RESEARCH ARTICLE

Growth and Recovery of Oak–Saw Palmetto Scrub through Ten Years After Fire

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ABSTRACT: Oak–saw palmetto scrub, a shrub community of acid, sandy, well-drained soils in Florida, is maintained by periodic, intense fire. Understanding the direction and rates of changes in scrub composition and structure after fire is important to management decisions. We followed changes in vegetation along 15-m line-intercept transects that were established in 1983. Two stands (8 transects) burned in a prescribed fire in December 1986; the stands had previously burned 11 y (N=4) and 7 y (N=4) before. We sampled transects at 6, 12, 18, and 24 mo and then annually through 10 y after the 1986 fire. We measured cover by species in two height classes, > 0.5 m and < 0.5 m, and measured height at four points (0, 5, 10, and 15 m) along each transect. Saw palmetto cover equaled preburn values by one year postburn and changed little after that. Cover of oaks > 0.5 m (*Quercus myrtifolia, Q. geminata, Q. chapmanii*) equaled preburn values by 5 y postburn and changed little by 10 y postburn. Height growth continued, increasing from a mean of 84.0 cm at 5 y to 125.9 cm at 10 y postburn. Bare ground declined to <2% by 3 y postburn. Plant species richness increased slightly after fire and then gradually declined. These vegetation changes alter habitat conditions for threatened and endangered animals and plants.

Crecimiento y Recuperación del 'Oak–Saw Palmetto Scrub' Durante Diez Años Después del Fuego

RESUMEN: El 'Oak-saw palmetto scrub' es una comunidad de arbustos de suelos ácidos, arenosos y bien drenados en Florida, mantenidos por fuegos periódicos e intensos. Conocer la dirección y las tasa de cambio en la composición y la estructura del matorral después del fuego es importante para las decisiones de manejo. Seguimos los cambios en la vegetación a lo largo de transectas de intersección linear de 15 m que fueron establecidas en 1983. Dos lotes (8 transectas) quemadas en un fuego programado en Diciembre 1986; los lotes fueron quemados previamente hacía 11 años (N=4) y 7 años (N=4). Muestreamos las transectas a los 6, 12, 18 y 24 meses y luego anualmente durante 10 años después del fuego de 1986. Medimos la cobertura de las especies en dos clases de altura, >0,5m y <0,5 m, y medimos la altura en cuatro puntos (0, 5, 10 y 15 m) a lo largo de cada transecta. La cobertura post fuego de 'saw palmetto' se igualó a la cobertura pre quema al año y cambió poco después de eso. La cobertura de robles >0,5 m (*Quercus myrtifolia, Q. geminata, Q. chapmanii*) igualó los valores previos a las 5 años y cambió muy poco hasta los 10 años posteriores a la quema. El crecimiento en altura continuó aumentando, de una media de 84 cm a los 5 años a 125,9 cm a los 10 años posteriores a la quema. El suelo descubierto disminuyó a <2% durante 3 años posteriores a la quema. La riqueza de especies de plantas aumentó levemente después del fuego y luego gradualmente disminuyó. Estos cambios en la vegetación alteraron las condiciones para los animales y plantas amenazados o en peligro.

Index terms: Florida scrub, prescribed burning, vegetation recovery

INTRODUCTION

Florida scrub is a rare and declining ecosystem (Myers 1990, Menges 1999) and is habitat for a number of threatened and endangered plant and animal species (Christman and Judd 1990, Stout and Marion 1993, Stout 2001). Management of remaining scrub is critical to the survival of these species. Scrub is a fire-maintained system (Myers 1990, Menges 1999), but landscape fragmentation and fire suppression have reduced fire size and frequency (Myers 1990, Duncan and Schmalzer 2001). Prescribed burning is the primary management technique for scrub reserves (Menges 1999); however, prescribed burning after decades of fire suppression does not result in reestablishment of presuppression conditions in all landscapes (Abrahamson and Abrahamson 1996a, 1996b; Duncan et al. 1999). Long-unburned scrub may become fire-resistant and require combinations of mechanical treatment and burning for restoration (Schmalzer and Boyle 1998, Schmalzer and Adrian 2001).

Florida scrub is characterized by evergreen, xeromorphic shrubs including oaks (*Quercus* L. spp.), repent palms (*Serenoa repens* [W. Bartram] Small, *Sabal etonia* Swingle ex Nash), and ericaceous shrubs (*Lyonia* spp., *Vaccinium* spp.). Scrub ecosystems vary regionally (Myers 1990, Schmalzer et al. 1999) and along local environmental gradients (Abrahamson et al. 1984, Schmalzer and Hinkle 1992b). Specific

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types of scrub include sand pine scrub, oak scrub, rosemary scrub, and scrubby flatwoods (Myers 1990, Abrahamson and Hartnett 1990).

Recovery of oak scrub and scrubby flatwoods after fire is primarily through sprouting and, in some species, clonal spread of the dominant shrubs (Abrahamson 1984a, 1984b; Schmalzer and Hinkle 1992a; Menges and Hawkes 1998).

An understanding of the direction and rates of changes in scrub composition and structure after fire is important to management decisions. In this study, we examined changes in scrub community composition and structure with data from permanent transects sampled for 10 y after burning. Previously, we reported on the first 3 y of recovery (Schmalzer and Hinkle 1992a).

