Restoration of Dry Prairie Using Fire and Roller Chopping

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ABSTRACT

Florida's dry prairies are rare and threatened due to suppression of natural fire regimes in these fire-dependent ecosystems. Ecological restoration of dry prairies reduces the growth of shrubs resulting from lack of fire, while encouraging the growth of grasses and forbs. In addition to prescribed burning, these efforts often use mechanical disturbance such as roller-chopping. In this study we investigated effects of three restoration treatments—roller chopping, prescribed burning, and a combination of the two—applied in either summer or winter, on dry prairie vegetation at Myakka River State Park. After 12 to 13 years of restoration treatments (3 choppings and 5 burns) we used floristic density and similarity analysis to compare areas under restoration with high-quality reference sites. Findings indicate that long-unburned dry prairies cannot be effectively restored by the use of roller chopping alone. Chopping was not an effective substitute for prescribed burning in reducing shrubs and encouraging growth of grasses and forbs. Effects of season of treatment on restoration effectiveness were mixed, but it appears that prescribed burning alone is not as effective as a combination of the two treatments.

INTRODUCTION

Floristically, Florida dry prairies have often been described as similar to pine flatwoods (Abrahamson and Hartnett 1990), except for the lack of trees (slash and longleaf pines, *Pinus elliottii* var. *densa* and *P. palustris*). However, these flat, treeless (or nearly so) areas are also home to a large number of forbs (Abrahamson and Hartnett 1990, Huffman 1997). Overall, more than 200 plant species are known to occur in dry prairies (Huffman and Benshoff 1996; for a more comprehensive treatment see Orzell and Bridges 2006).

Dry prairies occur extensively in south Florida along the Kissimmee River in Glades, Highlands, and Okeechobee Counties, and also in DeSoto, Manatee, and Sarasota Counties (Ward 1978). Small, isolated patches ("islands") of pine trees or cabbage palms often occur in a landscape dominated by dry prairie, serving to illustrate the similarities between dry prairies and flatwoods. Soils in the two associations are similar—both have acidic, sandy soils with a spodic horizon. The well-drained, sandy upper horizons and underlying spodic horizon combine with the subtropical weather of South Florida to create challenging hydrological conditions. During the dry winter, what little precipitation occurs quickly disappears below the root zones of many plants, and in the summer, entire root systems and even aboveground plant parts may be submerged for days after the heavy rains. The hardy plants found in dry prairies are uniquely adapted to cope with these seasonally demanding conditions.

The frequent fires common to many ecosystems in the Southeast (Komarek 1964, Platt et al. 1988) are as important as hydrology in influencing and maintaining dry prairie flora. Southwest Florida, where dry prairies occur, is considered the "thunderstorm capital of the United States" (Wade et al. 1980), with more thunderstorms annually (75% of them during the period from June to September) than anywhere else in the U.S. (Wade 1983). It is widely thought that in this lightning-prone area, historic fire-return intervals in dry prairies were 1-3 years (FNAI 1990, Huffman 1997). An increase in the importance of woody plants follows a shift from lightning-season burns to those in the non-lightning season (Boyer 1990, Robbins and Myers 1992, Glitzenstein et al. 1995, Olson and Platt 1995). These findings reveal an important implication of the change to an anthropogenically-dictated fire season in the dry prairie: despite temporarily reducing the cover of woody plants, winter burning has actually increased the importance of shrubs to the detriment of desirable forage grasses.

The flammable nature of dry prairie vegetation is conferred largely by grasses, whose senesced aboveground parts dry rapidly and carry fire easily. As shrubs replace grasses and grow in height and biomass, vegetation is held higher off the ground and herbaceous fine fuels decline. The prairie will still burn, but stronger ignition sources are required. The resulting decrease in fire frequency can allow the establishment of less fire-associated species from adjacent areas of scrub or hammock. Their arrival may presage the development of a cycle of positive feedback, wherein the fire-resistant community becomes increasingly favorable for the establishment of fire-resistant species and, consequently, increasingly fire-resistant. Richardson (1977) interpreted the sequence induced by fire suppression—from dry prairie to flatwoods or scrubby flatwoods—as a transition toward a low hammock-type community.

