THE EFFECTS OF BURN FREQUENCY ON THE DENSITY OF SOME GRASSHOPPERS AND LEAF MINERS IN A FLORIDA SANDHILL COMMUNITY

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ABSTRACT

The frequency and intensity of wildfires are known to affect plant diversity and growth. We examined whether the periodicity of burning affected the density of insect herbivores. A Florida sandhill community in West-Central Florida was divided into ten sections, two sections of which each had a different periodicity of burning: one year, two years, five years, seven years, and control (zero years). Each burn cycle had been repeated many times, but all plots had been burnt in the summer of 1996, three months prior to the onset of our study. We censused the most common herbivores of the low-growing herbs: grasshoppers, and the most common herbivores of the trees: leaf miners, every month for a year. Grasshoppers were counted on two common flowering plants in the community, *Carphephorus corymbosus* (Nutt.) Torrey & A. Gray, and *Eriogronum tomentosum*, Michaux. Leaf miners were counted on the two most common trees, *Quercus geminata*, Small, and *Quercus laevis*, Walter. Grasshopper densities were significantly higher on the flowering plants in the 1 year, 2 year, and 5 year burned plots than on the 7 year or control plots. Leaf miner densities on the oaks were not significantly different between treatments. The differences in grasshopper densities could be due to a higher density of forbs and the occurrence of healthier forbs in the more frequently burned plots.

Key Words: burn frequency, Florida sandhill, oak trees, herbaceous plants, herbivore densities

RESUMEN

Es bien conocido que la frecuencia e intensidad de los incendios afectan el crecimiento y diversidad de las poblaciones de plantas. En este estudio se examinó si la frecuencia de los incendios afecta la densidad de insectos hervíboros. Una comunidad de dunas de arena en la parte centro-occidental de la Florida se dividió en diez secciones y en cada dos secciones se probaron las siguientes periodicidades de incendio: cada uno, dos, cinco, siete y cero (testigo) años. Los ciclos de incendio ya habían sido repetidos en varias ocasiones anteriores, pero todos los lotes fueron incendiados en el verano de 1996, tres meses antes de comenzar este estudio. Cada mes durante un año se hizo un censo de saltamontes (grasshoppers), los insectos hervíboros más comunes de las hierbas de porte bajo, y de minadores del follaje (leaf miners), los más comunes en los árboles. Los saltamontes se contaron en dos plantas con flor comunes en el sitio experimental, *Carphephorus corymbosus* (Nutt.) Torrey & A. Gray, y *Eriogronum tomentosum*, Michaux. Los minadores se contaron en las dos especies de árboles más comunes, *Quercus geminata* Small, y *Quercus laevis* Walter. Las densidades de saltamontes fueron significativamente más altas en las plantas con flor en los lotes incendiados cada uno, dos, y cinco años, que en los lotes incendiados cada siete años o en los que no fueron incendiados. Las densidades de minadores en los robles no variaron entre tratamientos. Las diferencias en las densidades de saltamontes podrían deberse a una mayor densidad de "forbs" (plantas herbáceas aparte de gramíneas) o a la presencia de forbs más saludables en los lotes con mayor frecuencia de incendio.

Periodic burning has long been known to be an integral factor in maintaining plant diversity. Fire removes species which would otherwise smother and prevent the growth of perennial grasses and herbaceous plants. Without fire, grass vegetation can be replaced by woody plants (Evans 1984). In Florida, spring burnings are an important tool in maintaining healthy sandhill communities. Sandhill requires frequent, low intensity, fires in order to thrive and the natural burn frequency in these communities is thought to be between 1 and 10 years (Menges and Hawkes 1998). Fire stimulates pine cones to release their seeds, furthermore, seeds of many species depend on the heat of fire to germinate. Fire can also protect longleaf pines from disease caused by fungus (Whelan 1995). In addition, the nutrients of the burned vegetation penetrate the soil with rainwater, providing nutrients for the remaining plants (Kozlowski and Ahlgren 1974).

Periodic burning may directly and indirectly affect the density and richness of insect herbivores by killing insects and by affecting the richness of the flora and the quality of the vegetation, which can improve subsequent to burning because of the nutrient flush (Bergeron and Dansereau 1993, Mutch 1970). In this study, the effect of fire periodicity on herbivorous insects was observed in study plots which had been subjected to controlled burning at various intervals: seven years, five years, two years, one year and unburned (control).