STUDY AREA

This study was conducted in an inland area on the central part of Kennedy Space Center/Merritt Island National Wildlife Refuge (KSC/MINWR) on the east coast of central Florida (28°38′ N, 80°42′ W). The climate is warm and humid; precipitation averages 131 cm y^{-1}, but year-to-year variability is high (Mailander 1990). Summer thunderstorms are common. Scrub at this site occurs on Pomello sand (Arenic Haplohumod), a moderately well drained, sandy, acid soil (Huckle et al. 1974) low in nutrients (Schmalzer and Hinkle 1992b, 1996; Schmalzer et al. 2001). The scrub type represented here is oak–saw palmetto scrub—the predominant scrub type on KSC/MINWR, along with scrubby flatwoods that have an open pine (*Pinus elliottii* Engelm. var. *densa* Little & Dorman) canopy (Schmalzer et al. 1999). The stands we studied lack pine. Myrtle oak (*Quercus myrtifolia* Willd.), sand live oak (*Quercus geminata* Small), Chapman oak (*Quercus chapmanii* Sarg.), saw palmetto, and ericaceous shrubs such as fetterbush (e.g., *Lyonia* spp.) are the dominant species (Schmalzer and Hinkle 1992a, 1992b).

METHODS

A December 1986 prescribed fire burned 10 transects in two scrub stands. We had

Table 1. Mean percent cover in the >0.5 m stratum by species, and mean total cover, mean height, and mean number of species on oak–saw palmetto scrub transects in Florida, preburn through 10 y (120 mo) postburn. Nomenclature follows Wunderlin (1998).

Taxa	Preburn	6 mo	12 mo	18 mo	24 mo	36 mo	48 mo	60 mo	72 mo	84 mo	96 mo	108 mo	120 mo
Sample Size	8	8	8	8	8	8	8	8	8	8	7	7	7
Andropogon spp.	–	–	–	–	0.1	–	–	–	–	–	–	–	–
Aristida stricta	1.4	–	0.3	1.2	2.4	8.2	5.4	4.0	1.4	0.5	0.3	0.6	0.5
Befaria racemosa	1.5	–	0.3	1.3	0.6	1.8	2.4	2.3	3.4	2.3	2.8	2.9	3.2
Galactia elliottii	–	0.4	–	0.8	–	–	–	–	–	–	0.2	–	–
Hypericum reductum	–	–	–	–	–	–	–	0.1	–	–	-7	–	–
Lyonia fruticosa	2.9	0.2	0.3	0.7	1.1	1.9	3.2	3.0	3.7	3.3	2.7	3.1	2.4
Lyonia lucida	15.9	0.5	2.1	3.3	7.5	12.1	13.8	18.0	16.9	15.0	15.3	16.3	12.6
Myrica cerifera	0.6	0.2	0.2	1.7	1.8	2.7	2.7	2.4	3.5	4.4	2.0	1.9	1.3
Pteridium aquilinum	–	–	–	0.04	–	–	–	–	–	–	–	–	–
Quercus chapmanii	5.2	–	0.8	1.2	1.4	3.1	3.8	4.8	4.8	5.7	7.0	6.9	6.3
Quercus geminata	14.0	2.5	3.8	7.3	7.6	11.4	12.7	15.7	15.9	15.7	15.9	16.5	15.7
Quercus myrtifolia	33.2	1.1	1.4	7.7	9.6	17.4	26.5	32.9	37.4	36.5	33.4	34.9	34.3
Serenoa repens	31.5	16.8	29.3	33.4	31.1	26.6	29.9	32.4	37.0	36.5	31.1	38.5	34.9
Smilax auriculata	–	0.04	–	–	0.04	–	–	–	–	–	–	–	0.1
Vaccinium myrsinites	–	–	–	–	–	0.1	0.1	0.6	0.4	0.2	1.1	1.2	0.8
Vaccinium stamineum	–	–	–	–	–	–	–	–	0.1	0.2	0.1	–	–
Mean Total Cover	106.1	21.8	38.4	58.5	63.2	85.1	100.3	116.0	124.3	120.2	111.9	122.8	112.1
Mean Height (cm)	107.9	31.8	49.8	58.4	60.2	69.6	78.2	84.0	94.6	106.3	116.0	112.2	125.9
Mean Species Number	6.8	2.8	4.0	6.4	6.3	6.6	6.8	7.4	7.5	7.0	7.6	7.0	7.3
Mean Species Number in Both Strata[a]	8.5	10.5	10.4	11.1	9.9	10.1	9.5	10.0	10.5	9.9	9.0	8.7	9.1

[a] 0–0.5 m and > 0.5 m height strata.

established 15-m line-intercept transects in these stands originally in January 1983 and resampled them in January 1985. The two stands were 11 y (N=4) and 7 y (N=6) from the previous fire. We sampled cover of vascular plants by species on the burned transects at 6, 12, 18, and 24 mo postfire and then annually through ten years after the 1986 fire. Cover by species was sampled in 0–0.5 m and > 0.5 m height layers (Muelller-Dombois and Ellenberg 1974); cover was estimated to the nearest 5 cm. Bare ground was recorded when there was no plant cover in either height strata. Nonvascular plants (mosses, lichens) were uncommon at this site. We recorded vegetation height at four points (0, 5, 10, and 15 m) along each transect. Previous analysis (Schmalzer and Hinkle 1992a, 1992b) indicated that two transects were wetter and had little or no cover of scrub oaks; those transects are not considered here. One transect burned in November 1994; the sample size for the last three time-since-fire periods was reduced to seven. The last sampling included here is from January 1997. All transects burned again in June 1997.