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From the standpoint of ecological resilience theory, first advanced by Holling (1973, 1986), each of the community types above represents a stable state, where major system attributes are controlled by a set of driving forces. In dry prairies, hydrology and frequent fire combine to maintain characteristic vegetative components. Although fire is traditionally considered a disturbance in the sense that it kills or damages plants (Sousa 1984), its presence is vital to the persistence of the system and is encouraged by the pyrogenic vegetation. Indeed, the exclusion of fire, a regularly-occurring and natural process, could be considered a human-induced disturbance in such fire-maintained systems. From this perspective the presence of grasses and fine-fuel vegetation discourages a lack of fire and is a major contributor to the system's ecological resilience: its ability "to maintain its structure and patterns of behavior in the face of disturbance" (Holling 1986).

When fire is excluded from the dry prairie for extended periods, much of the pyrogenic vegetation component is relegated to the seed bank. With this mechanism of resilience to fire exclusion thus lost, the long-unburned dry prairie can be thought of as nearing an ecological threshold or breakpoint (Holling 1973). Once this threshold is surpassed, succession can proceed toward the two aforementioned alternative stable states—hammock or scrubby flatwoods. In these latter systems, fire is either virtually absent as a controlling process or occurs very infrequently. The fire-dependent dry prairie is then lost to a different community with other system drivers and fundamental characteristics, such as the fire-resistance of hammocks. When this transition occurs, return to the former condition (dry prairie) may not be possible without a severe system perturbation or human intervention: "In short, there is a level of the state variable 'trees' that, once achieved, moves the system from one domain of attraction to another. Return to the original domain can only be made by an explicit reduction of the trees and shrubs" (Holling 1986). Once a system has made the transition from a desired state to a degraded or undesired state, the task of assisting its recovery belongs to those who practice the science and art of ecological restoration.

The long absence of frequently-occurring fire—followed by its return—provides an opportunity for study. The use of fire and roller chopping could result in rapid and better restoration than disturbance by fire alone. The application of restoration treatments in both summer and winter presents an opportunity to test for differences in the effectiveness of restoration efforts made in the two seasons, as well as the response of dry prairie plant species to them. For this study we tested the following hypotheses:

> 1) The use of roller chopping alone as a substitute for frequent fire is not as effective as prescribed fire treatments in restoring fire-suppressed dry prairie to a desired condition by reducing shrub density and increasing grass and forb density.
>
> 2) The return of frequent fire is not as effective as prescribed burning supplemented with roller chopping at achieving management goals of a reduction in shrub density and an increase in densities of grasses and forbs.
>
> 3) Restoration treatments applied in summer months are more effective than treatments applied in winter in reducing shrub density and increasing density of grasses.

STUDY SITE AND METHODS

This study was conducted at Myakka River State Park (11,686 ha), which lies on both sides of the Myakka River southeast of Sarasota in Sarasota and Manatee counties in central peninsular Florida. The landscape is a mosaic of dry prairies with embedded ephemeral and permanent wetlands and scattered islands of pine flatwoods and hammocks, marshes, sloughs, and wet prairies. The mean annual temperature is 22.3° C, and average annual rainfall (61% between June and September) is 1,425-1,440 mm (Fitzgerald et al. 1995, Huffman 1997). The park ranges 10.7 m-12.2 m above sea level, with soils of a Myakka-Immokalee-Basinger Association containing a spodic horizon (Fitzgerald et al. 1995). The combination of low elevation and topographic relief and an impeding soil horizon contribute to periodic inundation when heavy summer rains occur.

