Post-Fire Saguaro Community: Impacts on Associated Vegetation Still Apparent 10 Years Later

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Abstract—*Fire impacts on saguaro (*Carnegiea gigantea*) associated vegetation were studied in unburned and burned areas over a 10 year post-fire period after the 1993 Vista View fire, Tonto National Forest, Arizona. Many associated species, crucial for saguaro survival, regenerate by vegetative growth after fire. Bushes were the most common nearest-neighbor, physiognomic, fuel group. Burned area species diversity was maintained by resprouts. Average and total cover m^2 in burned areas was less for trees, cactus, and yucca; similar for bushes; and greater for shrubs than in unburned areas. The burn site has yet to recover its tree and saguaro components.*

Introduction

Saguaro (*Carnegiea gigantea* [Engelm.] Britt. & Rose), a valuable scenic and wildlife resource, is protected in Arizona and California by law. Although saguaros rely on associated "nurse plants" for survival, they may become a liability as fuel for fire. Fire management in this desert is compounded by unpredictable weather and urban encroachment. Fires have burned and continue to re-burn across a considerable portion of mature saguaro-shrub habitat on and near the Tonto National Forest (Narog et. al. 1995, 1999; Alford 2001). Saguaro loss from fire is reported by McLaughlin and Bowers (1982), Rogers (1985, 1986), Schmid and Rogers (1988), Thomas (1991), Wright (1988), and Alford (2001), but there is little documentation on long-term associated plant species response.

The 1993 Vista View fire on the Tonto National Forest exemplifies the consequences of fuel build-up following a few wet years. Our studies track the Vista View post-fire saguaro and associated vegetation growth for a decade. We reported on post-fire initial survival, injury, and mortality of saguaro and associated vegetation (Wilson et. al. 1995), saguaro delayed mortality (Narog and Wilson 2003), and associated vegetation as fuel (Wilson et. al.1998). Long-term post-fire studies are necessary to document the impact of fire on this "slow to recover" saguaro-shrub community.

In this paper, we compare unburned and burned saguaro associated species: diversity, distribution, mortality, and cover m^2 from 2003 saguaro nearest-neighbor data, and 1994 line transect data. Trees, shrubs, and bushes are our major focus because of their dominant size and number, and contribution as fuels.

Results from this unburned and burned saguaro-shrub research provide valuable insight into 10 year post-fire associated plant recovery. This information should be useful when planning conservation and fuels management programs for this vegetation type.

Methods

Our study site is located in saguaro-shrub vegetation on The Rolls, Mesa District, Tonto National Forest, Arizona (R8E: T3-Sec. 2, 4, 5 and T4-Sec. 26, 27, 35 of the Four Peaks Quad). Within the burned 1993 Vista View fire and adjacent unburned area, sample points were placed along randomly selected 350 m transect lines at 50 m intervals. Around each point and in each of four quarters, the nearest saguaro was located and became a nearest-neighbor sample site (Wilson et. al. 1996). Two nearest-neighbor methods were used: (1) a physiognomic characterization, and (2) a quadrant specific approach. Values from the two nearest-neighbor methods provide different perspectives for species and growth forms.

We used physiognomic groups and plant status categories to describe fuel components. Our physiognomic view forces all growth forms to be included in equal numbers around the sample saguaro—if they occur within a 10 m radius. Plants were identified to species when possible. We grouped species into five growth forms based on average structural and fuel characteristics: tree—woody plant with primary trunk (3.0-3.5 m), shrub—large woody multi-stemmed plant (1.5-2.5 m), bush—low growing multi-stemmed woody plant (0.4-0.8 m), cactus—succulent (0.14-0.19 m), and yucca—fibrous woody (1.4 m).

