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Herb-layer response to burning in pine flatwoods of the lower Coastal Plain of South Carolina[1]

Frank S. Gilliam[2]
Division of Biology, Kansas State University, Manhattan, Kansas 66506
and
Norman L. Christensen[3]
Department of Botany, Duke University, Durham, North Carolina 27706

GILLIAM, F. S., AND N. L. CHRISTENSEN (Div. Biol., Kansas State Univ., Manhattan, KS 66506, and Dept. Bot., Duke Univ., Durham, NC 27706). Herb-layer response to burning in pine flatwoods of the lower Coastal Plain of South Carolina. Bull. Torrey Bot. Club 113:42–45. 1986.—Cover of herb-layer species was estimated in flatwoods plots that received either no fire, winter fire, or winter fire followed by late summer fire. Cover and species richness were significantly higher in winter-burned areas compared to either unburned or summer-burned areas. Causes of these differences appeared to be related to seasonal differences in post-burn soil nutrient status.

Key words: vegetation, Atlantic Coastal Plain, canopy trees, understory shrubs, fire treatment

The herb layers of southeastern Coastal Plain flatwoods are generally sparse and species poor (Hodgkins 1958; Moore *et al.* 1982; Abrahamson 1984). This is a consequence of shading by taller shrubs (Lewis and Hart 1972) and accumulation during interfire periods of substantial amounts of strongly acid pine litter (Hodgkins 1958). Both herb cover and richness have been reported to increase following fire in these communities (Lewis and Harshbarger 1976; Christensen 1981). These increases have been attributed to increased irradiance owing to shrub removal and increased soil fertility in these nutrient-limited ecosystems (Wells *et al.* 1973). McKee (1982) found that increased availability of phosphorus was particularly important following fire in flatwoods.

Little is known about the effects of variation in season of burning on herb response. Lewis and Harshbarger (1976) reported on the long-term consequences of the application of several different fire regimes, including chronic summer and winter fires. We report here on the status of herb communities in unburned flatwoods, and flatwoods 1 to 3 years after winter fire and a combination of winter followed by summer fires.

Materials and Methods. STUDY AREA. This study was done in Watershed 77 (WS77) of the Santee Experimental Forest, Francis Marion National Forest, Berkeley County, South Carolina, USA. This watershed occupies 160 ha of relatively flat terrain and is traversed by a small creek. The climate in the area is humid mesothermal (Trewartha 1954) with mild winters and warm, moist summers. Mean monthly minimum temperatures for January and July, respectively, are 4 and 20°C and mean monthly maximum temperatures are 12 and 32°C.

Soils of WS77 are clayey, mixed, thermic, vertic Aquults of the Bayboro, Bethera, Carolina, Meggett, and Wahee series. They are strongly acid and have low base saturation (see Richter 1980 and Gilliam 1983). These soils are poorly drained as a consequence of argillic horizons high in montmorillonite. They are markedly gleyed in low-lying areas and distinctly mottled in upland areas.

The vegetation of the study area is characteristic of Atlantic Coastal Plain pine-dominated flatwoods (Christensen 1985). Loblolly pine (*Pinus taeda*) was the dominant overstory tree (Basal Area (BA) = 23.8 $m^2 \cdot ha^{-1}$). Other canopy trees included *Pinus palustris* (BA = 5.5 $m^2 \cdot ha^{-1}$), *P. echinata* (BA = 0.52 $m^2 \cdot ha^{-1}$), *Liquidambar styraciflua* (BA = 1.30 $m^2 \cdot ha^{-1}$), *Nyssa sylvatica* (BA = 0.81 $m^2 \cdot ha^{-1}$), and scattered individuals of *Quercus stellata, Q. nigra,* and *Acer rubrum.* Un-

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[2] Current address: Dept. Environ. Sci., Clark Hall, University of Virginia, Charlottesville, VA 22903.

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Table 1. Top 20 important herb-layer species of WS77 and relative cover (%).

Species	Relative Cover (%)
Andropogon virginicus[a]	11.8
Liquidambar styraciflua	8.2
Ilex glabra	6.4
Myrica cerifera	6.4
Vaccinium tenellum	5.9
Rubus betulifolius	4.6
Lonicera japonica	4.2
Andropogon ternarius	3.5
Festuca elatior	3.2
Vitis rotundifolia	2.5
Andropogon scoparius	2.5
Rhus copallina	2.0
Lespedeza sp.	1.6
Rhus radicans	1.5
Pinus taeda	1.5
Arundinaria gigantea	1.4
Smilax bona-nox	1.4
Elephantopus tomentosa	1.3
Lyonia ligustrina	1.3
Panicum sp.	1.3

[a] Nomenclature follows Radford *et al.* (1968)

derstory shrubs included *Myrica cerifera, Ilex glabra,* and *Vaccinium tenellum.* In drier localities the herb layer was dominated by *Andropogon virginicus* with a diverse mixture of grasses and forbs (Table 1). Near seeps and stream channels *Arundinaria gigantea* was abundant.

The watershed was divided into 20 compartments of approximately 8 ha each. Fire treatments were applied on a compartment basis. Fire had been excluded from this watershed for at least 10 years prior to the initiation of this study.