In May 1986 wildfire burned through an area between Power Line Road and State Road 72 that had not previously experienced fire for 12 to 15 years. The restoration experiment plots were established in this area, each approximately 6 ha in size (Fitzgerald et al. 1995). Plots were separated by fire lanes, and the wetlands that occur scattered across the landscape were excluded from the experiment. The treatments applied were prescribed burn only, roller chop only, and combination (chop and burn), with each applied in the wet (summer) or dry (winter) seasons. Summer treatments were applied in June or July; winter treatments in January or February. Burn treatments consisted of head fires and were applied to the plots every 3 years. Roller chopping (Marden M-7 in offset, tandem configuration) treatments (single pass only) were applied every sixth year. The management objective for chopping was to sever saw-palmetto rhizomes while incurring minimal soil disturbance. For combination treatments, on years when both treatments were scheduled to be applied, roller chopping was done approximately 2 weeks to 1 month prior to burning. All treatments were staggered in time, so that half of the treatments received initial treatments in 1988 and the other half in 1989. Treatments continued according to the above schedule, with the most recent treatments taking place in January 2001. In total, plots were roller chopped 3 times and burned 5 times prior to final vegetation sampling.

Data were collected from late May through early September 2001. Density of all shrub species and wiregrass (*Aristida stricta* var. *beyrichiana*) was obtained within 16, 1-m × 1-m quadrats randomly placed within each of the 24 study plots. Density of all other species was counted within a randomly chosen half of each of these quadrats. Individual stems of clonal species were counted. A reference site of dry prairie was located 6 km north of the treatment plots. This reference area experienced more fires during the era of fire-suppression policies than the areas comprising the restoration experiment. Yet it still had been subject to fire suppression, and was subjected to restoration and management that included roller chopping, mowing, and prescribed burning every 2 years since the 1980s (Robert Dye, *personal communication*). A second reference was located at Kissimmee Prairie Preserve State Park. Dry prairies on this Park have been prescribed burned on a 2- to 3-year cycle for the past several decades.

Statistical Analysis

The 79 plant taxa observed in this study were categorized as forbs, graminoids (grasses and sedges), or shrubs (including tree species) based on Huffman and Benshoff's (1996) descriptions. Two-way analyses of variance (ANOVA) in four randomized complete blocks were performed to test for effects of treatment (burn, chop, combination) or season (summer, winter) on the average number of individuals of each vegetation type observed per quadrat. ANOVA also was used to test for differences in the number of taxa of each category recorded per quadrat in the restoration treatment plots. Where significant differences were detected in vegetation density or diversity, multiple comparison tests using Scheffé's method (Ott 1993) were used to compare the effects of the restoration treatments.

Endpoint-difference (ED) similarity (Provencher et al. 1999, 2001) was used to compare the reference sites to treatments at the restoration site. The formula used to measure ED similarity is as follows:

$$ED = \sum \exp[-\left| X_{ik} - X_{jk} \right| / \sigma_{eij}] / n_{sp}$$

in which X represents the density of species k in plots i and j, and σ_{eij} is the joint standard error of X_{ik} and X_{jk}. The exponential function (e raised to the power of the term in brackets) is divided by n_{sp}, the number of species found in both plots. The formula as presented provides a value between 0 and 1 expressing the similarity of one treatment plot to one reference plot. As the ED value approaches 1.0, the similarity of the vegetation in the plots compared increases. In this case each treatment plot was compared with each reference plot; these values were then averaged to provide one mean similarity value for each treatment plot.

RESULTS

Shrub plant density was affected by treatment ($p = 0.009$) (Fig. 1). Plots subjected to roller chopping had lower average densities of shrub plants (19.6/m^2) than plots subjected to both chopping and burning in combination ($p = 0.009$), although no differences were detected between shrub plant density at chop-only plots and burn-only plots or between burn-only plots and combination plots.

The number of shrub taxa also depended on treatment ($p = 0.043$), with combination-treated plots having higher shrub species richness than either treatment alone; but season effects were only significant (t-test, $p = 0.025$) in chop-only plots (Fig. 2).

Treatment effects on the abundance of forbs were significant ($p < 0.001$), but no significant season effects on forb density were detected (Fig. 3). Forb density was higher in plots treated by chopping and burning in combination than by either method alone (Scheffe's test; $p < 0.001$ for both comparisons). The number of forb taxa encountered in the plots was significantly affected by both treatment ($p < 0.001$) and season ($p = 0.001$) (Fig. 4). The number of taxa was higher in combination-treated plots than in plots subjected to either burning alone ($p < 0.001$) or chopping alone ($p < 0.001$). Forb species richness also was higher in winter-treated plots than in summer-treated plots.

