7 Pine Savannas of Everglades National Park—An Endangered Ecosystem

James K. DeCoster, William J. Platt and Sarah A. Riley
Department of Biological Sciences, Louisiana State University, Baton Rouge, Louisiana 70803; btplat@unix1.sncc.lsu.edu

Abstract

Rockridge pine savannas of Long Pine Key, Everglades National Park, are among the most species-rich communities in the world, yet face numerous anthropogenic threats. Many species are endemic to the pine savannas and the associated glades. This ecosystem's integrity is seriously threatened by habitat loss, past changes in fire management, and invasions of exotic species. Introductions of exotic grass, e.g., *Imperata brasiliensis* Trin., and shrubs, e.g., *Schinus terebinthifolius* Raddi., threaten the native species. Moreover, altered fire regimes, including fire suppression and prescribed fires carried out at times other than when they occurred naturally, have caused shifts in dominance from herbaceous to shrub species. To determine species composition of groundcover communities, we established elevational transects, running from high elevation pine savannas to low elevation glades, at various locations in Long Pine Key. In tenth hectare plots, species richness and frequency of occurrence were determined at spatial scales ranging from 100 cm^2 to 0.1 ha. Species richness was high on all spatial scales, with maxima of 15 species in 100 cm^2, 42 species in 1 m^2, and 132 species in 0.1 ha. Plots that have not been burned in 10 yr show a decrease in species richness when compared to frequently burned plots. With the cooperation of Everglades fire management staff, we are exploring how variations in lightning season fire management regimes influence these endangered plant communities.

Introduction

The pine savannas of the Miami rock ridge comprise an extremely endangered ecosystem. Once covering much of the Miami rock ridge, less than 10% of the original savannas exist, largely due to urban growth (Snyder et al. 1990). The small fragments that do exist face further threats: fire suppression and invasion of exotic plants are two forces that are changing the composition and structure of the savannas. Moreover, Hurricane Andrew's damage to these savannas in August 1992 showed how vulnerable these systems are. Many stands across Miami-Dade County were devastated by the hurricane, leaving few intact pine savannas in the region.

Long Pine Key (LPK) in Everglades National Park, comprising 8100 ha, is the largest area of this ecosystem that remains (Doren et al. 1993). It remains far from being undisturbed, however. Invasions of exotic species are a continual problem. *Schinus terebinthifolius* Raddi (Brazilian pepper) and *Imperata brasiliensis* Trin. (cogon grass) are rapidly becoming established. Not only do such introductions replace the native species, but they can also alter ecosystem properties, such as changing characteristics of the fire regimes. Logging occurred in the 1930s and 1940s, prior to park establishment, leaving few old growth trees within the park. The natural fire regime has also been greatly altered. With the establishment of the park in 1947, management first practiced fire suppression. Prescribed burns began in 1958, although burns were conducted in the dry season, when natural fires were not likely to occur. It wasn't until 1981 that a policy of growing-season burns was instituted, in attempts to mimic the natural fire regimes.

The pine savannas of southern Florida are characterized by a discontinuous canopy of South Florida slash pine (*Pinus elliottii* Engelm. var. *densa* Little & Dorman) and a groundcover of hardwood shrubs, palms, graminoids, and forbs. Hardwood shrubs include *Guettarda scabra* (L.) Vent. (rough velvetseed), *Myrsine floridana* A. DC. (myrsine), and *Metopium toxiferum* (L.) Krug & Urb. (poisonwood); palms include *Serenoa repens* (W. Bartram) Small (saw palmetto) and *Sabal palmetto* (Walter) Schult. & Schult. f. (sabal palm); graminoids include *Andropogon cabanisii* Hack. (fire grass), *Muhlenbergia filipes* M.A. Curtis (muhly), and *Schizachyrium rhizomatum* (Swallen) Gould (zig-zag grass); forbs include *Dyschoriste angusta* (A. Gray) Small (twin flower), *Melanthera parvifolia* Small (small-leaved cat tongue), and *Solidago odora* Aiton (scented goldenrod) These pine savannas have a number of rare and endemic species. Snyder et al. (1990) list 42 plants that are endemic to the pine savannas and hardwood hammocks of the Miami rock ridge. Some of these are quite common throughout the system, e.g., *Schizachyrium rhizomatum*, *Spermacoce terminalis* (Small) Kartesz & Gandhi, *Melanthera parvifolia*, while others are quite scarce (*Polygala smallii* R.R. Sm. & D.B. Ward, *Chamaesyce porteriana* Small).