Plant status categories used were live, resprout, and dead. Resprouts in burned areas exemplify new vegetative growth emerging from charred roots, stumps, and branches. Resprouts observed in unburned areas typically emerge from plants containing large amounts of dead material. We distinguished living non-sprouting plants from resprouting plants as "live"

and "resprout live," respectively. Measurable dead material within a plant was recorded as "dead in plant." Distance from the saguaro and plant dimensions (height, and two diameters) were measured for each nearest-neighbor. In addition, 1994 data from five 100 m line transects in burned and adjacent unburned areas were used to calculate 1-year post-fire cover m^2.

The quadrant specific method was used around each sample saguaro to count species within a 5 m radius (78.5 m^2) circular plot and identify the one nearest-neighbor per quadrant—regardless of growth form. Total quadrant density and cover m^2 per species were used to calculate average cover m^2 for the circular plots.

Total cover m^2 was standardized to adjust for the higher number of saguaro sample sites on the burned plot. Values were converted to relative percent to compare burned and unburned samples of different sizes. Details for other computations are listed in footnotes on table 1.

Discussion of Results

Ten year post-fire physiognomic data from unburned and burned sample areas are represented by number and relative percent occurrence for each species under each growth form (table 1). We observed differences in species occurrence between burned and unburned areas. Plants with the highest relative percent occurrence were: trees—paloverde in unburned and crucifixion thorn in burned areas; shrubs—wolfberry in unburned and whitethorn in burned areas; and bushes—golden bush and bursage in unburned, and globe mallow and white

Table 1—Ten-year post-fire saguaro nearest-neighbor plant species and numbers for each physiognomic group[a] and species[b] in unburned (U) and burned (B) 2003 point quarter physiognomic and quadrant specific samples on the 1993 Vista View Fire, Tonto National Forest, AZ.

		Physiognomic method[c]				Quadrant specific method[d]			
		Number of samples of occurrence		Relative[e] percent occurrence		Relative[f] percent number		Abundance[g] index number	
Growth form Scientific name	Common name	U	B	U	B	U	B	U	B
Tree—small woody trunks		**24**	**25**	**100**	**86**	**3**	**3**	**1.4**	**1.2**
Canotia holacantha	Crucifixion thorn	3	15	13	52	--	3	3.0	1.6
Cercidium microphyllum	Foothill paloverde	21	9	88	31	3	--	1.2	1.2
Unknown charred		--	1	--	3	--	--	--	--
Shrub—large woody multiple stems		**23**	**29**	**96**	**100**	**9**	**12**	**2.2**	**1.7**
Acacia constricta	White thorn	8	18	33	62	1	4	2.0	1.9
Acacia greggii	Catclaw	2	--	8	--	--	2	2.3	1.6
Larrea tridentata	Creosote bush	1	--	4	--	--	--	2.0	--
Lycium spp.	Wolfberry	12	11	50	38	8	6	2.2	1.2
Bush—woody bases and low branches		**24**	**28**	**100**	**97**	**77**	**77**	**7.1**	**5.7**
Ambrosia deltoidea	Bursage	4	3	17	10	19	10	31.8	9.3
Calliandra eriophylla	Fairy duster	1	1	4	3	4	10	5.3	9.6
Encelia spp.	Brittle bush	0	1	0	3	1	2	1.4	8.2
Ephedra spp.	Mormon tea	4	4	17	14	6	6	2.4	2.0
Ericameria spp.	Golden bush	9	1	38	3	24	7	9.5	3.5
Krameria grayi	White ratany	1	4	4	14	4	8	2.6	3.7
Sphaeralcea ambigua	Globe mallow	--	7	--	24	1	19	1.3	10.4
Thamnosma montana	Turpentine broom	2	3	8	10	7	3	2.2	1.5
Cacti—succulents		**22**	**25**	**92**	**86**	**4**	**3**	**3.2**	**1.7**
Echinocereus engelmannii	Hedgehog	2	2	8	7	--	--	2.7	1.7
Opuntia engelmannii	Prickly pear	1	2	4	7	--	--	1.5	1.0
Opuntia leptocaulis	Desert Christmas	4	1	17	3	1	--	2.5	1.0
Opuntia versicolor	Staghorn cholla	15	20	63	69	3	3	4.2	2.1
***Carnegiea gigantean*—giant woody succulent**		**2**	**3**	**8**	**10**	**--**	**2**	**--**	**--**
***Yucca torreyi*—woody and fibrous**		**4**	**15**	**17**	**52**	**3**	**3**	**2.3**	**2.4**