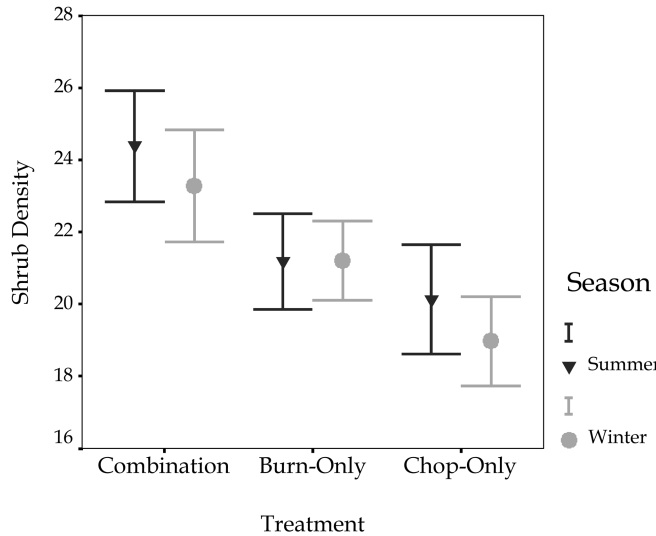

Figure1. Mean (±1 S.E.) shrub plant density (individuals/m^2) among six restoration treatments, Myakka River State Park, FL.

Effects for season and treatment were significant ($p < 0.001$ for both) for density of graminoid taxa (Fig. 5). Tests for similarity of means using Scheffe's method revealed significantly higher graminoid density in burn-only plots than chop-only plots ($p < 0.001$), and higher densities in combination-treated plots than burn-only plots ($p < 0.001$). Overall, plots had higher densities of graminoids when treated in summer than in winter ($p < 0.01$). Graminoid richness was affected by treatment ($p < 0.001$) but not season, with combination-treated plots and burn-only plots containing greater numbers of grass and sedge taxa than chop-only plots ($p < 0.001$) (Fig. 6).

The plots that most strongly resembled the reference sites were those that experienced both chopping and burning, or burning alone, during the summer season (Fig. 7). Those that underwent roller chopping alone dur-

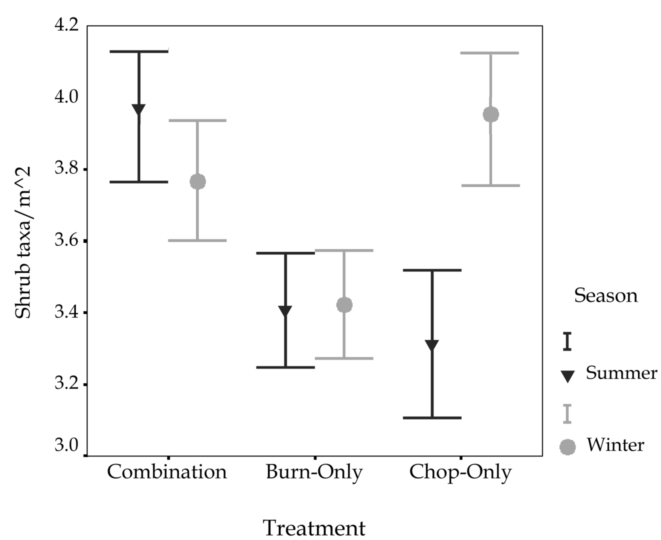

Figure 2. Mean (±1 S.E.) shrub richness (taxa/m^2) among six treatments, Myakka River State Park, FL.

