen; twin saguaros still standing
06/04/97: Letterboard + slides taken
Saguaro is decaying; twin saguaros still standing

Photopoint 06

Location: At large, multi-armed burned saguaro to be monitored, about 45M WSW of PP#05; saguaro is on the N edge of area cordoned off as point of fire origin

06/07/94: 9 prints taken, plus letterboard shot

05/09/96: Letterboard shot; 5 slides match June 1994 shots (01-04, 06)
Saguaro living, in flower

06/04/97: Letterboard + slides taken
Saguaro still living, in flower

Photopoint 08

Location: At small ironwood with double trunk, with small saguaro just N of it; 23M toward the road (SSE) from PP#06

06/07/94: 13 slides shot

05/09/96: Letterboard shot; 11 slides match June 1994 shots (01-04, 06-12)
Ironwood is dead & standing; small saguaro is dead, still present

06/04/97: Letterboard + slides taken
Ironwood still present

Photopoint 10

Location: At stake [rebar?] in open area N of wash and S of PP#08; about 10M SW of 3-armed saguaro

06/07/94: 11 slides shot

05/09/96: Letterboard shot; 5 slides match June 1994 shots (01-02, 06-08); sequence of 1994 slides photographing outside of burn area not duplicated in 1996
Saguaro still living

06/04/97: Letterboard + slides taken
Saguaro still living

II. PHOTOPPOINTS OF INDIVIDUAL PLANTS TO BE MONITORED

June 7, 1994 notes (from old files)

Ten plants were chosen for monitoring; 2 of these are the locations chosen for long term overview photopoints. Letterboard shots, whole plant shots and close-ups were taken for each.

May 09, 1996 notes

All 10 photopoints were found either by finding the plant itself, or forensic evidence thereof. Some are in such a far gone condition that further monitoring is not recommended. By the way, who worked up the number scheme for these?

June 04, 1997 notes

We found all plants to be monitored. We decided to stop monitoring 5 additional plants that have been dead and are in the process of decaying.

Photopoint 05 - saguaro

Location: 25M NW of PP#04; twin saguaro to NW (see overview photopoints)
Pre-burn: Large (approx. 40') saguaro with 7 arms in very good, healthy condition; all arms had fruit at time of fire
06/07/94: Letterboard shot; 4 slides taken
Base burned all around; burn all the way up most arms w/ most fruit burned; overall looks good, maybe only superficial burn (spines burned off & some epidermal discoloration)
05/09/96: Letterboard shot; 2 slides taken
Saguaro dead & fallen (uprooted); two branches have trace of green in tips; approx. first meter of the base is devoid of outer epidermis, with only center ribs left - weird
06/04/97: Letterboard + slides taken
Saguaro in decay; no green left on branches

CEASE PHOTOGRAPHING

Photopoint 06 - saguaro

Location: 45M WSW of PP#05 (see overview photopoints)
Pre-burn: Large 5-armed saguaro with lean to S; fruit on all 5 arms at time of fire
06/07/94: Letterboard shot; 4 slides
Base burned heavily, especially on N/NE side; burned lower on S side; spines remain on main stem; ignited ironwood on NW side cooked undersides of arms
05/09/96: Letterboard shot; 4 slides
Despite lean and burn damage, saguaro is still standing; thick flowers on all arm tips; midway up stem outer ridges are browned but inner pleat is still green.
06/04/97: Letterboard + slides shot
Saguaro still living and in flower, though not in as great of profusion as nearby specimens

Photopoint 12 - mesquite

Location: On edge of wash S of cordoned off fire origin, 90M up wash from road
Pre-burn: 9' mesquite with three main stems (3", 5", 7" diameters) with the mid-sized stem growing almost horizontally on the ground; some new growth present
06/07/94: Letterboard shot; 3 slides
Base of all three stems burned all round; fire appears intense here
05/09/96: Letterboard shot, 3 slides
Tree dead, no resprouting, bark is beginning to slough off
06/04/97: Letterboard + slides shot
No evidence of resprouting

CEASE PHOTOGRAPHING

Photopoint 13a - prickly pear; 13b - ironwood

Location: 7M SE of saguaro in PP#06
Pre-burn: Large prickly pear, about 5' by 15'; small, 15' ironwood with upright form, 15" trunk diameter, 2 patches of mistletoe
06/07/94: Letterboard shot; 7 slides
Prickly pear 99% burned; pads yellow & wilted; large, woody stem may resprout; ironwood trunk burned all around.
05/09/96: Letterboard shot; 4 slides
Tree dead; unlike about half the ironwoods on the site, this one did not resprout; prickly pear is a pile of dead pads with new green ones resprouting.
06/04/97: Letterboard + slides shot
No sign of resprouting on ironwood; prickly pear appears about the same