[a] Physiognomic group (growth form) is designated by physical structure as tree, shrub, bush, cactus, and yucca.
[b] Species with low occurrence or relative percent number were removed from the table but used in calculations they include; Asteraceae, *Eriogonum* spp., *Gutierrezia* sp., *Lonicera* sp., *Mirabilis* sp., *Palafoxia* sp., *Psilotrophe* sp., *Senna* sp., and dead.
[c] Burned (N = 29), unburned (N = 24) saguaro sample sites with 1 each nearest-neighbor physiognomic type, within a 10 m radius.
[d] Bur
[e] Relative % occurrence; for growth form = total number of sample sites for growth form *x* / total number of sample sites X 100 = %; and for species = total number of sample sites for species *x* / total number sample sites for species growth form X 100 = %.
[f] Relative % number = total number of species *x* or growth form *x* / total number of all species X 100 = %.
[g] Abundance index (number species *x* / frequency species *x*) = total number of species *x* / number of saguaro sample sites for species *x* = average number for saguaro sample sites in which species x occurs (total live N = 906, burned and 1,251 unburned.

ratany in burned areas. Mormon tea was common in both areas. Among the cacti, staghorn cholla occurrence was highest in both unburned and burned areas. Yucca occurrence was lower in unburned than in burned areas.

Quadrant specific data presented as relative percent are close if not identical for growth forms in unburned and burned samples (table 1). Among growth forms, bushes were highest and trees, yucca, and cacti were lowest. Most species were evenly distributed among sample areas. Plants with a generally widespread yet clustered pattern around the saguaro scored high in relative percent and abundance index, e.g., bursage in unburned areas, and globe mallow in burned (table 1).

Plant status data from the physiognomic method was evaluated at 10 m, 5 m, 1.5 m and 1 m radii for average cover m^2 (table 2). Tree species numbers drop off sharply as the sample radii are reduced, shrubs follow, and bush number remains relatively constant within 1 m. New branch regeneration may obscure burned skeletons and makes it difficult to distinguish resprout status. Resprouting bushes reported for 2003 are low considering the high number observed in 1994 (table 3). Among burned area trees, 56 percent were dead persistent skeletons, and 54 percent of the living trees were resprouting, some with dead branches mixed within the live—dead in plant (table 2). Among burned shrubs 62 percent are still identifiable as resprouts.

Unburned area live relative percent total cover m^2 calculated from table 2 exceeds burned (figure 1). In burned areas, resprouts have twice the cover m^2 as live, largely attributable to shrubs. Dead cover m^2 in unburned areas is twice that of burned because of five large dead paloverde.

Table 2—Ten-year post-fire saguaro nearest-neighbor plant status[a], number and average for tree shrub and bush from 2003 point quarter 10 m, 5 m, 1.5 m, and 1 m radii physiognomic samples on the 1993 Vista View fire from burned and unburned plots, Tonto National Forest, AZ.