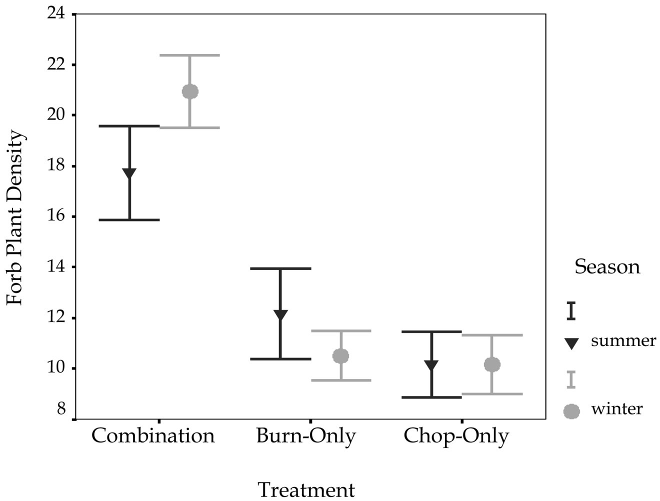

Figure 3. Mean (±1 S.E.) density (number/m^2)of forbs among six treatments, Myakka River State Park, FL.

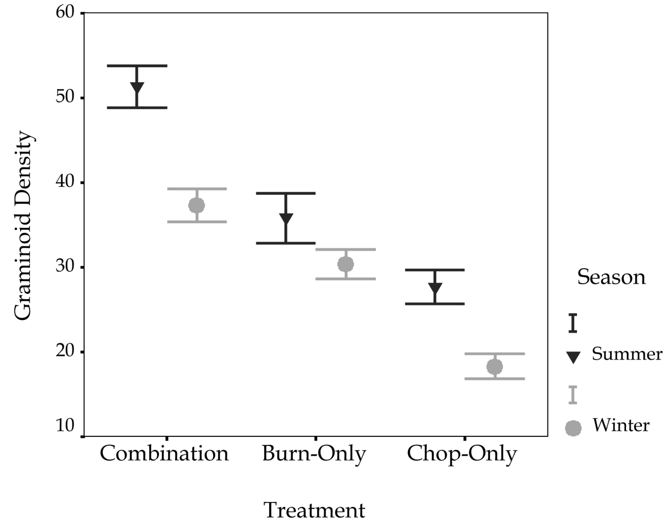

Figure 5. Mean (±1 S.E) graminoid density (individuals/m^2) among six restoration treatments, Myakka River State Park, FL.

ing the summer season resembled the reference sites least. An analysis of variance revealed significant effects of treatment (i.e., burning alone, chopping alone, or both in combination; p = 0.008) on the similarity of the restoration treatment plots to the reference sites (Table 1). Neither the season in which the treatment was applied, nor interaction effects between treatment and season influenced mean similarity of treatment and reference plots.

Similarity values were significantly higher for the both the burn-only treatments (p = 0.036) and combination treatments (p = 0.015) than for the chop-alone treatments. No significant differences in similarity values were found between burn-only and combination treatments.

DISCUSSION

Vegetation in plots burned every 3 years displayed greater similarity to the average reference site than vegetation in plots that were only roller chopped every 6 years. The abundance and diversity of shrubs in chop-only and burn-only plots were similar. The interpretation of this finding is complicated by the tendency of shrubs to resprout following fire or other damage (Hough 1968, Tanner et al. 1988). Forb and graminoid data may be more reliable when evaluating restoration success with respect to goals of increasing grass and forb density. The abundance of graminoids in burn-only plots was significantly higher than in chop-only plots, as was the average number of graminoid species. Abundance of forbs and forb richness were similar in plots receiving either chop-only or burn-only treatments. Additionally, prescribed fire treatments were significantly more effective than roller chopping at increasing species richness when both treatments were applied during summer months.

The results of similarity analysis and comparisons of vegetation density and richness indicate that roller chopping is not as effective as prescribed fire in restoring fire-

