

# EFFECTS OF MECHANICAL TREATMENTS AND FIRE ON LITTER REDUCTION IN FLORIDA SCRUB AND SANDHILL

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## ABSTRACT

Florida scrub, a xeric shrubland, and Florida sandhill, a xeric savanna, are fire-maintained ecosystems threatened by habitat loss and fire suppression. Mechanical treatments such as logging, mowing, and chainsaw felling of the subcanopy (vegetation 3–8 m high) are being used as alternatives to prescribed burning or in combination with burning to restore Florida ecosystems. We focused on litter cover as a key response variable because continuous litter cover in unburned areas of Florida scrub and sandhill adversely affects populations of rare endemic herbs by reducing seedling recruitment and may also reduce overall herb diversity. We initiated three experiments to evaluate the effects of mechanical treatments, with and without fire, on litter cover: “log and burn” and “mow and burn” in scrub; and “saw and burn” in sandhill.

Logging or mowing alone or combined with fire, and subcanopy felling combined with fire, had different effects on litter cover. Logging caused significant reductions in litter cover 2 y after treatment, while burning without prior logging caused only modest (nonsignificant) decreases. However, in contrast to the burn-only treatment, logging also resulted in large areas of soil disturbance, particularly along skid trails used for removing logs; these areas were rapidly colonized by weedy native species. Although mowing alone did not reduce litter cover, mowing was effective as a pre-treatment to burning, provided that the burn took place shortly after mowing. The mow-and-burn treatment reduced litter cover in one site when fire followed mowing by 1 mo, but not in another site where fire was delayed by 1 y. Chainsaw felling of the oak-dominated subcanopy followed by burning reduced litter cover significantly, while burning alone failed to do so. Subcanopy felling may be an advantageous pre-treatment for restoration of long-unburned sandhill.

We do not recommend mechanical treatments without fire for restoration of fire-suppressed Florida scrub or sandhill. Mechanical treatments followed by fire can be effective in removing litter and thereby creating bare sand microsites that are key to rare species recruitment and herb diversity. However, mechanical treatments should be applied cautiously and results should be closely monitored. Prescribed fire remains the preferred method for restoring and maintaining Florida scrub and sandhill and their rare plant species.

*keywords:* Florida sandhill, Florida scrub, logging, mowing, prescribed burning, restoration.

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## INTRODUCTION

Florida scrub, a xeric shrubland, and Florida sandhill, a xeric savanna, are fire-maintained ecosystems threatened by habitat loss, habitat fragmentation, and fire suppression (Menges 1999). Florida scrub and sandhill are rich in endangered and endemic plants (Christman and Judd 1990, USFWS 1999, Coile and Garland 2003), many of which are prominent in gaps among dominant shrubs and grasses. Fire removes litter and top-kills woody plants, opening up bare sand patches that provide critical habitat for many rare and imperiled species (Hawkes and Menges 1996, Menges and Kimmich 1996, Quintana-Ascencio et al. 2003). Long-unburned sites have declining populations of these species (Menges and Kohfeldt 1995), along with few bare sand patches and abundant subcanopy (3–8 m tall) oaks (*Quercus* spp.) and canopy pines (*Pinus* spp.). Historically, lightning-ignited fires in sandhills were frequent (2–10 y) and of low intensity, whereas lightning-ignited Florida scrub fires were infrequent (10–80 y) and of higher intensity (Abrahamson et al. 1984, Myers 1985).

Much of the remaining long-unburned scrub and

sandhill habitats occur near developed areas, where land managers may be hesitant to use prescribed fire because of potential control problems or smoke management concerns. Mechanical treatments such as logging, mowing, and roller chopping are being used across Florida as surrogates for burning or as pre-treatments to burning (Greenberg et al. 1995, Roberts and Cox 1999, Berish and Kubilis 2002, Schmalzer et al. 2003). Burns in mechanically treated areas may be easier to prescribe and conduct.