We analyzed data using SPSS 10.0 (SPSS, Inc. 1999). Normality of distributions was tested using Kolmogorov-Smirnov tests; most were not normal ($p<0.05$). For selected parameters, a nonparametric repeated measures analysis of variance (ANOVA) (Friedman test) was conducted using SigmaStat 2.0 (Fox et al. 1995); if the ANOVA was significant, postburn periods were compared to preburn using Dunnett's test.

RESULTS

Before the 1986 fire, saw pal-

Table 2. Mean percent cover in the <0.5 m stratum by species, and mean total cover, and mean number of species on oak–saw-palmetto scrub transects preburn through 10 y (120 mo) postburn. Nomenclature follows Wunderlin (1998).

Taxa	Preburn	6 mo	12 mo	18 mo	24 mo	36 mo	48 mo	60 mo	72 mo	84 mo	96 mo	108 mo	120 mo
Sample Size	8	8	8	8	8	8	8	8	8	8	7	7	7
Andropogon spp.	–	–	–	0.04	0.04	0.1	–	–	0.1	–	0.1	0.1	0.1
Aristida stricta	2.7	2.8	4.7	4.1	4.0	7.2	1.7	1.1	1.3	1.1	1.0	0.4	0.7
Bare Ground	–	22.9	14.6	6.1	4.9	0.7	1.5	0.7	0.3	–	0.3	1.9	1.0
Befaria racemosa	0.3	0.7	1.2	0.8	1.1	1.0	0.4	0.1	0.3	0.1	0.5	0.2	0.1
Carphephorus spp.	–	0.4	0.6	1.0	0.6	0.7	0.1	0.04	0.3	0.1	–	–	0.04
Drosera sp.	–	–	0.04	–	0.04	0.04	0.04	0.04	0.04		–	–	–
Galactia elliottii	–	1.3	–	1.5	–	–	0.04	–	–	–	–	0.1	–
Gaylussacia dumosa	–	0.6	0.9	0.7	0.3	0.6	0.1	0.3	0.1	0.4	–	0.1	–
Hypericum reductum	0.2	–	–	–	–	–	0.04	0.1	0.2	0.04	0.1	0.04	–
Licania michauxii	–	0.04	0.04	0.04	–	–	–	0.04	–	–	–	–	–
Lyonia fruticosa	0.5	1.3	1.8	1.5	1.6	1.4	0.8	0.7	0.4	0.4	0.1	0.6	0.04
Lyonia lucida	1.7	9.7	11.8	11.2	6.5	6.3	2.5	1.5	1.5	1.2	1.3	3.3	2.2
Myrica cerifera	1.3	3.0	2.4	2.2	2.4	3.6	1.4	2.2	2.5	0.8	1.1	1.1	1.9
Panicum spp.	–	0.04	0.1	0.1	0.4	0.5	–	0.1	0.04	0.04	–	0.04	0.04
Pteridium aquilinum	–	0.5	–	0.9	–	–	–	–	–	–	–	–	–
Quercus chapmanii	1.5	4.3	3.4	4.3	4.8	3.9	2.4	1.5	0.9	0.9	0.1	0.5	0.7
Quercus geminata	1.4	9.2	6.8	6.6	4.0	5.1	3.2	2.0	2.2	0.9	0.5	1.2	0.3
Quercus minima	–	–	–	–	–	–	0.1	0.1	–	0.04	–	–	–
Quercus myrtifolia	2.8	16.6	17.0	19.9	17.8	15.4	8.7	6.1	4.5	2.6	2.1	4.8	2.2
Serenoa repens	0.3	1.2	1.1	0.7	1.3	1.2	0.2	0.4	0.3	–	–	0.6	0.9
Seymeria pectinata	–	–	–	0.6	–	–	–	–	–	–	–	–	–
Smilax auriculata	0.1	0.1	0.1	0.1	–	–	–	–	–	–	0.1	–	–
Vaccinium myrsinites	1.5	2.3	2.4	3.0	3.0	3.6	3.6	3.3	4.2	5.1	3.7	6.9	1.8
Vaccinium stamineum	–	0.1	–	0.2	–	–	–	–	–	–	–	–	–
Mean Total Cover	14.1	54.0	54.1	59.4	47.8	50.5	25.1	19.7	18.8	13.5	10.9	20.0	11.0
Mean Species Number	6.6	10.0	10.1	10.5	8.5	9.5	7.8	7.8	8.3	6.5	5.6	6.1	5.9

metto, myrtle oak, and fetterbush (*Lyonia lucida* [Lam.] K. Koch) were the species with the greatest cover in the > 0.5 m stratum in these stands (Table 1). Sand live and Chapman oaks were relatively common, with lesser amounts of other ericaceous shrubs and few herbs (Table 1, Table 2). Mean height was about 108 cm (Table 1).

Nearly all the species present before the fire were present by 6 mo postburn (Table 1, Table 2); the only exception was *Hypericum reductum* (Svenson) W.P. Adams, which had been present in minor quantities (Table 2). A few herbs and subshrubs appeared after burning that were not recorded previously: *Carphephorus* spp., *Galactia elliottii* Nutt., *Panicum* spp., and *Pteridium aquilinum* (L.) Kuhn (Table 2). The subshrub dwarf huckleberry, *Gaylussaccia dumosa* (Andrews) Torr. & A. Gray, also occurred after burning (Table 2). Most woody species (e.g., *Quercus myrtifolia*) showed increased cover in the < 0.5 m stratum (Table 2) followed by increased cover in the > 0.5 m stratum for the larger shrubs (Table 1). Cover of shiny blueberry (*Vaccinium myrsinites* Lam.) increased, and the increase persisted for most of the period (Table 2).

