Notes on Some Characteristics of Lopsided Indiangrass (*Sorghastrum secundum*)

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ABSTRACT

As interest in ecosystem restoration in the Southeast continues to increase it will be important to understand how to maintain and increase the health and diversity of the herbaceous groundcover. This paper describes some characteristics of one such component, lopsided indiangrass (*Sorghastrum secundum*). Lopsided indiangrass is a locally abundant groundcover graminoid in the Florida dry prairie on the Avon Park Air Force Range in south-central Florida. A seed viability study indicated that only 1% of the planted seeds survive to adulthood. A seed-stalk study indicated that as the time since fire increases, the percentage of plants producing stalks increases. Burning from March through mid-June results in the greatest aboveground biomass production. A RAMAS/Stage model was developed based on the data collected. The model suggests that recurrent biennial fires may cause populations to decline. A heterogeneous burn history of 2-4 year fire-return interval appeared to maintain populations. Based on the low dispersal capabilities of *S. secundum*, the model predicts that it would take approximately 50 years for a single plant to propagate only 33 m across suitable landscape. Therefore, it is extremely important to prevent local extirpation of existing populations. These may be important factors to consider in native groundcover restoration efforts.

INTRODUCTION

The precise pre-European settlement composition of Florida's longleaf pine and prairie plant communities and frequency of natural fire may never be known. However, evidence continues to mount that historically these communities were dominated by grass and grass-like species rather than shrubs or woody vegetation. Although natural fires could occur at any time during the year, natural large-scale fires probably occurred in May or June, toward the end of the dry season, on a 2-5 year fire-return interval (Myers and Ewel 1990).

The current shrub-dominated condition of many of Florida's pinelands and prairies is believed to be due in part to fire management and grazing practices introduced by European settlers. Domestic cattle have been grazing in Florida since the 1500s. In the 1850s, cattle producers began to alter the fire regime, subjecting large areas of central Florida to biennial winter burning. Typically, livestock had immediate access to freshly burned areas and would graze heavily until another area was burned. Fire suppression and winter-season burning combined with long-term livestock grazing have been shown to reduce grass cover and favor shrubs and woody plants (Robbins and Myers 1992).

Because of the amount of grazing and methods of land management that occurred in central Florida from the 1860s until the 1970s (DeVane 1983), one would presume that pre-settlement grass populations were higher than they are today. Indeed, grass species that are preferred year-round by cattle currently compose a very small portion of the annual biomass produced in typical longleaf pineland and prairie plant communities. As interest in ecosystem restoration in the southeast continues to increase (Brockway et al. 2005) it will be important to understand how to maintain and increase the health and diversity of the herbaceous groundcover.

Lopsided indiangrass *Sorghastrum secundum* (Elliott) Nash, is one example of a long-lived perennial grass that has likely been adversely impacted by fire and grazing practices. *S. secundum* is locally abundant in the pine savanna-flatwoods/dry prairie region of south-central Florida. It is one of the species that is grazed by cattle year-round. Despite the fact that the genus is found in the eastern U.S., the Caribbean, South America, and West Africa, it has received little study (Davila 1988). This paper describes efforts to begin to understand the response of *S. secundum* to fire at different times of year and at varying intervals, with emphasis on the effects of frequent fire return on *S. secundum* populations.

Because the species has been poorly studied, it was first necessary to determine some of its basic characteristics. The author observed that *S. secundum* consistently matures seed on October 1, plus or minus 15 days, and that seed stalk production increases as time since fire increases. I am unaware of any other grass species' reproductive life cycle that follows this pattern in this pyrogenic ecosystem.

To further understand this species, studies were conducted to follow (1) seed survival up to two years after planting, (2) seed stalk production and plant density in relation to time since fire, and (3) plant biomass production after burning in different months. With this information, it was possible to develop a basic model to predict some effects of short fire-return intervals on populations of the species.

METHODS

Seedling Survival

This seed study was designed to examine seedling emergence and survival. In October of 1992 and 1993 seed was obtained from sites at the Avon Park Air Force Range by hand or with a tractor-mounted flail vac seed harvester. Two planting sites were chosen. Both sites have Myakka fine sands. The first site was developed in 1992 as a native seed restoration project. The site was chopped in June and then chopped again at 90 degrees in August 1992. Sixty-two 1-m^2 plots were hand cleared. In October and November 1992, 2,000 freshly harvested seeds were broadcast on each plot and raked into the soil to a depth of 3 cm.