STUDY SYSTEM

The study system was a typical Florida Sandhill community dominated by longleaf pine, *Pinus palustris* Mill. Deciduous oaks, such as turkey oak, *Quercus laevis* Walter, and sand live oak, *Quercus geminata* Small, underlie the pines, and wiregrass, *Aristida stricta* Michaux, is the primary ground cover (Myers and Ewel 1990). Turkey Oak is often stunted, up to 20m tall, but usually smaller, with long, oblong leaves with three, five, or seven pinnate lobes. Sand live oak is a shrub or small to medium-sized tree. Leaves are oblong, to elliptic, thick, and strongly revolute. Other plants common to this landscape include: *Carphephorus corymbosus* (Nutt.) Torrey & A. Gray, (Deer tongue), *Eriogonum tomentosum* Michaux (Dog tongue or Wild Buckwheat), and *Serenoa repens* (Bartr.) Small (Saw Palmetto). Deer tongue is a perennial herb (Compositae) with stems up to one meter tall and with purple/lilac paint brush flowers and lower spatulate leaves spread upon the ground. Dog tongue is a member of the Polygonaceae and exhibits small white or pinkish flowers in terminal and subterminal clusters.

MATERIALS AND METHODS

The study was conducted in the 200 ha University of South Florida Ecological Research Area in Hillsborough County, Florida (28.05'N, 82.20'W) (see McCoy 1987 for details), which contains two one hectare replicates of five burn treatments: unburned (29 years since the last fire), one, two, five, or seven years. All the burning regimes began in 1976, except the seven year plots which began in 1975. By 1996 all regimes had run for at least twenty-one years. The seven year plots had been burned four times, the five year plots five times, the two year plots eleven times, and the one year plots twenty-one times. The control plots had not been burned in at least 29 years. In 1996 every plot received a burn treatment in July. Any subsequent differences in herbivore density between plots in 1996 and 1997 would then be attributable to the history of burn, not the year that the plots were last burned. This provided a good opportunity to examine the influence of fire on herbivorous insects.

Four plant species were examined for herbivores on each plot: two low-lying understory plants and two oak species. The understory species observed were *Carphephorus corymbosus* (Deer Tongue) and *Eriogonum tomentosum* (Dog Tongue), and the trees were *Quercus geminata* (Sand Live Oak), and *Quercus laevis* (Turkey Oak).

The number of herbivores was counted monthly on each plant species with a variation of counting technique for each plant species. Counts consisted of visual counts of 500 leaves for each of the flowering species (about 50 plants worth), and 500 leaves for one oak tree per plot. Most of the herbivores were sessile or unwinged juveniles that did not fly away during censuses. Counts were made every month for 13 months, starting in October, 1996 and ending in October, 1997. No fires were set in the plots during this period. Each month a count was performed, a random selection of plants was counted in each plot. Densities of each insect species were summed on each plot for the year. Comparisons of burn treatments on insect densities were then made using a one-way ANOVA on untransformed total counts, which were normally distributed.

The density of dog tongue and deer tongue on each of the plots was also determined. This was done by taking a 50 meter rope and counting the number of each of these two plant species that it touched as it cross-sected the plot. Unfortunately, it was not possible to collect data on plant quality in this study.

Results

In this study the most common visually censused herbivores of the flowering plants were two species of grasshoppers belonging to the genera *Melanoplus* and *Aptenopedes*. Both species had one generation a year at our study sites with wingless nymphs appearing in the spring and adults feeding until early fall. The most common herbivores of the oaks were species of the leaf mining genera *Buccalatrix, Stigmella, Cameraria,* and *Stilbosis* (Stiling and Simberloff 1991). These leaf miners were multivoltine and new mines could be found throughout the year. We therefore focused our study on these species.

In general, grasshopper densities on the flowering plants were significantly affected by burn frequency with higher numbers in one, two and five year plots than in the seven year plots or unburned controls (Fig. 1). However, densities of leaf mining insects on oaks were not affected by burn frequency (Fig. 2). There was no significant difference in plant density of dog tongue or deer tongue between the treatments (dog tongue: $F_{4,5} = 3.547$, $P = .099$; deer tongue: $F_{4,5} = 1.820$, $P = .263$). However, there was a trend for the highest densities to occur in the more frequently burned plots (Table 1), and lack of significance may have been due to low statistical power (n = 2). This trend was not so pronounced for dog tongue.