The unique flora of the LPK pine savannas is a result of the unique environment. Southern Florida is the only area of continental United States with a subtropical climate. This allows for the coexistence of tropical hardwood shrubs with temperate herbs and grasses. The substrate is calcareous Miami oolite limestone. All soil development results from the accumulation of organic matter. Topographic is very subtle. Nevertheless, small changes in elevation results in substantial changes in the vegetation.

Fire is an integral process of these ecosystems. A long history of natural wild fires has resulted in an ecosystem wherein the species have become adapted to fire. The thick bark of the pine trees allows them to resist fires. In contrast, the above-ground portions of hardwood shrubs and herbaceous species die back and re-sprout from below-ground structures. Fire suppression results in the hardwood species forming a dense understory and changing the composition and structure of the community. LPK is currently being managed with prescribed fires. The area is divided into fire management blocks with a variety of different prescribed fire regimes. Half of the blocks are burned in wet years and the other half in dry years. Within each of these, half the blocks are burned in the transition from dry to wet season (May through June) and the other half are burned late in the wet season (mid-July through September). This system allows us to examine the effects of different fire regimes on the composition and structure of the pine savanna communities.

Methods

The goal of this study is threefold: to understand the composition of the vegetation, to understand the environmental variables that control the vegetation, and to determine how fire controls the dynamics of the system. To these ends, we have established permanent 0.1 ha plots along transects in fire blocks with different fire regimes. The transects span elevational gradients that begin in sloughs or willowheads, cross short-hydroperiod prairies, and end in high-elevation pine savannas. The plots are placed at approximately 10 cm elevational differences along these gradients. To date, 49 plots within 8 transects have been sampled

Our sample design is a modification of that used by the North Carolina Vegetation Survey (Peet et al 1998). The plots measure 20 x 50 m and are divided into 10 modules that measure 10 m x 10 m. Four of the modules are sampled intensively, with two corners containing nested submodules which decrease by orders of magnitude down to a scale of .01 m^2 (Fig. 1). This sampling design allows us to examine species richness (numbers) at a variety of different scales. We also determine the relative abundance of species. Using a 1 m square frame that is divided into 100 squares, we count the number of 10 x 10 cm squares that each species cover in each of the eight 1 m submodules. At larger scales we consider only those species which did not occur at the smaller levels and count the number of 10 x 10 cm squares that each species occupies. Species dominance is calculated by averaging species frequencies at each scale and extrapolating these to the 0.1 ha scale. The result is a calculation of the absolute abundance of each species in the plot. While this is a very intensive sampling method, it is also very powerful. For example, this exact frequency data allows us to resample the plots after a fire and determine which species increase and decrease under the various fire regimes.

Results and Discussion

Elevation is an important factor in structuring vegetation in LPK because it determines the length of hydrologic inundation. The 10 cm elevational differences between our plots produce substantial changes in composition of the vegetation (Fig. 2). For example, examining the graminoid species, *Cladium jamaicense* Crantz (sawgrass) and *Paspalum monostachyum* Chapm. reach their highest abundance in the sloughs; *Muhlenbergia filipes* and *Schizachyrium rhizomatum* reach their highest abundance in the short-hydroperiod prairies; *Andropogon cabanisii* reaches its highest abundance in the high-elevation pine savannas. The changes in the relative abundance are gradual, however. Species overlap is a result of the wetter species occurring in solution holes of the higher habitats. The abrupt transition between the pine savannas and the short-hydroperiod prairies is not evident when examining the relative abundances of graminoids.

Our data demonstrates that these communities have very high levels of species richness across the range of spatial scales that we have sampled. Pine savannas can have extremely high diversity on coarse spatial scales. We have identified up to 128 species in a 0.1 ha plot and 86 species in a 100 m² (.001 ha) subplot (Fig. 3).