Dominant species showed different growth rates after fire. Cover of saw palmetto >0.5 m tall was reduced 6 mo postburn but was similar to preburn by 12 mo postburn (Figure 1A). Saw palmetto cover varied within a narrow range between 1 and 10 y postburn (Table 1, Figure 1A). The repeated measures ANOVA was significant ($p<0.001$), but only the 6-mo postburn sample differed from preburn ($p<0.05$). Cover (>0.5 m tall) of fetterbush (Figure 1B), the most abundant ericaceous shrub, was reduced significantly through 18 mo postburn (repeated measures ANOVA, $p<0.001$; Dunnett's test, $p<0.05$). Mean cover increased through 4 to 5 y postburn (Table 1, Figure 1A) and then remained at similar values to 10 y postburn.

The three scrub oak species reestablished cover rapidly after burning but at different rates. Cover (>0.5 m tall) of myrtle oak (Figure 2A) required 36 mo to return to values similar to preburn. The repeated

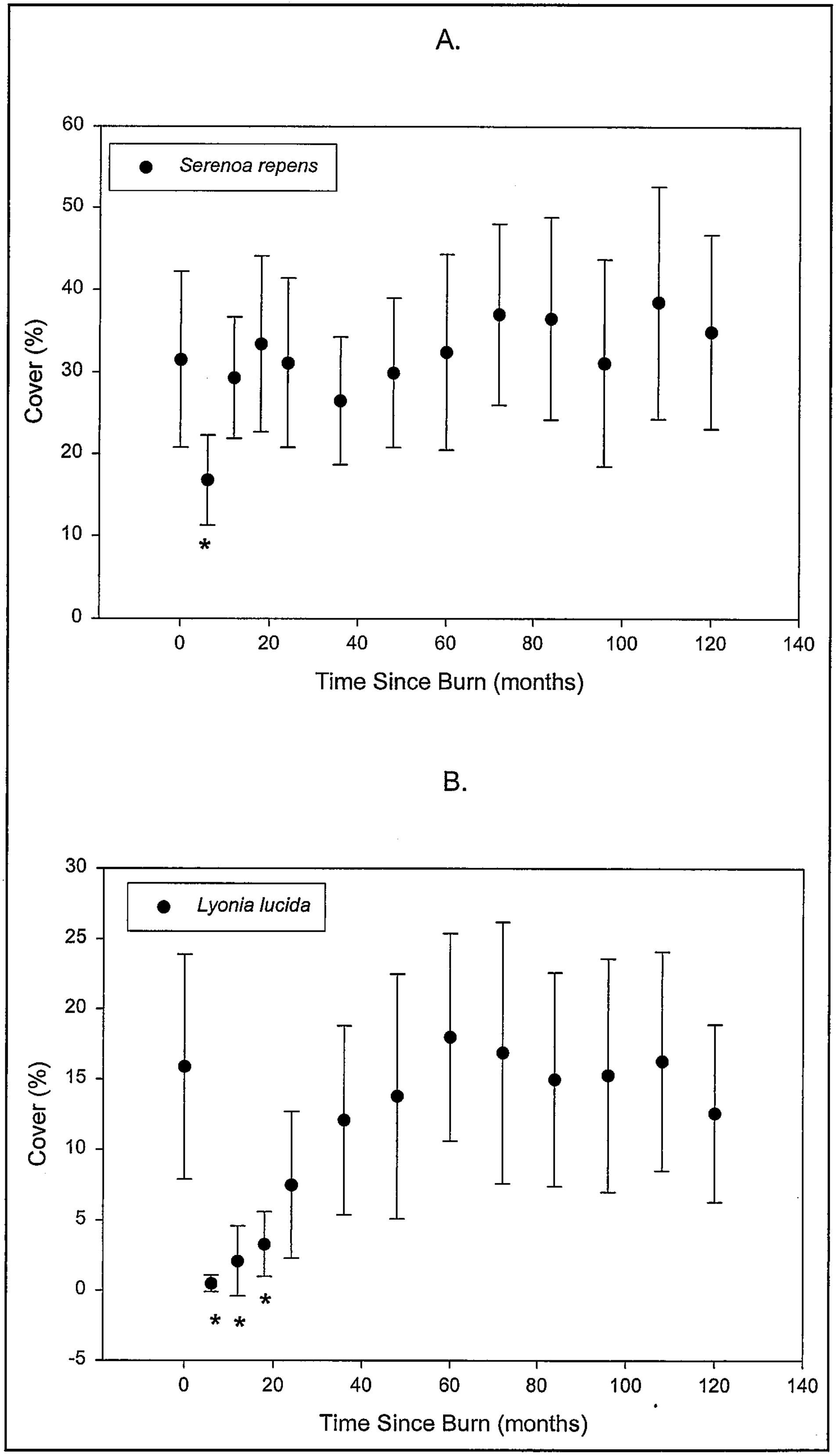

Figure 1. Changes in percent cover of saw palmetto (A) and fetterbush (B) from preburn (time = 0) through 10 y (120 mo) postburn. Sample size is n = 8 transects from preburn through 7 y postburn and n = 7 for the last 3 y. Shown are means and 95% confidence intervals. Repeated measures ANOVAs indicated significant ($p<0.001$) differences among time periods. Asterisks indicate time periods different from preburn (Dunnett's test, $p<0.05$).

measures ANOVA was significant ($p<0.001$), and the 6-, 12-, 18-, and 24-mo postburn samples differed from preburn ($p<0.05$). Cover (>0.5 m tall) of sand live oak (Figure 2B) was reduced significantly 6 and 12 mo postburn (ANOVA, $p<0.001$, Dunnett's test, $p<0.05$). Chapman oak cover >0.5 m tall (Figure 2C) was reduced significantly 6, 12, and 18 mo postburn (ANOVA, $p<0.001$, Dunnett's test, $p<0.05$). Cover of all three oaks increased through 4–5 y postburn (Table 1, Figure 2) and remained at similar values through 10 y postburn.