Discussion

Grasshopper densities on both deer tongue and dog tongue were the highest in the one year, two year and five year plots, and lowest in the seven year and control plots. This could be caused by at least two factors. First, the host plants could simply be less frequent in the seven year and control plots, than in the one, two or five year plots. Second, host plant quality could vary between plots. Although there was no significant difference in plant density between plots, the trend was for lower plant densities in less frequently burned plots. Although we do not have data on plant quality, it is known that fire replenishes nutrients by burning ground cover and allowing nutrients to quickly seep into the soil (Harvey 1994, Kozlowski and Ahlgren 1974, Maclean and Wein 1977). Protein content of prairie grasses has been shown to be higher on burned

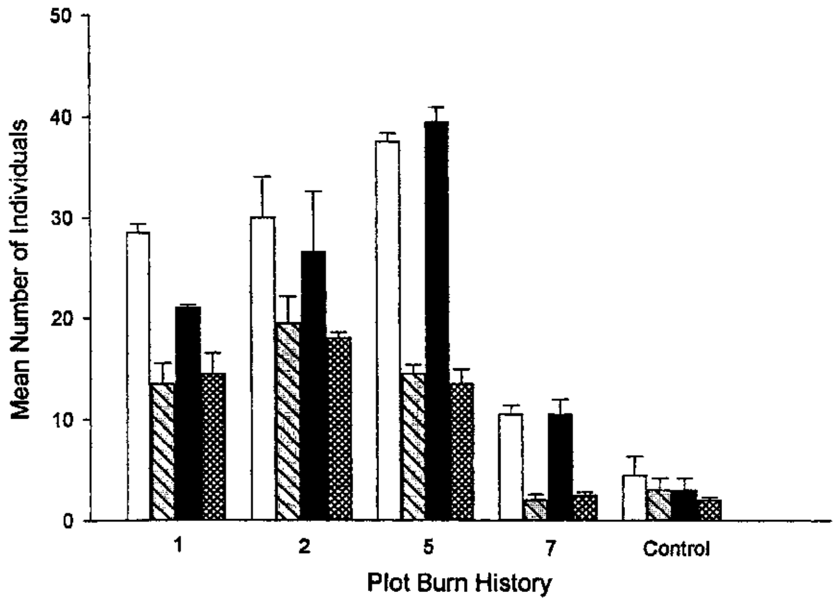

Fig. 1. Number of grasshoppers on plots with different burn periodicities (1 = 1 year, 2 = 2 years, 5 = 5 years, 7 = 7 years, control = never burned). Means and standard errors shown. [open bar] = *Melanoplus sp.* on deer tongue, *Carphephorus corymbosus*. One way ANOVA: $F_{4,5} = 12.908$, $P = .008$. [hatched bar] = *Aptenopedes sp.* on deer tongue. One way ANOVA: $F_{4,5} = 7.374$, $P = .025$. [solid bar] = *Melanoplus sp.* on dog tongue, Eriogronum tomentosum. One way ANOVA: $F_{4,5} = 7.911$, $P = .022$. [cross-hatched bar] = *Aptenopedes sp.* on dog tongue. One way ANOVA: $F_{4,5} = 13.05$, $P = .007$.

than on unburned areas (Owensby et al. 1970, Smith and Young 1959). The plants in the more frequently burned (one year, two year and five year plots) appeared to us to be healthier than those in the seven year and control plots because they were a richer green color, the leaves were more abundant and appeared to be in better condition.

Leaf miner densities on the trees were unaffected by burn frequency, suggesting either that any post-fire nutrient pulse was not great enough to affect tree foliage quality or that trees behave differently to ground cover. In this regard, it is interesting that McCullough and Kulman (1991) found that young jack pine trees on burned areas had lower foliar nitrogen than trees on unburned sites, and that jack pine budworm, *Choristoneura pinus* Freeman, survival was related to foliar nitrogen concentration.

We can compare and contrast our results to the few other studies that have addressed the effects of burning herbaceous vegetation on insect densities. At the University of Missouri Tucker Prairie Research Station, Cancelado and Yonke (1970) found statistically greater numbers of Hemiptera and Homoptera on burned areas over unburned areas. Similarly, Rice (1932) found that many phytophagous insects quickly returned to burned areas because the vegetation grew more rapidly there. A study in a prairie grassland in Kansas found that the biomass of herbivores on burned land was significantly higher than on the unburned land and that most of the difference was caused by increased abundance of grasshoppers (Nagel 1973). Finally, a study of postfire insect succession in southern California chaparral indicated that due