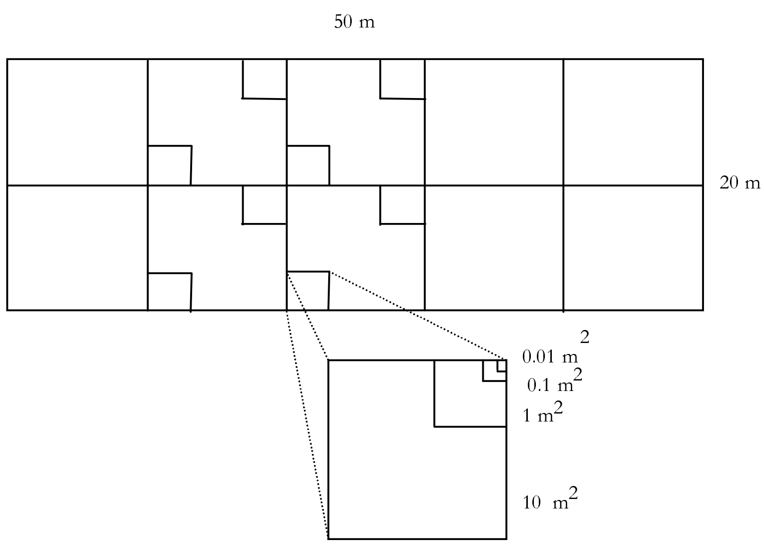

Figure 1. Plot design. The vegetation plots are 0.1 ha, measuring 20 m x 50 m. The are divided into 10 x 10 m modules. Four of the modules are sampled intensively, containing nested submodules in two of their corners that decrease by orders of magnitude. This design allows for the determination of species richness at the following spatial scales: 0.01 m², 0.1 m², 1 m², 10 m², 100 m², 1000 m².

The high levels of species richness found at the coarser spatial scales of the pinelands are likely due to habitat heterogeneity. A 10 m² area in a pine savanna might contain numerous microhabitats such as solid limestone with scattered herbs, areas of broken limestone with hardwood shrubs, solution holes filled with sawgrass and willow, and areas of accumulated organic matter dominated by grasses. The short-hydroperiod prairies and some low-elevation pine savannas have very high species richness at fine spatial scales. We have found up to 15 species in a .01 m² area (10 cm x 10 cm) and 42 species in a 1 m² area (Fig. 3). These levels of species diversity are among the highest found in grasslands worldwide (Rosenzweig 1995). The factors that allow for such a degree of species coexistence at these scales are not clear. Proposed mechanisms include low fertility (Tilman 1982) and disturbance (Huston 1979).

We have begun to examine how fire acts to maintain high species richness by ex-

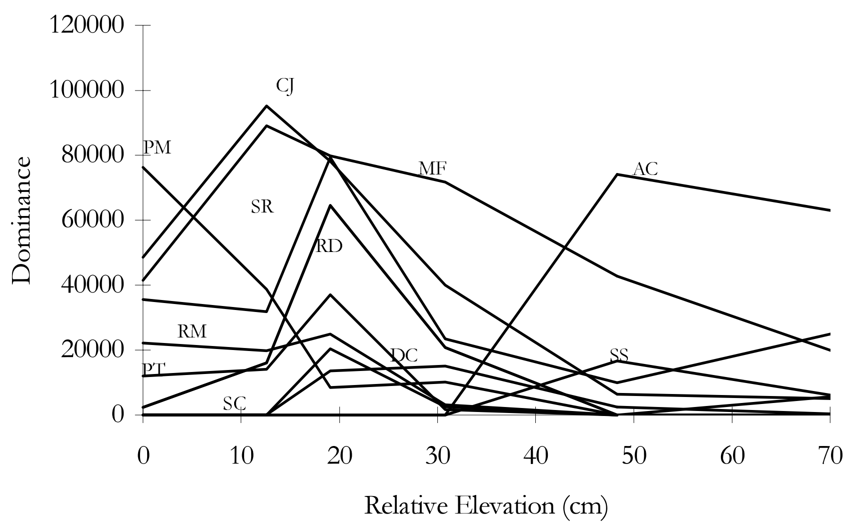

Figure 2. Changes in species composition of dominant graminoids along topographic gradient. The relative abundance of grasses and sedges in 6 plots in Transect A are plotted against relative elevation. Dominance is quantified in terms of the number of .01 m² squares that a species covers, 100 000 being the maximum. The transition between prairie and savanna is between 20 and 30 cm. Each species is indicated by a code: PM= *Paspalum monostachyum*, RM = *Rhynchospora microcarpa*, PT= *Panicum tenerum*, CJ= *Cladium jamaicense*, SR= *Schizachyrium rhizomatum*, SC = *Scleria ciliata*, RD= *Rhynchospora divergens*, DC= *Dichromena colorata*, MF= *Muhlenbergia filipes*, SS= *Sorghastrum secundum*, AC= *Andropogon cabanisii.*

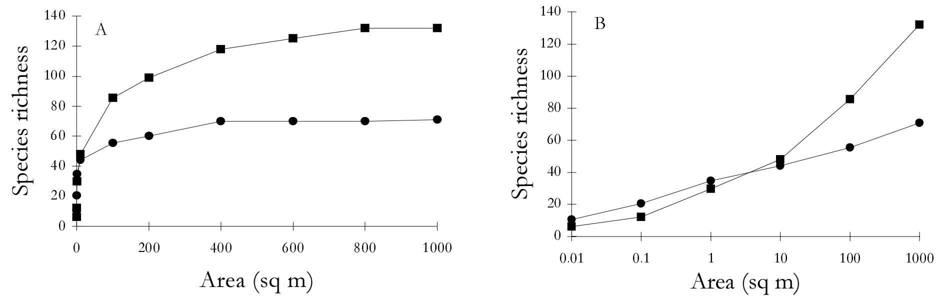

Figure 3. Species area curves, averaged across six spatial scales, are graphed for two plots. The squares indicate Plot A-1-7, a savanna plot; the circles indicate Plot A-1-6, a prairie plot. A, Untransformed; B, Log transformed.