			Plant status											
			Number and average											
			Live			Resprout			Dead			Dead in plant[b]		
Treatment Growth form	Radius	Total N	Number	Distance (m)	Cover (m^2)	Number	Distance (m)	Cover (m^2)	Number	Distance (m)	Cover (m^2)	Number	Distance (m)	Cover (m^2)
Unburned														
Tree														
	10.0 m	24	19	4.74	28.40	No resprouts			5	4.82	41.27	3	8.60	5.97
	5.0 m	15	11	2.85	37.17	No resprouts			4	3.58	33.33	No dead in plant		
	1.5 m	1	1	1.30	15.68	No resprouts			No dead			No dead in plant		
	1.0 m	0	No live			No resprouts			No dead			No dead in plant		
Shrub														
	10.0 m	23	23	2.13	3.89	No resprouts			No dead			1	1.60	2.20
	5.0 m	23	22	1.98	3.81	No resprouts			No dead			1	1.60	2.20
	1.5 m	9	9	0.79	3.26	No resprouts			No dead			No dead in plant		
	1.0 m	7	7	0.64	3.02	No resprouts			No dead			No dead in plant		
Bush														
	10.0 m	24	21	0.55	0.70	1	0.30	0.02	2	0.30	0.02	No dead in plant		
	5.0 m	24	21	0.55	0.70	1	0.30	0.02	2	0.30	0.02	No dead in plant		
	1.5 m	23	20	0.50	0.63	1	0.30	0.02	2	0.30	0.02	No dead in plant		
	1.0 m	22	19	0.45	0.62	1	0.30	0.02	2	0.30	0.02	No dead in plant		
Burned														
Tree														
	10.0 m	25	5	7.20	10.32	6	2.98	7.57	14	3.00	8.87	3	4.70	3.75
	5.0 m	19	2	4.65	20.78	6	2.98	7.57	11	1.93	9.80	2	2.10	4.09
	1.5 m	12		--		1	1.50	8.28	11	0.92	7.92	No dead in plant		
	1.0 m	3	No live plants			No resprouts			3	0.53	7.25	No dead in plant		
Shrub														
	10.0 m	29	11	2.91	2.44	18	2.24	6.71	No dead			4	2.43	2.82
	5.0 m	27	10	2.34	2.09	17	2.04	6.89	No dead			4	2.43	2.82
	1.5 m	11	3	1.22	3.57	8	0.79	7.90	No dead			2	0.95	3.33
	1.0 m	6	1	0.95	3.80	5	0.53	7.78	No dead			1	0.50	3.96
Bush														
	10.0 m	28	26	0.60	0.88	2	0.40	0.00	No dead			2	0.40	0.02
	5.0 m	28	26	0.60	0.88	2	0.40	0.00	No dead			2	0.40	0.02
	1.5 m	28	26	0.59	0.88	2	0.90	0.00	No dead			2	0.40	0.16
	1.0 m	27	25	0.57	0.85	2	0.40	0.00	No dead			2	0.40	0.16

[a] Plant status classification = live, resprout, dead, and dead in plant.
[b] Dead in plant is dead plant parts in an otherwise live plant.

Table 3—Number, plant status, and average cover m^2 for tree, shrub and bush, saguaro associated vegetation from five 100 m line transects for both 1994 unburned and burned sample plots on the 1993 Vista View fire, Tonto National Forest, AZ.

Treatment Growth form	Number	Plant status[a]	Average cover m^2
Unburned[a]			
Tree	29	Live	10.82
Shrub	46	Live	3.27
Bush	174	Live	0.55
Burned[b]			
Tree	15	Resprout	4.86
Shrub	29	Resprout	3.34
Bush	45	Resprout	0.44

[a] Unburned; dead—1 bush.
[b] Burned; dead—7 bushes, 6 trees, and live—2 bushes, 1 tree.

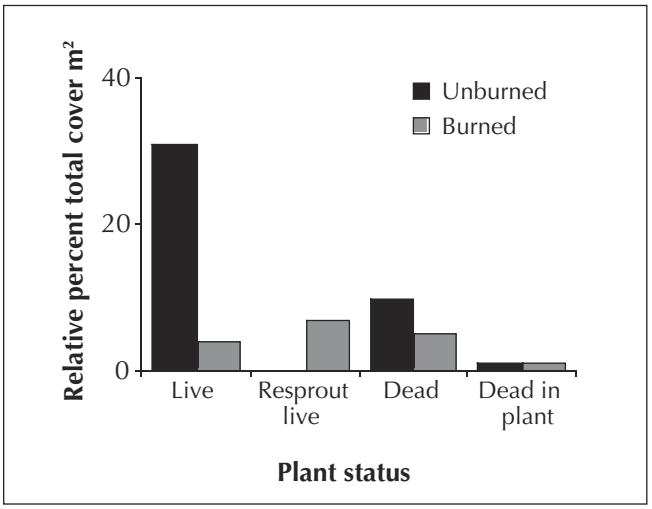

Figure 1—Physiognomic data for unburned and burned samples as relative percent total cover m^2 (tree, shrub, and bush; N = 1,117 m^2), for plant status from 2003 saguaro nearest-neighbor 10 m radius samples (N = 153) on the 1993 Vista View fire, Tonto National Forest, AZ.