CEASE PHOTOGRAPHING 13b

Photopoint 14 - cholla

Location: 12M NW of saguaro at PP#06
Pre-burn: Two-stemmed cholla (2.5" and 5" diam.), about 5' tall, with several chains of fruit
06/07/94: 3 slides
One entire stem burned; top half of other stem did not and still green; 90% of spines burned off, most of plant burned to brown color
05/09/96: Letterboard shot; 4 slides
One stem tip has a little green left, but looks unhealthy; rest of plant is dead
06/04/97: Letterboard + slides shot
Last year's green tip has browned and died; plant is beginning to break apart

CEASE PHOTOGRAPHING

Photopoint 15 - saguaro

Location: 5M WSW of PP#14, NW of PP#06
Pre-burn: Healthy, 12', armless saguaro with fruit on arms at time of fire
06/07/94: 3 slides

Base totally burned, S third except for base is unburned; spines singed off & epidermis is yellowed but intact
05/09/96: Letterboard shot; 2 slides
Dead and blown down (broken mid-stem)
06/04/97: Letterboard + slides shot
Saguaro continues to decay

CEASE PHOTOGRAPHING

Photopoint 16 - creosote bush

Location: 12.5M N of PP#14
Pre-burn: Healthy 6' multi-stemmed creosote
06/07/94: 3 slides
Entire base burned, many branches burned / singed to tips
05/09/96: Letterboard shot; 3 slides
Resprouted from stem; new shrub approx. 3' in diameter
06/04/97: Letterboard + slides shot
Shrub approx. 4' in diameter; foliage green and healthy; plant in seed

Photopoint 18 - palo verde

Location: 12M WSW of PP#05, 41M ESE of PP#16
Pre-burn: Multi-trunked, 15' tall palo verde with 2'9" saguaro at its base; 2 large masses of mistletoe in tree
06/07/94: 5 slides
Base of palo verde burned, top third still green but all of tree affected by heat; smaller palo verde to N almost completely burned
05/09/96: Letterboard shot; 3 slides
Both palo verdes and saguaro are dead; most of smaller branches have fallen off; remains of mistletoe aided in ID; all but one or two small palo verde trees perished in the blaze
06/04/97: Letterboard + slides shot
Palo verdes have succumbed to termite attack and are in decay

CEASE PHOTOGRAPHING

Photopoint 19 - barrel cactus

Location: About 28M straight into burn from S side of pull out; 22M SW of PP#04
Pre-burn: Thick, well-shaped, 4.5' tall barrel cactus
06/07/94: 4 slides
Completely scorched on whole body, except for deep pleats; needles gone
05/09/96: Letterboard shot; 2 slides
Cactus completely disintegrated; barrels showed a lot of variation in burn response: dead & hollowed out from the inside; healthy looking but up-rooted; healthy new growth starting above burned epidermis

CEASE PHOTOGRAPHING

06/04/97 The majority of the injured barrel cacti on the site have died since last year. Many have been uprooted and hollowed out from the inside, perhaps by rodents or javelina. Of two injured barrel cacti that were being monitored, one had uprooted and both showed a reduction in height, suggesting loss of inner water and mass and a process of slow mortality.

Photopoint 20 - saguaro

Location: E side of Golden Gate Road, 2M SE of road in spot fire area
Pre-burn: Healthy, 12', armless saguaro with fruit on arms at time of fire
06/07/94: Letterboard shot; 4 slides; 1 slide of small nearby burned saguaro (4")
 Burned / blackened at base, except for SE side; S side yellowed w/ black at top; spines didn't burn on N side
05/09/96: Letterboard shot; 7 slides; 1 slide of small nearby saguaro (w/ pencil)
 Still living; bottom 3/4 to 5/6 on S side is exfoliating w/ needles to expose dry, spongy layer underneath; N side still has healthy green deep in pleats; about 5 flower buds at top on S side
06/04/97: Letterboard + slides shot
 Still living; south side continues to exfoliate to expose dry under layer; only 1 flower bud present

OVERALL STATUS OF PLANTS TO BE MONITORED

May 1996

photo

<u>point</u>	<u>plant</u>	<u>status</u>	
05	saguaro	dead	watch & discontinue
06	saguaro	living	
12	mesquite	dead	watch & discontinue
13a	prickly pear	resprout	
13b	ironwood	dead	watch & discontinue
14	cholla	living (one small tip)	
15	saguaro	dead	watch & discontinue
16	creosote	resprout	
18	palo verde	dead	watch & discontinue
19	barrel cactus	dead	discontinue
20	saguaro	living	

June 1997

photo

<u>point</u>	<u>plant</u>	<u>status</u>	
05	saguaro	dead	discontinue
06	saguaro	living	
12	mesquite	dead	discontinue
13a	prickly pear	resprout	
13b	ironwood	dead	discontinue
14	cholla	dead	watch & discontinue
15	saguaro	dead	discontinue
16	creosote	resprout	
18	palo verde	dead	discontinue
20	saguaro	living	