Studies of mechanical treatments in Florida scrub have mostly focused on the response of shrub cover and/or shrub height or have not always included a burn-only treatment (Roberts and Cox 1999, Berish and Kubilis 2002, Schmalzer et al. 2003). One such study (Berish and Kubilis 2002), conducted at the Lake Wales Ridge Wildlife and Environmental Area, concluded that mowing or mowing plus burning caused no negative effects in scrub; however, this study did not include a burn-only treatment or pre-treatment data. Another study of logging at Ocala National Forest also did not include a burn-only treatment (Greenberg et al. 1995). Roberts and Cox (1999) compared burning with mechanical treatments and burning in scrub and found that, with or without a mechanical pre-treatment, fire was essential for scrub manage-

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ment. Schmalzer et al. (2003) found that mechanical treatments were as effective as fire in reducing shrub height. In sandhill ecosystems, frequent fire is necessary to support high species diversity (e.g., Glitzenstein et al. 2003, Provencher et al. 2003), but introduction of fire to long-unburned sandhills can have negative consequences such as excessive pine mortality (Varner et al. 2005). Consequently, mechanical removal of hardwood subcanopies has been used as an alternative to fire. However, in the most thorough study, with many treatments and a comparison to reference sites, fire alone was the least expensive and most effective treatment for increasing species richness and herbaceous cover (Provencher et al. 2001). Although fire is also important to restoring fire-suppressed sandhills in peninsular Florida (Reinhart and Menges 2004), no work has been published on the effects of mechanical treatments on sandhill restoration in this region.

Despite the increasing application of mechanical treatments alone or combined with fire, we still do not have a good answer to key questions: Can mechanical treatments achieve the ecological benefits of fire, or will they cause unintended harmful effects to vegetation and rare species? Can mechanical treatments and fire be used together to speed up restoration of long-unburned areas? Our goals in restoring fire-suppressed Florida scrub and sandhill, regardless of whether fire, mechanical treatments, or their combination are used for restoration, are to reduce shrub height and cover and to remove litter to provide bare sand habitat for the rare herbaceous species endemic to these ecosystems (Christman and Judd 1990, Menges 1999).

To address these questions, we conducted three experiments: "log and burn," "mow and burn," and "saw and burn." The log-and-burn experiment studied the effects of logging and its compatibility with managing Florida scrub vegetation and its endemic plants. The mow-and-burn experiment examined the effects of mowing used as a fire surrogate and as a pre-treatment to fire on the regeneration of Florida scrub at two sites. The saw-and-burn experiment appraised the effects of chainsaw felling of the subcanopy followed by burning and burning alone as restoration treatments for Florida sandhill. In this paper, we focus on changes in litter cover because the removal of litter by fire is key to the recruitment and persistence of many listed plant species (Hawkes and Menges 1996, Menges and Kimmich 1996, Quintana-Ascencio et al. 2003) and because mechanical treatments have the potential to accumulate rather than to remove litter.

## STUDY AREA

Our studies of mechanical treatments in Florida scrub and sandhill are from long-term experiments taking place on four long-unburned sites on the Lake Wales Ridge of central peninsular Florida. The log-and-burn experiment took place on the Lake Wales Ridge State Forest, Arbuckle tract (27.67°N, 81.42°W). The Arbuckle study site includes both rosemary phase

and oak phase sand pine scrub (sensu Abrahamson et al. 1984); in rosemary scrub the dominant shrub is Florida rosemary (*Ceratiola ericoides*), while in oak scrub the dominants are several species of clonal shrubby oaks. The mow-and-burn experiment occurred in the Lake Wales Ridge Wildlife and Environmental Area, Lake Apthorpe Scrub (LAS) (27.36°N, 81.33°W) and Lake Placid Scrub (LPS) (27.22°N, 81.394026°W). The LAS and LPS study sites are rosemary phase Florida scrub. The saw-and-burn experiment took place on the Lake Wales Ridge National Wildlife Refuge, Carter Creek tract (27.54°N, 81.41°W). The Carter Creek study site is Florida sandhill on xeric yellow sand with sparse longleaf pine (*Pinus palustris*) cover.