The second site was disked and leveled in August 1993. Seventy-two 0.5-m^2 plots were established. Two planting methods were used. In October and November of 1993, seed was either broadcast on each plot or broadcast and then raked into the soil to a depth of 3 cm. We recorded seed germination one month after planting and seedling survival one and two years after planting.

Seed Stalk Production Study

This study examined plant density and seed-stalk production at different post-fire intervals, with and without livestock grazing. Nine sites were selected throughout the Avon Park Air Force Range, Florida. Two sites were located in exclosures where grazing was stopped in 1983. A third site became an exclosure in 1994. The remaining six sites were subjected to the typical grazing regime at Avon Park. All sites were sampled twice, once in October 1994 and once in October 1995. At time of sample, the days since fire ranged from 137 days to 2,132 days (0.4 to 5.8 years).

At each site, 50 1-m^2 plots were set up by randomly throwing a 20 cm pin and placing the plot frame with the pin on the NW corner of the frame. In each plot the number of plants with and without seed stalks was recorded. The height of the tallest seed stalk in the plot was measured. These data were then compared to the post-fire interval and whether or not cattle grazed the site.

Biomass Production Study

This study measured total annual above-ground biomass production following a fire at different times of year. The site on which this study was conducted had not been grazed for at least 40 years. Each month for two years, two 6x6 m plots were set up and the following procedure was followed. All *S. secundum* plants in each plot were tagged. The two plots were then burned. In one plot all plants were clipped at 30, 60, 120, 180, 240, and 300 days after the burn. The mass of the plant material at each time point was recorded in grams. In the second plot plants were clipped only after 300 days, and the mass was determined. Rainfall was recorded from the date of burn through the final clipping.

RAMAS/Stage Model

The RAMAS/Stage Generalized Stage-based Modeling for Population Dynamics software program (Ferson 1991) was used to model the effect of frequent fire on *S. secundum* populations. I incorporated information about seed-to-adult survival and field data collected on the plant density and percentage of reproductive plants in post-fire situations. Fire was treated as an environmental fluctuation. In a second part of the model, it was assumed that seed dispersal would be limited by seed-stalk height. I input data on reproductive plant density and stalk height to model population expansion over time.

RESULTS

Seedling Survival

Seed emergence rates varied from 90% (1,800 plants per m^2) in 1992 to 20% (400 plants per m^2) in 1993. At site 1, first year survival rates were approximately 4% (80 plants per plot). Second year survival rates were approximately 1% (20 plants per plot). At site two, the first year survival rate was 1.1% (Table 1).

Seed Stalk Production

As time since fire increased, the number of plants without stalks decreased linearly ($R^2 = 0.83$) (Fig. 1). For sites that were not burned between sampling, there was a significant decrease in percentage of plants without stalks ($F = 7.21$, $p = 0.04$) (Fig. 2). As time since fire increased the number of stalks increased linearly ($R^2 = 0.47$). Statistically, this relationship is not very strong. This may be because the data set is small and because large fire-interval differences exist among the sites. For example, in October 1995 sites varied from 679 to 1409 days since fire. Of the unburned sites, only site 1, the unburned site with the longest time since fire (2.8 years), had a decrease in percentage of reproductive plants in the second sampling.

For sites that were burned between sampling, there was a significant increase in the percentage of plants without stalks ($F = 488.00$, $p < 0.00$) (Fig. 2). After burning, the number of reproductive plants decreased based on linear regression ($R^2 = 0.98$).

In general, there was no statistically significant relationship between plant density and number of days since fire ($F = 0.05$, $p = 0.83$) (Fig. 3). However, if sites are separated into two groups, unburned between sampling, and burned between sampling, the results are different.

Of the sites that were not burned between sampling, sites 1, 3, and 7 had almost no change in plant density. At site 9, density decreased from 3.5 plants/m^2 to 2.7/m^2. For sites that were burned between sampling, plant density decreased by as much as 50% (Fig. 4). Only one site, site 5 (which has been a cattle exclosure since 1983), remained unchanged post fire. The other cattle exclosure site, site 4, had the smallest decrease in density (29%) of the burned sites. For grazed, burned sites, there was a significant decrease in plant density in the year after burn

Table 1. Site 2 first year survival rates by planting method.