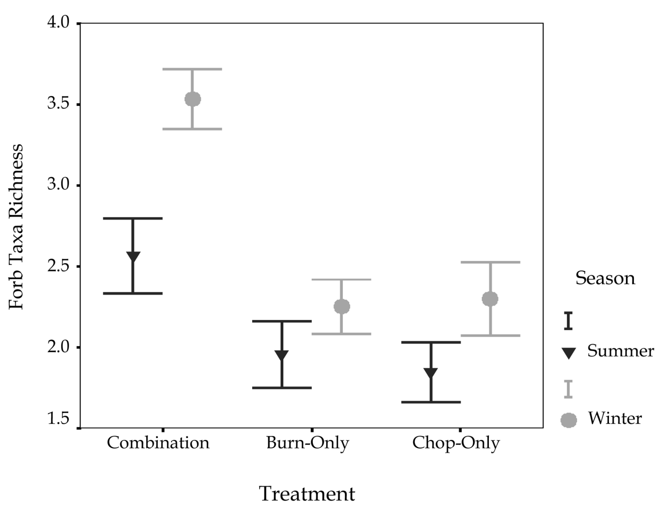

Figure 4. Mean (±1 S.E) forb taxa per m^2 among six treatments, Myakka River State Park, FL.

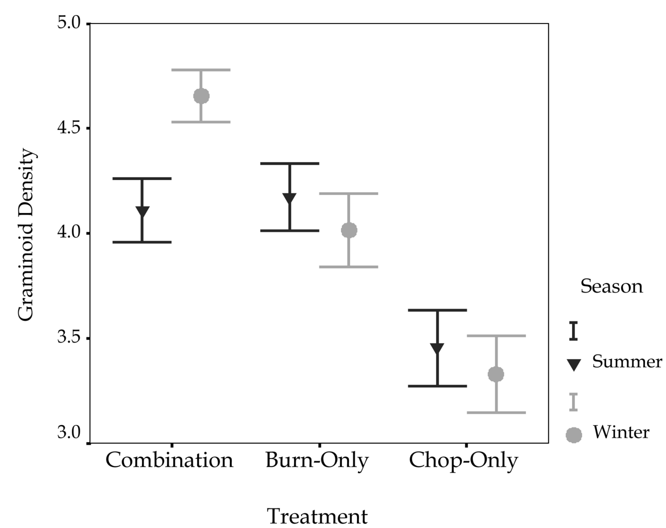

Figure 6. Mean (±1 S.E) graminoid taxa (number/m^2) among six treatments, Myakka River State Park, FL.

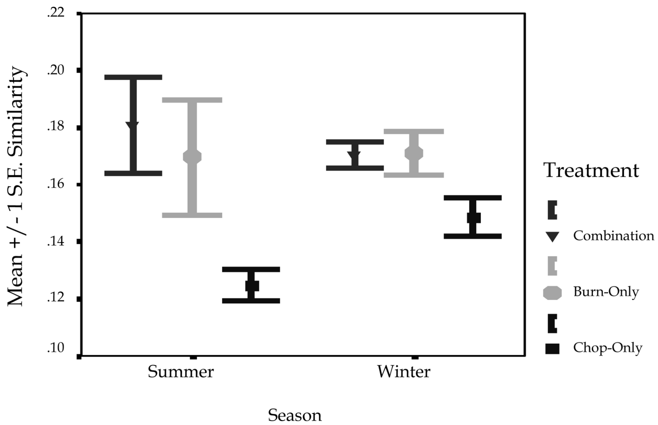

Figure 7. Mean (±1 S.E.) Endpoint Difference similarity values for vegetation density in six restoration treatments, Myakka River State Park, FL.

suppressed dry prairie areas, particularly when the encouragement of grasses is a management concern. Although roller chopping has been shown to remove large shrubs, the technique, when applied at 6-year intervals, is not an effective replacement for burning, likely due to the absence of the beneficial effects of burning in this fire-dependent ecosystem.

Analysis of similarity values failed to find significant differences between vegetation in burn-only plots vs. those receiving both prescribed burn and roller chop treatments. Data concerning shrubs alone are inconclusive, since the higher richness and stem density of shrub taxa found in combination-treated plots may be due to either greater damage to shrubs by burning alone or to disturbance-induced shrub sprouting in response to the combination of chopping and burning (see Tanner et al. 1988). In fact, more prolific resprouting of shrubs in combination-treated plots than in burn-only plots could make combination-treated plots appear less similar to the averaged reference sites (which have relatively few shrubs), even if other vegetation categories were made more similar. The combination of mechanically-induced belowground disturbance and aboveground damage seems more severe *a priori* than burning alone; if so, forbs and graminoid plants would be expected to take greater advantage of the potential reduction in competition. Such seems to be the case, because forb richness and density were higher in combination-treated plots than in burn-only plots. Also, plots that received combination treatments had higher densities of grass species than burn-only plots. Species richness, as measured by the average number of taxa, was higher in combination-treated plots than in burn-alone plots. Although more time and additional measurements should elucidate the responses of shrubs to the two treatments, these findings support the hypothesis that a combination of fire and roller chopping is more effective at restoring fire-suppressed dry prairie than burning alone.