Summary variables also returned to their preburn values after fire. Mean total cover >0.5 m tall (i.e., the sum of cover values of individual species) (Figure 3A) was reduced significantly after burning but was similar to preburn values by four years postburn (Figure 3A, Table 1). Mean total cover <0.5 m tall (Figure 3B) increased significantly after burning; it remained elevated (Table 2), but differed significantly from preburn only through 4 y postburn (Figure 3B). Percent bare ground (Figure 4) increased after burning but declined rapidly, being reduced to minor amounts by 3 y postburn.

In contrast, height growth continued throughout the postburn period (Figure 5), increasing from a mean of 84.0 cm at 5 y to 125.9 cm at 10 y postburn. Height was significantly less than preburn through 5 y postburn (ANOVA, $p<0.001$, Dunnett's test, $p<0.05$).

There was a short-term reduction in mean species richness for the > 0.5 m stratum (Table 1) and an increase in species richness for the < 0.5 m stratum (Table 2). Considering both strata together, there was a small increase in species richness after fire (Table 1).

DISCUSSION

Oak–saw palmetto scrub displays remarkable resilience at the fire return intervals experienced during this study. All the species that occurred before burning exhibit resprouting life histories, although some are also capable of seeding and clonal spread (Menges and Kohfeldt 1995). Re-

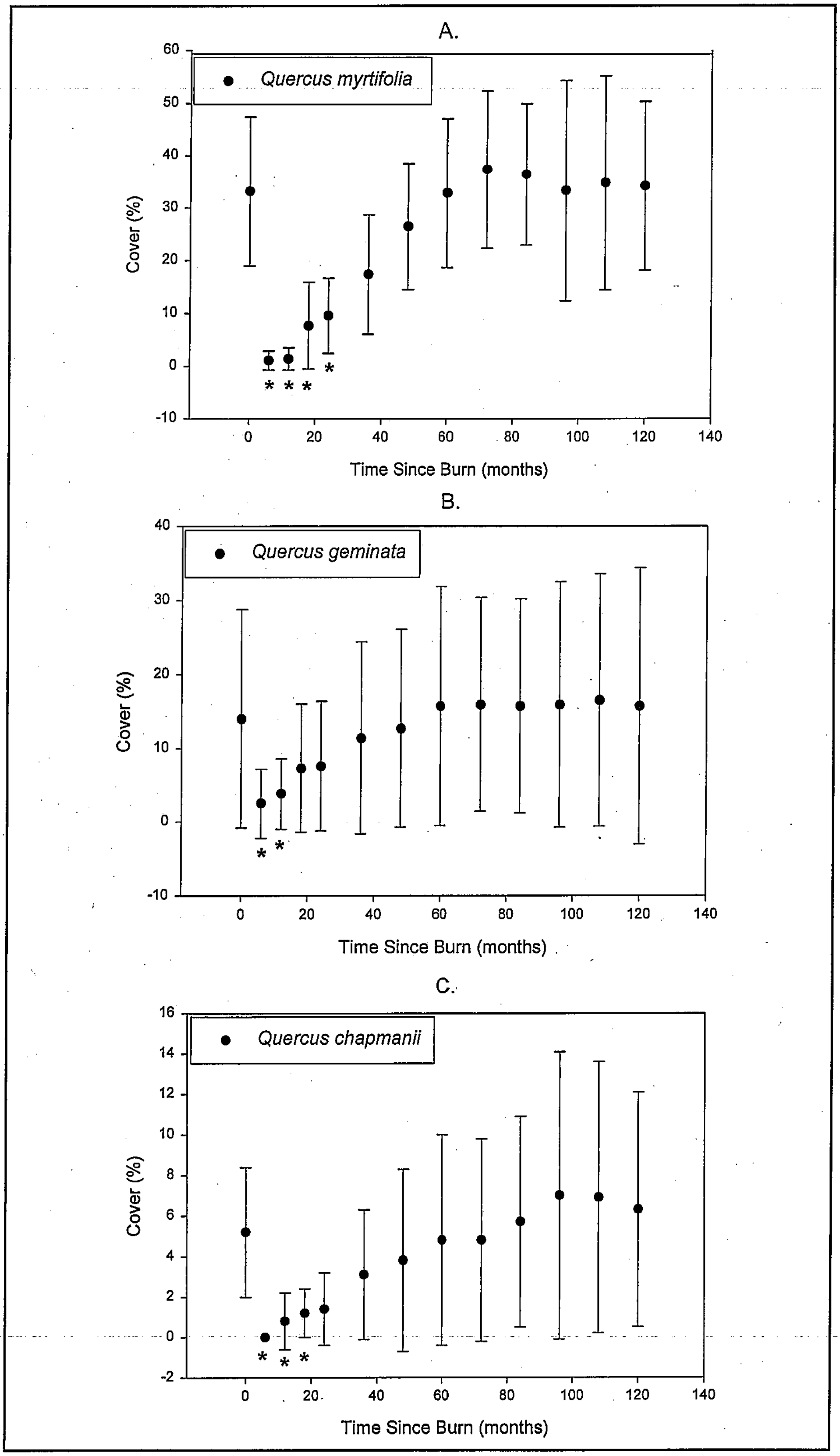

Figure 2. Changes in percent cover of myrtle oak (A), sand live oak (B), and Chapman oak (C) from preburn (time = 0) through 10 y (120 mo) postburn. Sample size is n = 8 transects from preburn through 7 y postburn and n = 7 for the last 3 y. Shown are means and 95% confidence intervals. Repeated measures ANOVA indicated significant ($p<0.001$) differences among time periods. Asterisks indicate time periods different from preburn (Dunnett's test, $p<0.05$).