Treatment	Number of Plants/Plot	% Survival After 1st Year
Raked	5.8	1.07
Scattered	5.0	1.00

See Pfaff and Gonter (2000).

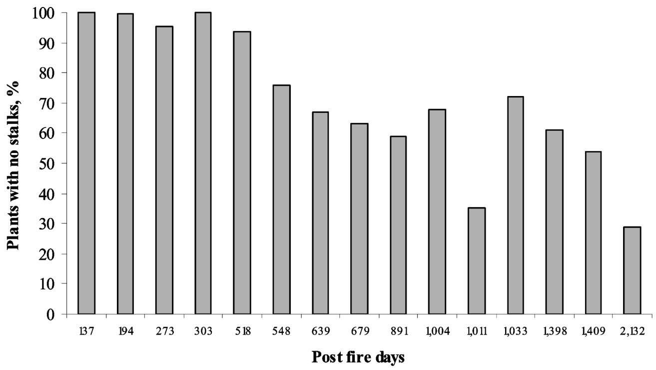

Figure 1. Percentage of plants with no stalks by number of post-fire days.

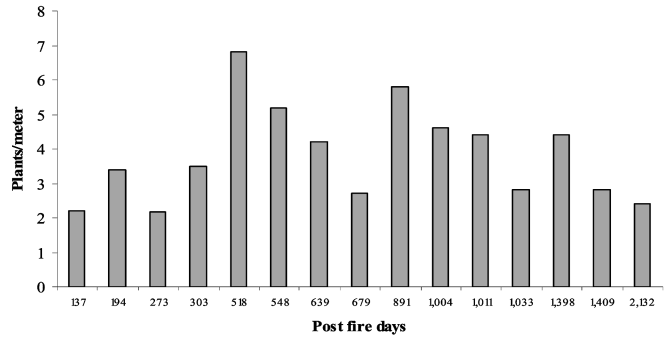

Figure 3. Plant density by number of post-fire days.

(F = 7.28, p = 0.036) and a positive linear relationship between plant density and number of days since fire (R^2 = 0.55).

The average height of the tallest seed stalks was 1.41 m. Tallest stalk height showed no correlation to post-fire interval.

Biomass Production

In both years, the plants produced the most biomass after a spring burn (Mar-Apr). Total biomass production declined with May through September burning. Both biomass production and the rainfall were higher after the January through June burns of 1992 than the same period in 1993. This study did not investigate whether season of fire affects seed stalk production or plant density.

RAMAS/Stage Model

The RAMAS/ stage is a generalized stage-based model for population dynamics (Ferson 1991). The graph presented in this paper results from entering parameters into the software program based on the seed stalk production and density data from site 8. At this site there were 5.2 plants/ m^2 in 1994 and after a burn there were 3.4 plants/ m^2 in 1995. The model predicted plant population response under fire-return intervals of 2 and 3 years. In the two-year burn-interval model, a simulated burn in 1997 dropped the density to 2.0 plants/ m^2 in 1998. A second simulated burn, two years later, resulted in a density of 1.3 plants/ m^2. In the model a consistent 2-year fire-return interval would extirpate this population by 2005 (Fig. 7).

A simple seed-dispersal model was developed using the data on average stalk height and the recognition that the seed has no wind dispersal mechanisms. I assumed simple dispersal because the seeds are relatively heavy and have awns that dig into soil or litter (personal observation). Using the characteristics of stalk height and seed weight and the 1% seedling survival, the model predicts that in 50 years a plant population could expand across the landscape a distance of 33 m.

DISCUSSION

Seedling Survival

Study results indicate that seed viability is fairly high, ranging 20-90%. Nevertheless, only approximately 1% of the seedlings survived. This 1% survival rate was used in the RAMAS/stage model. Pfaff and Gonter (2000) also reported significant losses after the first year. The study did not examine the potential interaction between climatic influences and seed viability or survival.