Table 1. ANOVA summary of treatment and season effects on the similarity values for experimental restoration plots, Myakka River State Park, FL.

Source	DF	MS	F	P
Season	1	0.00014	0.253	0.621
Method	2	0.00357	6.333	0.008*
Season × Method	2	0.0006	1.072	0.363
Error	18	0.00056		
Total	24			

Overall similarity values for vegetation in plots treated in the winter (dry) were higher than those found for that in summer-treated plots. Season effects were not significant with respect to shrub density, and forb plant density in summer-treated plots was similar to that in winter-treated plots. The average number of forb species recorded per quadrat was significantly higher in winter-treated plots than in summer-treated plots. Summer-treated chop-only and chop-and-burn plots had higher graminoid abundance than winter-chopped and winter-combination plots, but no difference according to season was observed for burn-only plots. Graminoid species richness was higher for plots chopped and burned in winter than in those receiving the combination treatment in summer, although there were no effects of season of treatment on graminoid diversity for either of the other two restoration treatments. The average number of plant species was similar in summer-burned and winter-burned plots, but for the other two treatments species richness was higher when treatments were applied in the winter.

The findings concerning season effects of treatment seem to be definitive: summer restoration treatments do not appear to be more effective than winter treatments. Rather, the data seem to indicate the opposite. Nevertheless, the considerable literature concerning season effects of fires in other southeastern ecosystems (Platt et al. 1988, Boyer 1990, Robbins and Myers 1992) and in the tallgrass prairies of the Midwest (Glenn-Lewin et al. 1990, Howe 1994) raises questions concerning the apparently higher effectiveness of winter restoration activities. Although the reference sites at Kissimmee Prairie were never subject to fire-suppression policies, intentional burning to encourage forage grass growth was traditionally done in winter. Changes in floristic composition caused by a possible shift toward winter burns may have occurred; if so, this shift would account for the greater resemblance of data from winter-treated plots to reference data.

LITERATURE CITED

Abrahamson, W. G. and D. C. Hartnett. 1990. Pine flatwoods and dry prairies. Pages 103-149 *In* R. L. Myers and J. J. Ewel, editors, Ecosystems of Florida. University of Central Florida Press, Orlando.

Boyer, W. D. 1990. Growing-season burns for control of hardwoods in longleaf pine stands. *In* USDA Forest Service Research Paper, SO-256.

Fitzgerald, S. M., J. M. Wood and G. W. Tanner. 1995. Small mammal and plant responses to the rehabilitation of a dry prairie grassland association using fire and roller chopping applied in two seasons. Florida Game and Fresh Water Fish Commission, Nongame Wildlife Program Project Report, Tallahassee, FL.

FNAI. 1990. Guide to the natural communities of Florida. Florida Natural Areas Inventory, Tallahassee.

Glenn-Lewin, D. C., L. A. Johnson, T. W. Jurik, A. Akey, M. Leoschke, and T. Rosburg. 1990. Fire in central North American grasslands: Vegetative reproduction, seed germination, and seedling establishment. Pages 28-45 *in* S. L. Collins and L. L. Wallace, editors, Fire in North American tallgrass prairies. University of Oklahoma Press, Norman.

Glitzenstein, J. S., D. R. Streng, and W. J. Platt. 1995. Evaluating the effects of season of burn on vegetation in longleaf pine savannas. Nongame Wildlife Program Project Report Florida Game and Fresh Water Fish Commission, Tallahassee.

Holling, C. S. 1973. Resilience and stability of ecological systems. Annual Review of Ecology and Systematics 4:1-23.