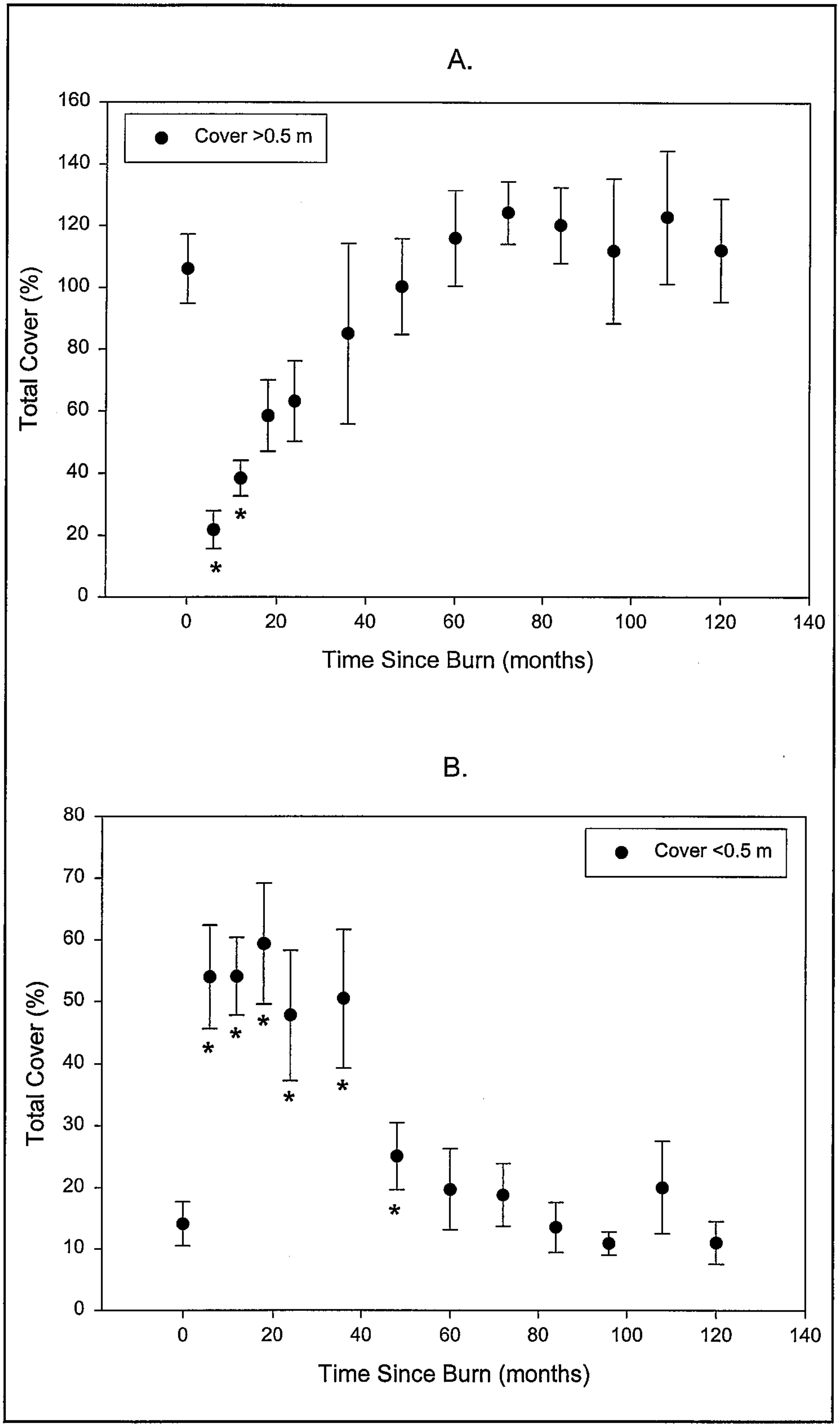

Figure 3. Changes in total percent cover >0.5 m tall (A) and total percent cover <0.5 m tall (B) from preburn (time = 0) through 10 y (120 mo) postburn. Sample size is n = 8 transects from preburn through 7 y postburn and n = 7 for the last 3 y. Shown are means and 95% confidence intervals. Total cover is the sum of cover values of individual species. Repeated measures ANOVA indicated significant (*p*<0.001) differences among time periods. Asterisks indicate time periods different from preburn (Dunnett's test, *p*<0.05).

sprouting and the high proportion of belowground biomass (Johnson et al. 1986, Guerin 1993) allow rapid reestablishment of cover of the dominant shrubs. However, the growth rates of individual species differ such that there are short-term shifts in dominance; in particular, saw palmetto reestablishes cover more rapidly than the woody shrubs. By 4 to 5 y after fire, cover of major species is nearly identical to that before burning. Few changes occur through 10 y postburn except for continued height growth. These observations support and extend earlier work showing rapid recovery of this vegetation (Schmalzer and Hinkle 1992b) and are similar to trends in postfire recovery of scrubby flatwoods on the Lake Wales Ridge (Abrahamson 1984a). These observations also fit the conceptual model of vegetation dynamics of xeric uplands in peninsular Florida developed by Menges and Hawkes (1998) as the type scrubby flatwoods, which are persistent under moderately frequent fires (5–20 y).