## METHODS

### Treatments

We compared three commonly used land management treatments for restoring xeric upland Florida ecosystems. The log-and-burn experiment included log-only, burn-only, log-and-burn, and control treatments. Between December 1998 and January 1999, all mature sand pines (*Pinus clausa*) in the logging treatment areas were removed by a commercial logging company. Following the standard practice, trees were "delimbed" on-site and dragged by heavy equipment to loading areas. Remaining slash was left in discrete piles, and the removal of logs resulted in considerable soil disturbance associated with skid trails. Prescribed burning in the log-and-burn treatment plots in August 1999 was interrupted by deteriorating fire weather. A second prescribed burn in September 2000 included the burn-only plots and the remaining log-and-burn plots. In both burns, firing techniques included head-and-strip headfires after the initial establishment of a blackline on the downwind perimeter of the area being burned.

The mow-and-burn experiment included mow-only, burn-only, mow-and-burn, and control treatments. Mowing was completed in June 1999 (LAS) and in July 2000 (LPS) with a Brown tree cutter (Brown Manufacturing Corp., Ozark, AL). The burn at LAS took place 1 mo after mowing (June 1999) and burned quickly and completely. The burn at LPS was conducted 1 y after mowing (July 2001) due to logistical constraints; this site burned slowly and patchily. Firing techniques were similar to the log-and-burn experiment.

The saw-and-burn experiment had burn-only, saw-and-burn, and control treatments; a saw-only treatment was not included because this treatment is not typically used by Florida land managers. We used chainsaws to fell oaks and other subcanopy (3–8 m tall) trees (except for longleaf pines) in a 15-m "fuel-enhancement zone" centered on each of 24 community plots within the saw-and-burn treatment area. This study site was prescribed burned in July 2001, 1 mo after chainsaw felling (May–June 2001). Backing and flanking fires

were ignited, followed by strip headfires throughout the burn units.

#### Date Collection and Analysis

Although sampling protocols varied among projects due to the nature of the vegetation and treatments, in all experiments we estimated litter cover in small plots or using line intercepts. In the log-and-burn experiment, we sampled litter cover within 24 50 × 25-m plots pre-treatment and 1, 2, and 5 y post-treatment. In the mow-and-burn experiment, we sampled 80 20 × 2-m belt transects, measuring litter cover along each transect pre-treatment and 1, 2, and 5 y post-treatment. In the saw-and-burn experiment, we sampled 61 5-m-radius community plots; 11 plots in the burn-only treatment did not burn and were excluded from the study. Within each community plot, we estimated litter cover in eight 0.19-m<sup>2</sup> quadrats. We sampled pre-treatment and 1, 2, 3, and 4 y post-treatment.

We summed litter cover data collected in herb quadrats (log-and-burn, saw-and-burn) or along line intercepts (mow-and-burn) to the community plot level. We used pairwise Kruskal–Wallis tests to compare the change in percent litter cover pre-treatment versus 2 y post-treatment (mow-and-burn, log-and-burn) or 1 y post-treatment (saw-and-burn) because the data were not normally distributed. Degrees of freedom = 1 for all statistics and  $\chi^2$  values are Kruskal–Wallis chi-square values.

Species names follow Wunderlin and Hansen (2003).

## RESULTS

### Log-and-Burn Experiment

Logging treatments were effective in reducing litter cover (Figure 1). Litter cover was reduced more in the log-only and the log-and-burn treatments reduced litter cover significantly lower than the control ( $\chi^2 = 9.00$ ,  $P = 0.003$ ;  $\chi^2 = 7.50$ ,  $P = 0.006$ , respectively). Litter cover reductions were only somewhat lower but not different in the burn-only versus the control treatment ( $\chi^2 = 0.410$ ,  $P = 0.522$ ); the log-and-burn versus the log-only treatments were not different ( $\chi^2 = 0.798$ ,  $P = 0.372$ ).