Seed Stalk Production

This study strongly suggests that seed-stalk production in lopsided indiangrass is related to the time since

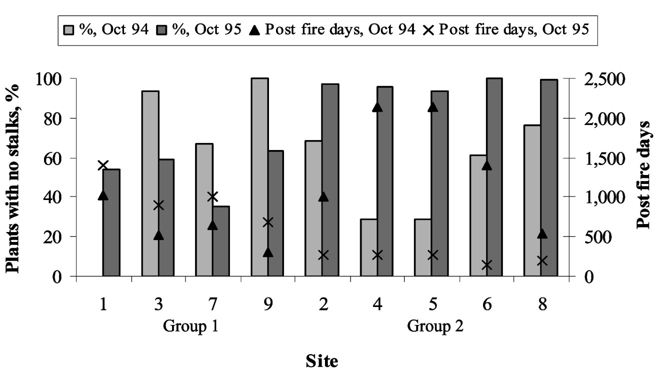

Figure 2. The percentage of plants with no stalks in October 1994 and October 1995 by site with number of post-fire days at each sampling. Group 1 sites were not burned during the intervening year (i.e., burn interval increased). Group 2 sites were burned during the intervening year (i.e., burn interval decreased).

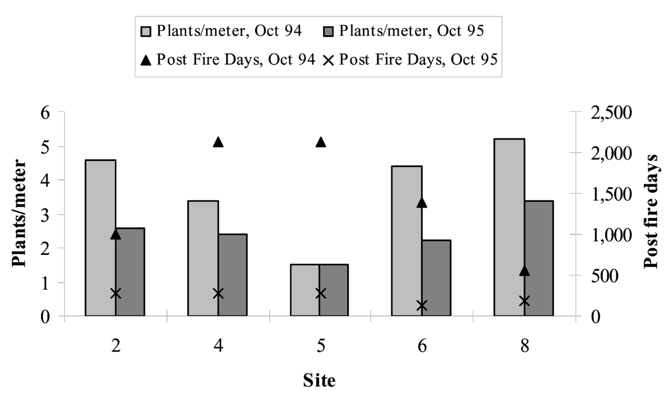

Figure 4. Plant density in October 1994 and October 1995 by site with number of post-fire days at each sampling and site. Only group 2 sites (burned during the intervening year) are shown.