TREATMENTS. Nine of the compartments (numbers 3, 5, 6, 8, 9, 10, 13, 15, and 16) were selected for this study to represent a variety of fire treatments. Prior to treatment, five 10 × 10-m quadrats were randomly located (using random numbers and Cartesian coordinates) in each compartment. Within each quadrat every stem > 0.6 cm dbh was identified and censused. Herbs were not sampled prior to treatment. However, given that there were no significant differences among compartments in pre-treatment woody-plant composition or basal area, or in soil characteristics, we assumed that pre-treatment herb communities were comparable. Fire treatment had already been administered to experimental areas in past years, so it was felt that an herb survey of both unburned and burned plots would be sufficient to characterize treatment effects on the herb layer. That is, a pre-burn homogeneity of the herb layer was assumed.

The treatments are summarized in Table 2. Winter fires were set in January and summer fires were set in July. In each case, fires were confined to surface fuels and all quadrats within a compartment were burned.

The herb layer was sampled in two 0.5 × 10 m transects traversing the quadrats at randomly-selected locations during June and July, 1979. Per cent cover was visually estimated for each species (<1-m tall) within these transects and the presence of any other species not in the transects but within the quadrat was noted. Species richness (number of species/quadrat) was estimated from these data.

Results and Discussion. Compared to either unburned or winter- and summer-burned compartments, herb cover was significantly greater in the winter-burned plots, particularly those in their second growing

Table 2. Total number of species per compartment, number of species per quadrat, and cover for the herbaceous layer of nine compartments of WS77. Values in a column followed by the same letter are not significantly different at $p < 0.05$.

compartment	treatment	# species (total)	richness (# spp./quadrat)	cover (%)
8	winter 1979	66	28.0^{ab}	17.1^{bc}
6	winter 1978	63	26.8^{ab}	41.1^{a}
3	winter 1978	62	31.8^{a}	32.2^{ab}
9	winter 1979	59	22.4^{bc}	27.5^{b}
10	unburned	50	18.0^{c}	15.2^{bc}
13	winter 1977	43	14.8^{c}	33.4^{ab}
5	unburned	42	15.0^{c}	17.2^{bc}
15	winter and summer 1977	41	18.0^{c}	17.4^{bc}
16	winter 1977, summer 1978	37	16.0^{c}	12.3^{c}

season following fire (Table 2). Species richness was significantly enhanced in plots burned in the winters of 1979 and 1978, and sampled one and two years, respectively, following burning. However, the compartment sampled three years following a winter fire was not different in species richness from the unburned or summer-burned compartments (Table 2).

Differences in species richness among treatments were reflected in differences in total numbers of species in each compartment (treatment). Highest species numbers were found in compartments sampled one and two years following winter fires. Lower species numbers occurred in compartments receiving no fire or combinations of winter and summer fires (Table 2).

Cover and abundance of woody species in the herb layer (i.e., tree seedlings and shrubs) were not different among treatments. Increased herb-layer richness and cover in winter-burned plots is attributable both to increased abundance of certain herbs found in all plots and to the occurrence of herbs found in these plots and not elsewhere. Taxa in this latter category included *Polygala lutea, P. curtisii, Pterocaulon pychnostachyum, Heterotheca graminifolia, Eupatorium pilosum, Aster* spp., *Andropogon* spp., and *Panicum* spp. These taxa have been described as "fire followers" in other Coastal Plain systems (Lemon 1949; Lewis and Harshbarger 1976).

Although not conclusive, these results appeared consistent with the hypothesis that nutrients limit production in interfire years and immediate postfire increases in production are a consequence of fire-caused nutrient release (Wells *et al.* 1973; Christensen 1977). Christensen (1977) found that available nutrients were increased for only 2–4 months following fire in similar fuel types. Thus, fires at the end of a growing season (i.e., summer fires) may result in nutrient release and loss to leaching before the onset of plant growth in the spring. Nutrients released by winter fires are available when plants are growing (Christensen 1977). If postfire herb response was determined only by microclimatic factors or removal of litter, season of burning would make little difference. Therefore, both post-burn microclimatic change and seasonal differences in fire-caused nutrient release were important in affecting herb response to different seasons of burning.

Comparisons between species richness and total species (per compartment) among treatments reveal further the effects of fire on the herb layer (Table 2). Significant increases in the number of species per quadrat could have resulted simply from more even spatial patterning of species already present in compartments or from actual increased recruitment of new species following fire. Those compartments with higher per quadrat species richness also had more species in the entire compartment. These data do indicate that there was considerable recruitment of new species, particularly the fire ephemerals listed previously, in response to winter fires. This response appeared to diminish over time, a pattern consistent with observations in other Coastal Plain communities (Christensen 1981) and presumably a result of the return of microenvironment and soil nutrient status to pre-burn conditions.

In summary, summer fires following winter fires had no effect on plant cover in the herbaceous layer of a Coastal Plain flatwoods. In contrast, there was increased herb cover following winter fires, a response which persisted for three years. There was also no effect of summer fires on species richness. Species richness was increased, however, by winter fires; this effect diminished after 30 months, probably resulting from rapid postfire accumulation of pine litter. The observed significant increases in richness was largely the result of recruitment of new species.

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