Holling, C. S. 1986. Resilience of ecosystems: local surprise and global change. Pages 292-317 *in* W. C. Collins and R. E. Munn, editors, Sustainable development of the biosphere. Cambridge University Press, Cambridge.

Hough, W. A. 1968. Carbohydrate reserves of saw-palmetto: seasonal variation and effects of burning. Forest Science 14:399-405.

Howe, H. F. 1994. Response of early- and late-flowering plants to fire season in experimental prairies. Ecological Applications 4:121-133.

Huffman, J. M. 1997. The response of *Lilium catesbaei* (pine lily) to fire and/or roller-chopping on Florida dry prairie. Master of Science. University of Florida, Gainesville.

Huffman, J. M. and P. Benshoff. 1996. Vascular plants of Myakka River State Park. Florida Park Service, Department of Environmental Protection.

Komarek, E. V., Sr. 1964. The natural history of lightning. Pages 89-105 *in* Proceedings of the Tall Timbers Fire Ecology Conference.

Olson, M. S. and W. J. Platt. 1995. Effects of habitat and growing season fires on resprouting of shrubs in longleaf pine savannas. Vegetatio 119:101-118.

Orzell, S. L. and E. L. Bridges. 2006. Floristic composition of the south-central Florida dry prairie landscape. Pages 64-99 *in* R. F. Noss, editor, Land of fire and water. Proceedings of the Florida Dry Prairie Conference. Painter, DeLeon Springs, FL.

Ott, R. L. 1993. An introduction to statistical methods and data analysis. Duxbury Press, Belmont, CA.

Platt, W. J., G. W. Evans, and M. M. Davis. 1988. Effects of fire season on flowering of forbs and shrubs in longleaf pine forests. Oecologia 76:353-363.

Provencher, L., K. E. M. Galley, B. J. Herring, J. Sheehan, J. P. McAdoo, N. M. Gobris, S. J. McAdoo, A. R. Litt, D. R. Gordon, G. W. Tanner, L. A. Brennan, J. L. Hardesty. 1999. Effects of hardwood reduction on trees and community similarity and sand pine harvest on groundcover vegetation in longleaf pine sandhills at Eglin Air Force Base, Florida. Annual Report to Natural Resources Division, Eglin Air Force Base, Niceville, Florida. Public Lands Program, The Nature Conservancy, Gainesville, FL.

Provencher, L., A. R. Litt, K. E. M. Galley, D. R. Gordon, G. W. Tanner, L. A. Brennan, N. M. Gobris, S. J. McAdoo, J. P. McAdoo, B. J. Herring. 2001. Restoration of fire-suppressed longleaf pine sandhills at Eglin Air Force Base, Florida. Interim final report to the Natural Resources Management Division, Eglin Air Force Base, Niceville, Florida. Science Division, The Nature Conservancy, Gainesville, FL.

Richardson, D. R. 1977. Vegetation of the Atlantic coastal ridge of Palm Beach County, FL. Florida Scientist 40:281-330.

Robbins, L. E. and R. L. Myers. 1992. Seasonal effects of prescribed burning in Florida: A review. *In* Miscellaneous Publication No. 8. Tall Timbers Research, Inc., Tallahassee, FL.

Sousa, W. P. 1984. The role of disturbance in natural communities. Annual Review of Ecology and Systematics 15:353-291.

Tanner, G. W., J. M. Wood, R. S. Kalmbacher, and F. G. Martin. 1988. Mechanical shrub control on flatwoods range in south Florida. Journal of Range Management 41:245-248.

Wade, D., J. Ewel, and R. Hofstetter. 1980. Fire in South Florida ecosystems. Gen. Tech. Rep. SE-17, USDA Forest Service, Southeast Forest Experiment Station, Asheville, NC.

Wade, D. D. 1983. Fire management in the slash pine ecosystem. Pages 202-223 *in* E. L. Stone, editor, Proceedings of 15th annual IMPAC conference, School of Forest Resources and Conservation, University of Florida, Gainesville.

Ward, D. B. 1978. Keys to the flora of Florida 8: Helianthus (Compositae). Phytologia 41:55-61.