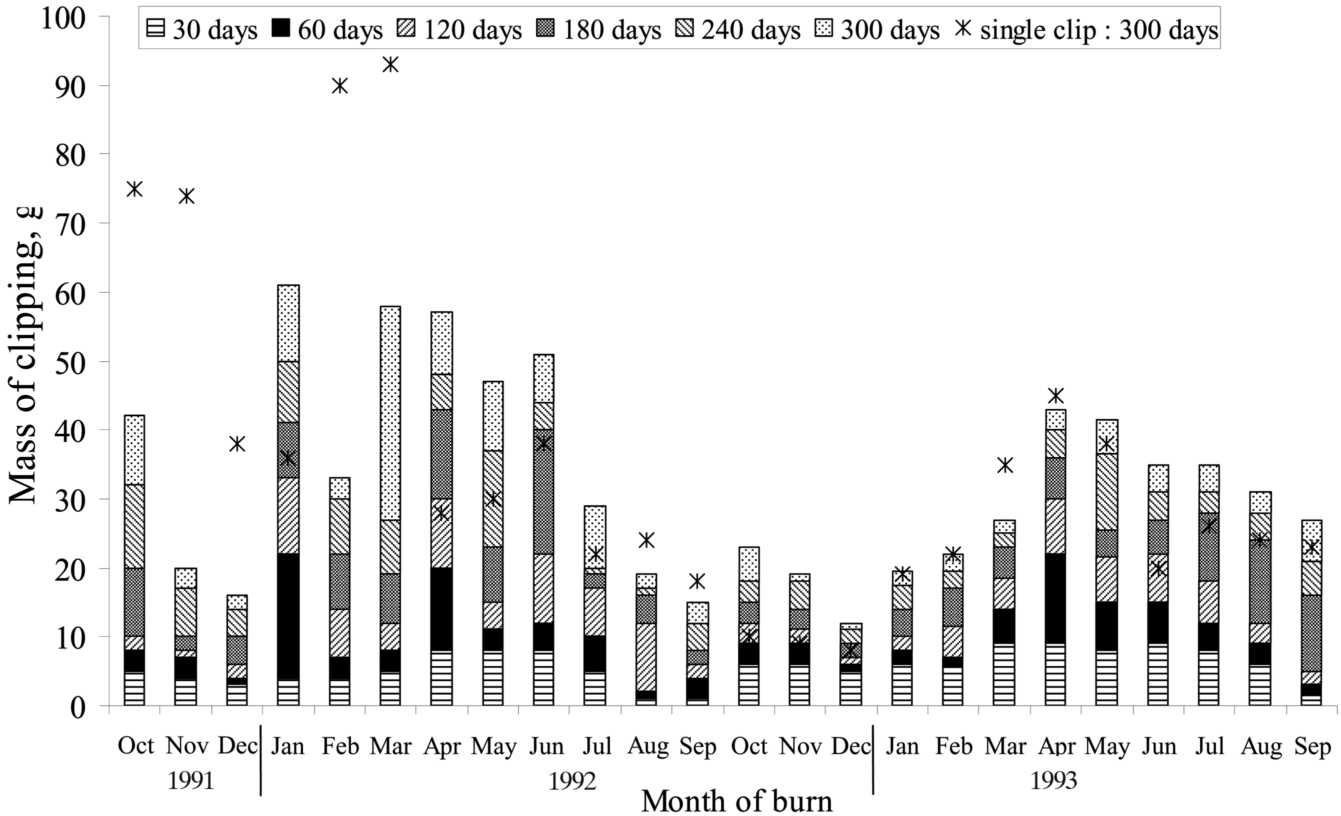

Figure 5. Cumulative clipped mass, in grams, of *Sorghastrum secundum* plants by the month the study area was burned. Number of days is time since burn, with ungrazed plants clipped at 300 days post-burn.

fire. Plants at sites burned within one year of sampling produced almost no stalks. At 2.8 years after a fire, every plant at site 1 had stalks. The following year, 3.8 years after fire, only about half the plants had stalks. This may indicate a peak in stalk production at around 3 years after fire. However, at two sites that had not been burned for almost 6 years, 70% of the plants had stalks. The stalk-productivity relationship to time since fire would need further study to determine the maximum time after fire for which plants remain productive. A short fire interval is most likely to adversely influence the number of plants. Plants at sites that are burned every 2 years or less will produce fewer seed stalks.

Fire-return interval also influences plant density. A consistent two-year fire-return interval will likely depress plant density. This may be because plants are killed by fire and because seed-stalk production is depressed. The study suggests that grazing interacts with fire frequency and climatic effects to further influence plant density and seed stalk production. The lack of an overall correlation between time since fire and plant density indicates that other site specific characteristics and site history, factors not measured in this study, also influence plant density. For the RAMAS/stage model, this study provided the average number of plants/ m^2 across a landscape and the average height of the tallest plant stalk, pre-and post-fire.

Biomass Production

The data indicate a seasonal nature in biomass production. Plants that burned from July through February did not produce as much biomass as plants burned from March through June. For optimum productivity, the best time for burning is from March to May.

Based on personal observation, I believe that further investigation would reveal that low temperatures and high rainfall in the period shortly after the burn depress plant productivity and survival. *S. secundum* is freeze sensitive, especially for approximately 30 days after it has been burned (personal observation). It tends to remain dormant when nighttime temperatures are below 55º F (personal observation). During this study, a freeze occurred in December 1991and December 1992. Additional freeze events occurred between December 1992 and March 1993. In some cases the combination of fire and frost killed or severely stunted the growth of plants. It was also observed the combination of fire and subsequent flooding shortly following the burn, which occurred in August of 1992, had a similar negative impact on the plants.

RAMAS/Stage Model

This description of *S. secundum* population modeling results is offered as a point of discussion to stimulate researchers and particularly land managers to think about the benefits of longer fire-return intervals for this plant, and to consider the slow rate at which this plant will likely colonize or re-colonize an area. These studies represent only the beginning of understanding the life history, reproductive strategies, and fire adaptation of *S. secundum.* The model suggests that burning at a 3-year interval or a