### Mow-and-Burn Experiment

At LAS, where burning was done 1 mo after mowing, litter cover was reduced in both the mow-and-burn and burn-only treatments compared with the control ( $\chi^2 = 27.774$ ,  $P < 0.001$ ;  $\chi^2 = 13.605$ ,  $P < 0.001$ , respectively), while the litter cover in the mow-only treatment was not different from the control ( $\chi^2 = 1.467$ ,  $P = 0.226$ ; Figure 2A). However, at LPS, where burning was delayed for a year after mowing, the mow-and-burn treatment was ineffective in reducing litter cover ( $\chi^2 = 2.599$ ,  $P = 0.107$ ; Figure 2B). The burn-only treatment effectively reduced litter cover versus all other treatments at LPS ( $P \leq 0.001$ ; Figure 2B).

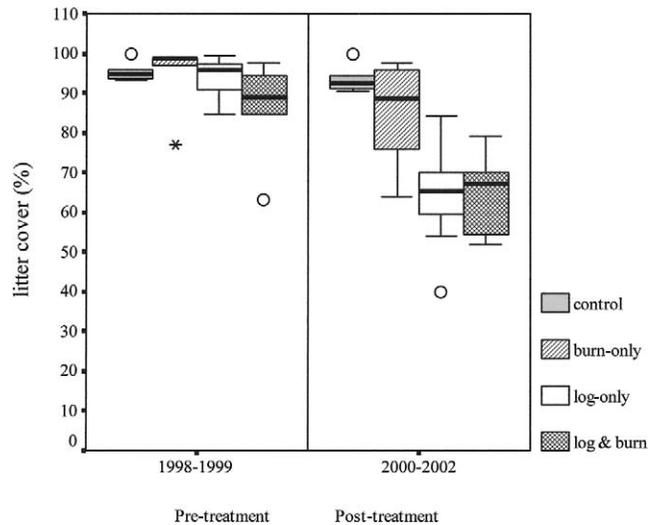


Fig. 1. Boxplots showing mean percent litter cover pre-treatment (1998–1999) and 2 y post-treatment (2000–2002) for a log-and-burn experiment to restore fire-suppressed scrub, Lake Wales Ridge, central Florida. The lower and upper horizontal bars of the boxplot represent the 25<sup>th</sup> and 75<sup>th</sup> percentiles, respectively; the solid middle bar represents the median. The lower and upper whiskers show the largest and smallest values that are not outliers. The circles are outliers (more than 1.5 box-lengths from 25<sup>th</sup> and 75<sup>th</sup> percentiles) and the asterisks are extreme outliers (more than 3 box-lengths from 25<sup>th</sup> and 75<sup>th</sup> percentiles).

### Saw-and-Burn Experiment

The saw-and-burn treatment was most effective in reducing litter cover (Figure 3). Litter cover in the saw-and-burn treatment decreased significantly compared with both the burn-only and the control treatments ( $\chi^2 = 15.478$ ,  $P < 0.001$ ;  $\chi^2 = 26.906$ ,  $P < 0.001$ , respectively). The burn-only treatment marginally reduced litter cover ( $\chi^2 = 3.762$ ,  $P = 0.052$ ).

## DISCUSSION

By the 1980s, >85% of fire-maintained Florida scrub and sandhill ecosystems on the Lake Wales Ridge of central peninsular Florida had been lost to development (Peroni and Abrahamson 1985). Much of the remaining Florida scrub and sandhill (currently <15% of its original area) is embedded in an increasingly urbanized landscape, making it difficult for land managers to apply prescribed fire safely. Remaining xeric uplands in other parts of the state are even rarer and more fragmented. Thus, land managers have turned to various mechanical means as either surrogates for fire or as pre-treatments to fire. When used as pre-treatments to fire, mechanical treatments reduce the height of fuel and make it more homogeneous, decreasing the risk of fire escape and facilitating even burn coverage. Based on preliminary results from three studies on four sites, we have found that some mechanical treatments are more effective than others in creating conditions that promote the restoration and maintenance of Florida scrub and sandhill ecosystems.