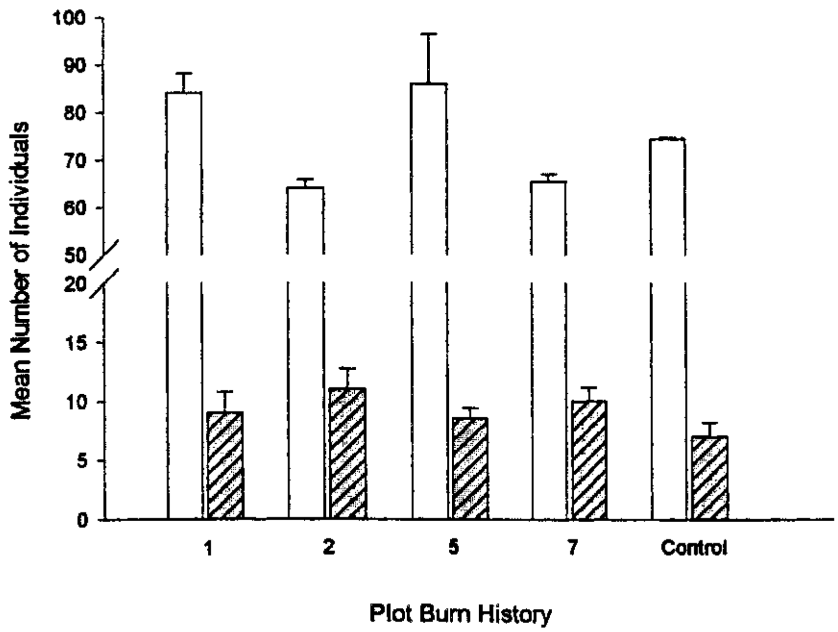

Fig. 2. Number of leafminers on plots with different burn periodicities (1 = 1 year, 2 = 2 years, 5 = 5 years, 7 = 7 years, control = never burned). Means and standard errors shown. ▭ = leafminers on sand live oak, *Quercus geminata*. One way ANOVA: $F_{4,5} = 1.330$, $P = .274$. ▨ = leafminers on turkey oak, *Quercus laevis*. One way ANOVA: $F_{4,5} = .407$, $P = .798$.

to increased plant richness and diversity after chaparral fire, the insect richness and diversity was also higher (Force 1981). These four studies, plus the present one, suggest that fire increases the density of some insects, particularly grasshoppers, on herbaceous vegetation and that increased plant quality may be the cause. Of three exceptions that we could find, one was a study by Bulan and Barrett (1971) who found Coleoptera, Homoptera, Hemiptera, and Diptera biomass to be significantly lower in burned oats grassland than similar unburned areas, probably because of decreased available producer energy and detritus. However, as Nagel (1973) points out, in natural systems burning is not likely to decrease available producer energy nearly as much as it does in annual plant monocultures. Another exception was a study of prairie grasslands in Kansas which showed forbs were killed by frequent fires and thus the densities of grasshoppers which fed on them were reduced in frequently burned plots, though the densities of grass-feeding grasshoppers were not (Evans 1984). This contrasts with our study where both the density of forbs and grasshoppers were elevated by fire. In does indicate, however, as Evans (1984) suggested, that grasshopper density can be intimately linked to forb density. Finally, a study by Porter and Redak (1997) showed reduced grasshopper density and biomass following spring burns in California, again because host plant densities were reduced. This again is the opposite to our study where the density of the forbs was increased by burning. Taken as a whole, these studies and our results suggest that frequent fire tends to increase the density of grasshoppers as long as it does not kill their host plants outright. This may

TABLE 1. DENSITY OF DEER TONGUE AND DOG TONGUE PER 50M TRANSECTS ON TREATMENT PLOTS WITH DIFFERENT BURN FREQUENCIES (MEANS AND STANDARD DEVIATION SHOWN).

Burn	Plant species	
Frequency years	Deer tongue	Dog tongue
1	35.0 + 21.2	15.2 + 4.9
2	21.5 + 5.0	14.5 + .7
5	25.0 + 21.5	10.0 + 2.8
7	4.0 + 1.4	5.0 + 2.8
Unburned	6.5 + 2.1	7.0 + 4.2

be because of increased plant quantity and quality due to the burns or, it may be due to lower chemical defense content of the plants. The reasons for the collapse in grasshopper densities between the 5 and 7 year burn regimes are not yet clear.

ACKNOWLEDGMENT

We would like to thank Henry Mushinsky and Earl McCoy whose maintenance of the fire plots at the University of South Florida made this research possible. This research was performed as part of the senior author's undergraduate honors requirements at the University of South Florida.

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