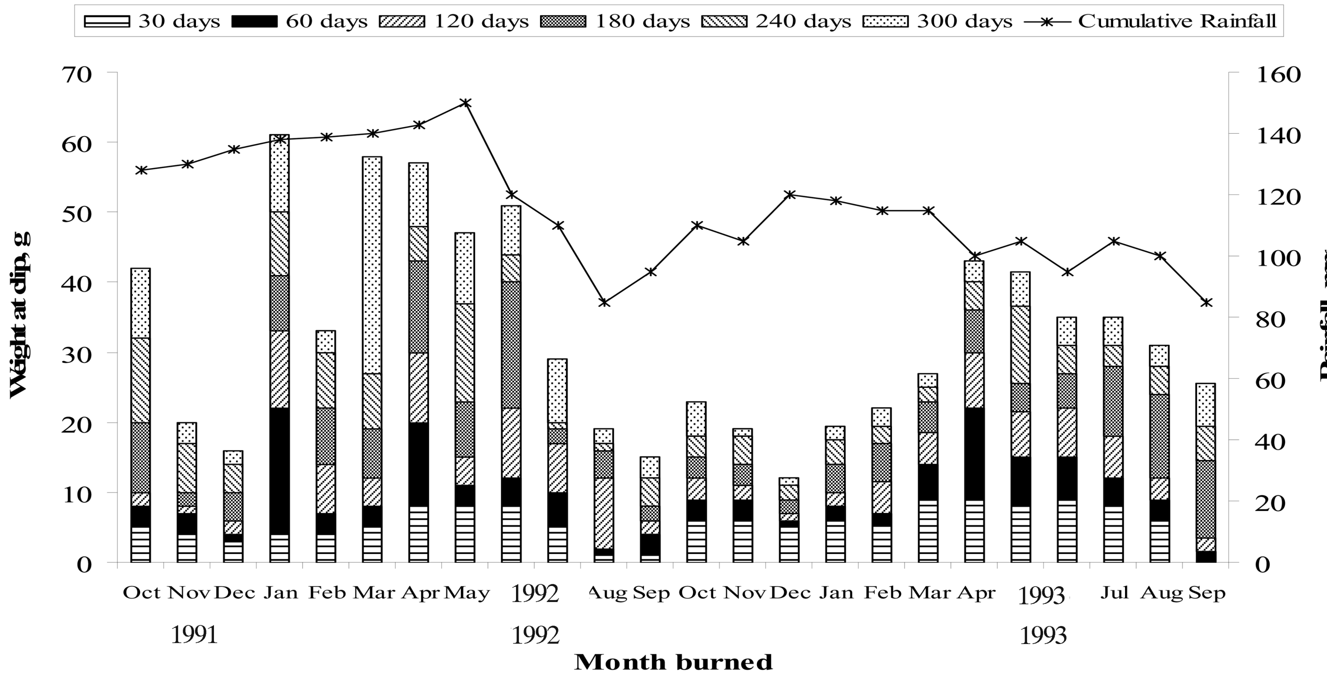

Figure 6. Cumulative clipped weight, in grams, of *Sorghastrum secundum* plants by the month the study area was burned and monthly rainfall, in mm. Number of days is days since burn.

mix of 2, 3, and 4 years would result in a stable population of *S. secundum.* To test and refine the model, it would be necessary to simulate the modeled scenarios in the field.

CONCLUSION

Over some long period of time (presumably thousands of years) *Sorghastrum secundum* has adapted to the soils, topography, and pyrogenic-climatological conditions of peninsular Florida in a different way from many other indigenous flora. Rather than taking advantage of bare soil and maximizing seed production in the fall after a fire, it instead produces more seed in subsequent years and has a seed with awns that can drill through litter. Rather than dropping seed under certain weather conditions, it has a photoperiod-based adaptation. The seed then presumably waits for the appropriate conditions to germinate. The studies reported here suggest that there is an optimal burning season and fire interval that best perpetuates this species. Controlled cattle grazing has the potential to increase annual biomass production; however, it could have a negative impact on seed-stalk production. Land managers who have a long term goal of perpetuating a broad and varied ecosystem of flora native to Florida should consider managing for this species.

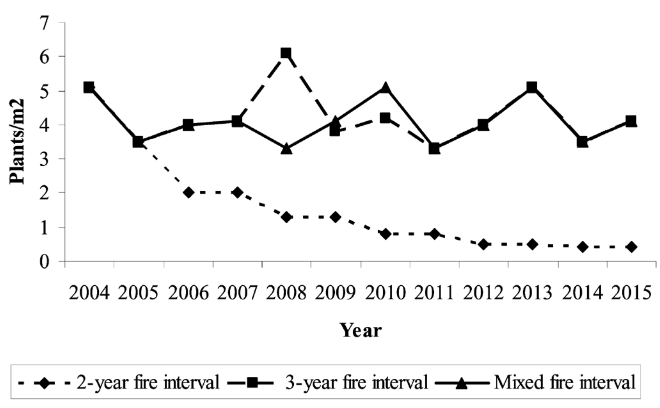

Figure 7. *Sorghastrum secundum* density model simulating various fire return intervals.

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