Logging reduced litter cover much more than

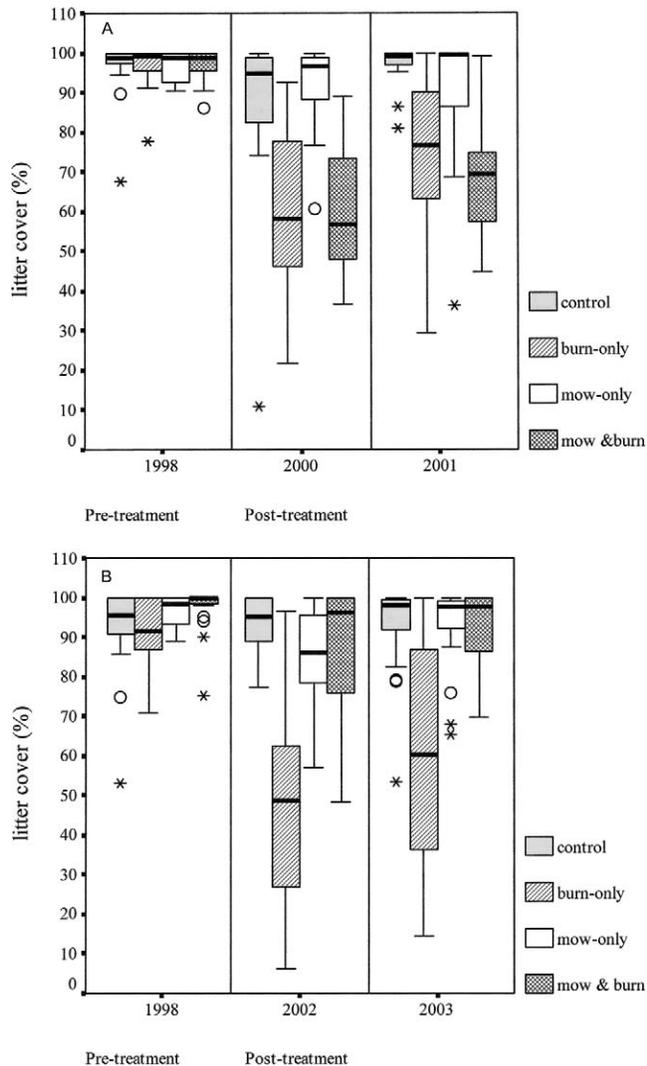


Fig. 2. Boxplots comparing percent litter cover pre-treatment (1998) and post-treatment (2000–2003) for a mow-and-burn experiment to restore fire-suppressed scrub, Lake Wales Ridge, central Florida. (A) Lake Apthorpe scrub. (B) Lake Placid scrub. The lower and upper horizontal bars of the boxplot represent the 25<sup>th</sup> and 75<sup>th</sup> percentiles, respectively; the solid middle bar represents the median. The lower and upper whiskers show the largest and smallest values that are not outliers. The circles are outliers (more than 1.5 box-lengths from 25<sup>th</sup> and 75<sup>th</sup> percentiles) and the asterisks are extreme outliers (more than 3 box-lengths from 25<sup>th</sup> and 75<sup>th</sup> percentiles).

burning alone; however, skid trails from timber removal in the log-only and log-and-burn treatments created large areas of bare sand characterized by considerable soil disturbance. Logged areas were dominated by weedy natives and are susceptible to invasion by exotics such as cogongrass (*Imperata cylindrica*) and natal grass (*Rhynchelytrum repens*). Logging produced more extreme changes than burning alone in the canopy layer (M.A. Rickey, E.S. Menges, and C.W. Weekley, unpublished data) and in litter cover. All treatments were successful in reducing the subcanopy layer and reducing shrub cover (M.A. Rickey, E.S. Menges, and C.W. Weekley, unpublished data). Because of the soil disturbances associated with logging, we recom-

mend caution when logging in Florida scrub. Over time, the negative effects of these soil disturbances may decline (P.A. Schmalzer, Dynamac Corporation, personal communication).