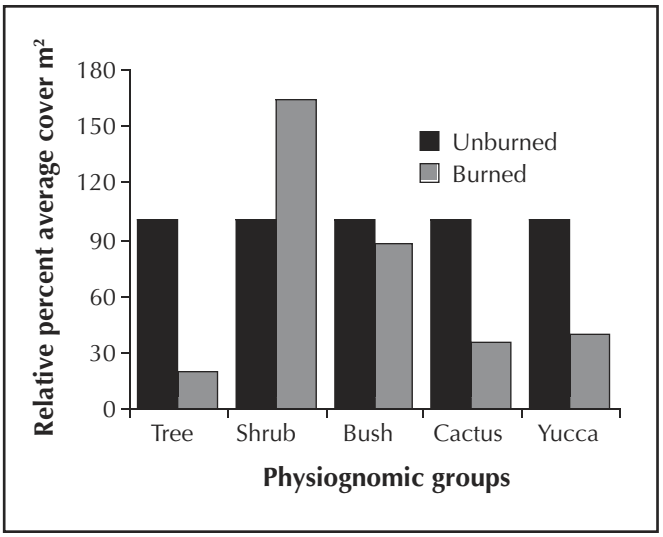

Figure 2—Quadrant specific data (saguaro nearest-neighbor per quadrant within a 5 m radius) relative percent average cover m^2 for unburned (100%) and burned (comparative %) areas, from 2003 samples (N = 211) on the 1993 Vista View fire, Tonto National Forest, AZ.

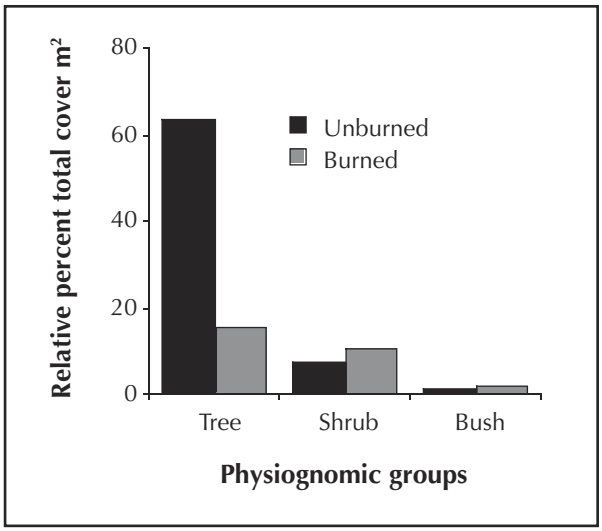

Figure 3—Physiognomic data for unburned and burned samples as relative percent total cover m^2 (N = 1,174 m^2) for tree, shrub, and bush from 2003 saguaro nearest-neighbor 10 m radius samples (N = 153) on the 1993 Vista View fire, Tonto National Forest, AZ.

Both quadrant specific (figure 2) and physiognomic (figure 3) data reveal similar trends, in tree, shrub, and bush size relationships. Average relative percent cover m^2 is smaller in burned than unburned areas for trees, cactus, and yucca (figure 2). Burned area shrub average cover m^2 exceeded unburned by 65 percent. Bush average cover m^2 varied little. Total relative percent cover m^2, regardless of status, illustrates that plant cover remains depressed in burned compared to unburned areas—especially for trees (figure 3).