amining fire suppressed savannas. While we generally establish and sample plots following fires, we have established two transects in fire blocks which have not been burned since 1990. By comparing these plots with other plots that have been burned 2-3 times during this interval, we are able to determine how eight years of fire suppression affects species richness. We hypothesized that species richness will decrease as a result of interspecific competition for light, nutrients, and space, and also possibly from shading from litter. Across all spatial scales, the species richness is lower in the plots which have not been burned (Fig. 4). We tested the statistical significance of this with a two-way Analysis of Variance (ANOVA) and found that the unburned plots had significantly lower diversity.

One interesting question is how the different fire regimes influence the composition of the communities. Unfortunately, we do not have enough data at this time to answer this question. Our sampling design allows us, however, to resample the plots following prescribed fires. In years to come, we should be able to determine how these different fire regimes affect the relative abundances of the various species. Based on observations over the past 10 years, we predict that the transition-season fires (May through June), and fires in dry years, will favor grasses and forbs by killing the hardwood shrubs.

We believe that historically, natural wild fires occurring during the transition period from dry to wet season were most common. This is based on four pieces of evidence. First, historical photographs of LPK taken during logging operations in the 1930s show abundant grass cover with very little cover of shrubs and palms. Second, many grasses, including *Muhlenbergia filipes*, *Sorghastrum secundum* (Elliott) Nash (Indian grass), and *Andropogn cabanisii*, demonstrate prolific flowering following early-season burns. Such a response suggests that they have evolved in the presence of such fire regimes. Third, lightning is thought to be the source of ignition for wild fires and occurs during the late spring and summer. While lightning

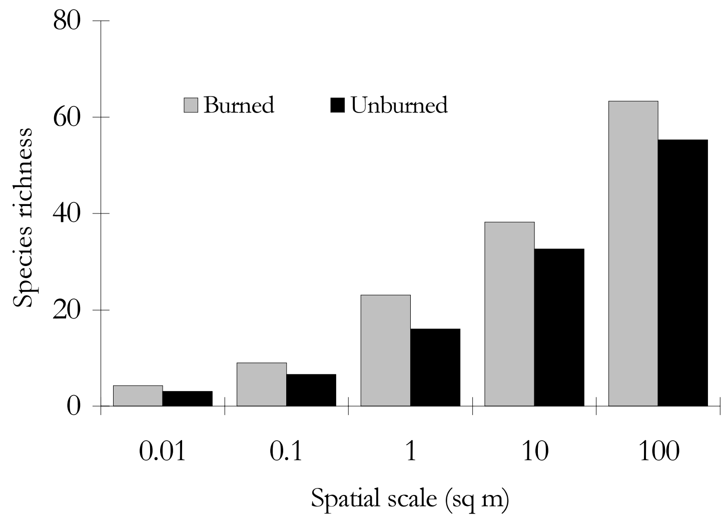

Figure 4. Species richness in burned and unburned plots. Species richness at five spatial scales is compared between five plots that had not been burned for 8 yr ("Unburned") and five plots in adjacent fire blocks that have been burned three times in this interval ("Burned").

strikes are more frequent in the late growing season than in the early growing season, fires in the early growing season burn much larger areas due to rapid spread with the relatively dry conditions (Doren and Rochefort 1984). Fourth, savannas burned during the dry season demonstrated very high mortality rates following Hurricane Andrew (Doren et al. 1998). The pines in the Everglades were much less impacted, as the park's fire managers had switched to growing season burns in 1981. Presumably, the combined stresses of winter burns and hurricane damage prevented the trees from being able to fight off attacks by bark beetles. We feel that the best chance for restoration of the pine savannas lies in trying to mimic the natural wild fire regimes.

In conclusion, the pine savannas of the Miami rock ridge are very threatened and endangered ecosystems. They contain a number of rare endemic plants and very high levels of species diversity. Despite the large amount of data that is being collected within these pine savannas, there remain many unanswered questions on how these systems function and how they may best be restored. How will different fire regimes change the relative abundance of species? What are the mechanisms that allow for such high levels of species richness at small spatial scales? How do the introductions of exotic species influence species diversity? In order to rescue and restore this ecosystem, we must begin restoration with the recreation of natural fire regimes using prescribed fire.

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