The effectiveness of the mow-and-burn treatment depended upon the timing of the burn. When the burn occurred 1 mo after mowing, the mow-and-burn treatment mimicked the burn-only treatment; when the burn was delayed for a year, litter reductions in the mow-and-burn treatment were more similar to mowing alone, which was not effective in reducing litter cover. This result is in agreement with that of Schmalzer et al. (2003), who found that mechanical treatments plus burning were most similar to burning alone when the fire occurred <6 mo after cutting. In our study, the mow-only treatment was not effective because it created a thick layer of thatch that reduced bare sand patches needed for seedling requirement by many rare Florida scrub plants. All treatments at both mow-and-burn sites were effective in reducing shrub heights relative to the control (M.A. Rickey, E.S. Menges, and C.W. Weekley, unpublished data). Chainsaw felling followed by fire was more effective in reducing litter cover than fire alone, perhaps because of the higher fire intensity (Wally et al. 2006) and more complete coverage (E.S. Menges, personal observation) associated with the chainsaw pre-treatment. All three mechanical treatments examined in this study, when used as pre-treatments for prescribed burning, were at least as effective in reducing litter cover as burning alone.

## MANAGEMENT IMPLICATIONS

Mechanical treatment followed quickly by fire can be a useful management tool to accelerate restoration of Florida scrub and sandhill sites degraded by decades of fire suppression. Because of the scarcity of data on the effects of various mechanical treatments or pre-treatments, we strongly recommend pre- and post-treatment monitoring of vegetation responses to the methods employed. This is particularly important if mechanical treatments are used as a surrogate for fire. Monitoring programs should explicitly target the rare herbaceous species endemic to Florida scrub and sandhill because they may be vulnerable to mechanical treatments. However, because these endemics are also especially vulnerable to fire suppression, the use of mechanical treatments followed by fire may be of benefit. Soil disturbance may lead to increases in exotic plants, or as in the case of our log-and-burn experiment, weedy native species. Mechanical treatments combined with fire may be especially useful for the first attempt to burn long-unburned sites; however, subsequent management of Florida scrub and sandhill should focus on prescribed burning.

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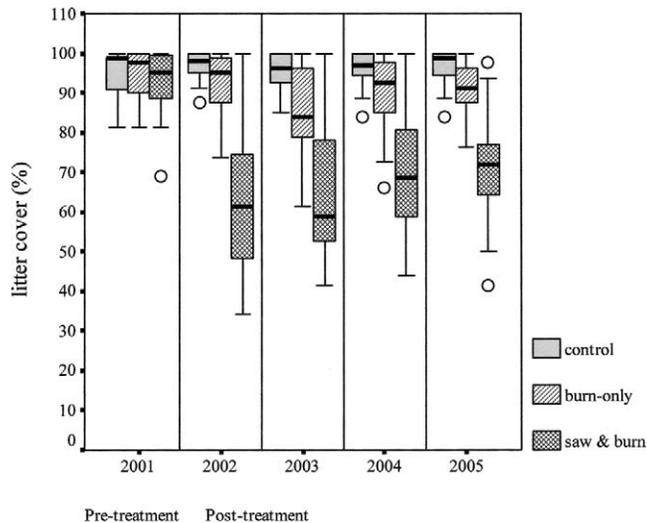


Fig. 3. Boxplots comparing mean percent litter cover pre-treatment (2001) and post-treatment (2002–2005) for a saw-and-burn experiment to restore fire-suppressed sandhill habitats, Lake Wales Ridge, central Florida. The lower and upper horizontal bars of the boxplot represent the 25<sup>th</sup> and 75<sup>th</sup> percentiles, respectively; the solid middle bar represents the median. The lower and upper whiskers show the largest and smallest values that are not outliers. The circles are outliers (more than 1.5 box-lengths from 25<sup>th</sup> and 75<sup>th</sup> percentiles) and the asterisks are extreme outliers (more than 3 box-lengths from 25<sup>th</sup> and 75<sup>th</sup> percentiles).

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