In 1994, both total number and average cover m^2 of burned area resprouting trees, shrubs, and bushes were about one-third that of unburned live plants (table 3). Between 1994 and 2003, both burned area tree resprouts and unburned live shrubs increased in average cover m^2 (table 2 cf. table 3). By 2003, burned shrub resprouts had doubled their average cover m^2 and were 2.7 times larger than their "non-resprouting" associates. Bush average cover m^2 increased for both unburned and burned areas. Live tree size was too variable to contrast between sample dates.

Fuel distribution around a saguaro is represented for unburned (figure 4) and burned (figure 5) areas. Total living cover m^2 in the unburned area is still about 20 percent greater than in the burned. About half of the burned area living plants are resprouts. Trees comprised most of the dead vegetation found in both burned and unburned areas. Compared to the unburned, the burn area has 12 percent more open area where the potential for fine herbaceous fuel accumulation persists while its tree, shrub, and bush components regenerate.

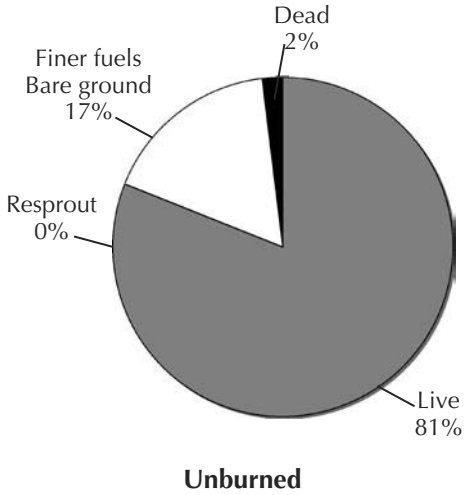

Figure 4—Relative percent cover m^2 for an average 78.5 m^2 circular plot around an average saguaro from an unburned 2003 sample site adjacent to the 1993 Vista View fire, Tonto National Forest, AZ. Quadrant density and cover m^2 from physiognomic and quadrant specific tree, shrub, and bush data were combined.

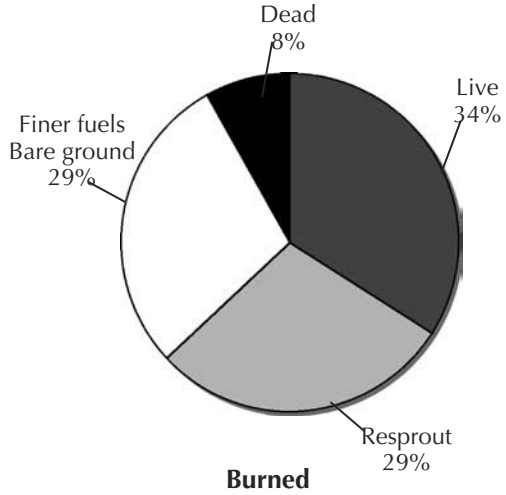

Figure 5—Relative percent cover m^2 for an average 78.5 m^2 circular plot around an average saguaro from a burned 2003 sample site on the 1993 Vista View fire, Tonto National Forest, AZ. Quadrant density and cover m^2 from physiognomic and quadrant specific tree shrub and bush data were combined.

Summary

Ten years after the 1993 Vista View fire, a once scenic vista, still displays burned and decaying giant saguaro. In this burned area, saguaro nearest-neighbor plants are recovering but still have less cover m^2 and twice the number of dead trees compared to the adjacent unburned area. In the burned area, trees have less than one-third the average cover m^2 of unburned trees and over half of them are dead. Diversity was maintained in this burned area mainly because the trees, shrubs, and bushes resprouted after fire. No indication of major species shifts between burned and unburned areas were found, only slight variations in abundance. Bush species tended to be more clustered as nearest-neighbors than shrubs or trees.

Fuels from dead and dying trees, and overlapping shrubs and bushes place the saguaro at great risk in both unburned and previously burned areas. Different approaches to fire management may be required in this complex vegetation type based on fuel accumulation that varies with time since fire. We suggest that active fire research, prevention, and suppression programs in the saguaro-shrub continue.

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