Extended periods without fire allow structural changes toward xeric hammock (Menges et al. 1993, Schmalzer et al. 1994, Menges and Hawkes 1998). Height growth continues, scrub oaks become fire-resistant, and fires may not readily reverse these conditions, particularly under typical prescribed conditions (Abrahamson and Abrahamson 1996a, 1996b; Schmalzer and Boyle 1998; Schmalzer and Adrian 2001). Growth rates vary regionally (Schmalzer and Adrian 2001), and the modal fire frequency may be less than 20 years in some scrub and scrubby flatwoods of the Atlantic Coastal Ridge, Merritt Island, and Cape Canaveral due to more rapid increases in cover and height.

Sprouting from underground buds (e.g., oaks, ericaceous shrubs) or buds protected by plant structures (e.g., saw palmetto) occurs in many fire-prone ecosystems (Whelan 1995, Bond and van Wilgen 1996). In many fire-adapted shrublands there is a range of regeneration patterns from obligate seeders to obligate sprouters (e.g., Keeley and Zedler 1978, Christensen 1985, van Wilgen and Forsyth 1992). The degree of dominance by sprouting species in pocosins (Christensen et al.

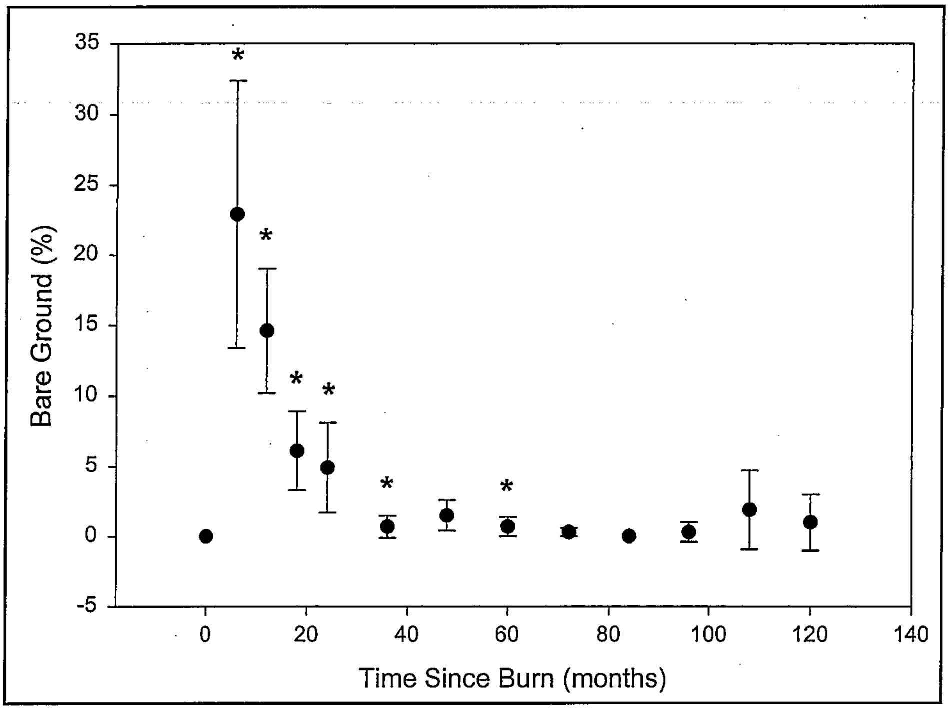

Figure 4. Change in percent bare ground from preburn (time = 0) through 10 y (120 mo) postburn. Sample size is n = 8 transects from preburn through 7 y postburn and n = 7 for the last 3 y. Shown are means and 95% confidence intervals. Repeated measures ANOVA indicated significant (p<0.001) differences among time periods. Asterisks indicate time periods different from preburn (Dunnett's test, p<0.05).

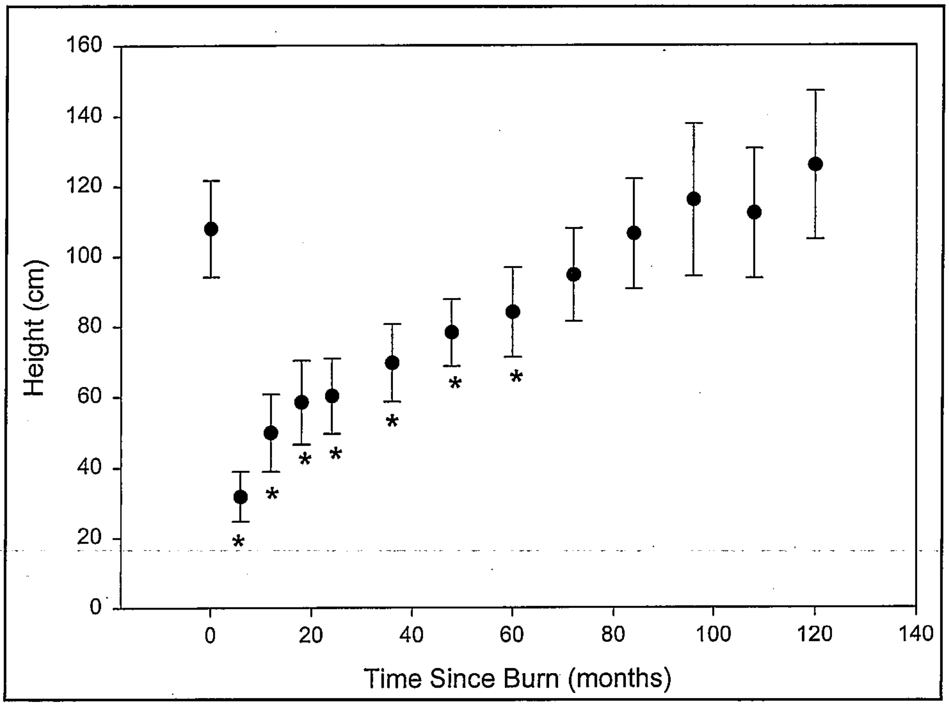

Figure 5. Vegetation height from preburn (time = 0) through 10 y (120 mo) postburn. Sample size is n = 8 transects from preburn through 7 y postburn and n = 7 for the last 3 y. Shown are means and 95% confidence intervals. Repeated measures ANOVA indicated significant (p<0.001) differences among time periods. Asterisks indicate time periods different from preburn (Dunnett's test, p<0.05).

1981) and *Quercus coccifera* garrigue (Malanson and Trabaud 1987, 1988) is similar to that of oak–saw palmetto scrub.

Bellingham and Sparrow (2000) suggested a general model in which resprouting (aboveground) is the predominant response to the least severe disturbance regimes; but resprouting is also a common response in disturbance regimes of high severity that destroy most or all aboveground biomass and which occur at medium to high frequency. Very frequent severe disturbances would tend to eliminate woody shrubs by preventing sufficient carbohydrate storage between disturbances. Sites with low productivity (e.g., xeric, infertile) also favor resprouting. The disturbance response of oak-saw palmetto scrub is generally consistent with this model. Fire in scrub is severe in that it kills most aboveground biomass. It is of intermediate frequency; very frequent fires on xeric sites in Florida favor sandhill vegetation dominated by grasses (and the fire resistant *Pinus palustris* Mill.) rather than shrubs (Myers 1985, Menges and Hawkes 1998).

One consequence of the rapid reestablishment of shrub cover is the rapid decrease in amount of bare ground (open sand or gaps). Young and Menges (1999) showed that gaps and open sand declined rapidly after fire in scrubby flatwoods on the Lake Wales Ridge. Openings are important for many scrub herbs and small shrubs, including endemic species (Hawkes and Menges 1996, Menges and Hawkes 1998, Boyle et al. 2001). Although scrub on Merritt Island lacks the endemic flora of the Lake Wales Ridge (Schmalzer and Hinkle 1992a), there are species that require openings such as *Selaginella arenicola* Underw., *Lechea divaricata* Shuttlew. ex Britton, and *Lechea cernua* Small. These species did not occur on this study site but are present in other scrub sites on Merritt Island.

The temporary openings created by burning did allow some expansion of herbs and small shrubs in this scrub. Modest increases in cover by *Aristida stricta, Carphephorus* spp., *Galactia elliottii*, and *Panicum* spp. may have occurred by sprouting (Menges and Kohfeldt 1995) followed by increased growth in the more open conditions that persisted for a few years. *Gaylusaccia dumosa* and *Vaccinium myrsinites* sprout and spread clonally (Menges and Kohfeldt 1995). Abrahamson (1984b) found that they increased rapidly and then declined after fire. Here the increase was less dramatic but persisted longer, particularly for the *Vaccinium.*

Analysis utilizing historic photography (Duncan et al. 1999) showed that openings in scrub on Merritt Island were much more common in the 1943 landscape. Openings declined during two decades of fire suppression. Prescribed burning since 1981 has reestablished openings in a scrubby flatwoods landscape (with pines) but not in a scrub landscape (lacking pines). More effective fire suppression in the scrub landscape may have contributed to the greater loss of openings. In the scrubby flatwoods landscape the presence of dead pine wood on the ground and pine stumps may have caused local hot spots contributing to more persistant openings (Myers 1990).

The rapid recovery to previous conditions occurs in scrub only when the sprouting ability of the dominant shrubs remains intact. Disturbances that remove roots and rhizomes of oaks, palmettos, and ericaceous shrubs cause long-lasting changes in composition and structure (Breininger and Schmalzer 1990, Schmalzer et al. 2002).

KSC/MINWR and the adjacent Cape Canaveral Air Force Station support one of the three core populations of the Florida Scrub-Jay (*Aphelocoma coerulescens*), a species federally listed as threatened (Stith et al. 1996). Scrub-Jays are very habitat specific (Woolfenden and Fitzpatrick 1984) requiring periodically burned scrub, scrubby flatwoods, or flatwoods with patches of scrub oaks (Breininger et al. 1998, 1999; Breininger and Oddy 2001). Optimal vegetation height for Scrub-Jay habitat is 1.2–1.7 m (Breininger and Oddy 2001). About 10 y may be required to reach that height based on growth rates here; considerable variability in growth rates also should be noted (Schmalzer and Adrian 2001). However, openings are also important to jays (Woolfenden and Fitzpatrick 1984, Breininger et al. 1998), and they close quickly in this scrub. Prescribed burning regimes that will maintain an open landscape but leave sufficient scrub patches at optimum height is one of the management challenges in this system.

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