PERIODIC BURNING IN TABLE MOUNTAIN-PITCH PINE STANDS

Russell B. Randles, David H. Van Lear, Thomas A. Waldrop, and Dean M. Simon[1]

Abstract—The effects of multiple, low intensity burns on vegetation and wildlife habitat in Table Mountain (*Pinus pungens* Lamb.)-pitch (*Pinus rigida* Mill.) pine communities were studied in the Blue Ridge Mountains of North Carolina. Treatments consisted of areas burned from one to four times at 3-4 year intervals, and controls which remained unburned. The burns altered stand structure by reducing the density of understory trees and shrubs, which inhibits establishment of many shade intolerant species. Woody fuel loading was not reduced by burning although duff depth decreased. With the exception of the four burn treatment, in which fire intensity was higher, these understory burns proved inadequate to regenerate pine. Fire intensity had a more pronounced effect than burning repetition on vegetative structure and composition, as well as pine regeneration.

INTRODUCTION

Fire in the Southern Appalachians was a frequent visitor prior to European settlement due to both anthropogenic burning as well as natural lightning strikes (Delcourt and others 1998, Pyne and others 1996, Van Lear and Waldrop 1989). Plant communities adapted to a regime of frequent burning; one such forest type in the Appalachians is the Table Mountain-pitch pine community (Della-Bianca 1990, Little and Garrett 1990) This ecosystem has been in decline since fire exclusion policies were initiated in the early twentieth century (Williams and others 1990).

The intensity and frequency of fire necessary to create optimum habitat for sustaining Table Mountain-pitch pine ecosystems has not yet been determined. Some suggest that stand replacement fires may be necessary to create the environment necessary for regeneration (Elliot and others 1999, Turrill 1998), while others suggest more frequent, lower intensity fires may create suitable seedbed habitat (Waldrop and Brose 1998, Van Lear 1999). It is likely that a mix of surface and crown fires burned in Table Mountain-pitch pine stands prior to fire exclusion in the early 1900s.

Fire reduces the cover of species such as mountain laurel (*Kalmia latifolia*) and red maple (*Acer rubrum*) which compete with pines and oaks (Elliot and others 1999). Mountain laurel is an important understory competitor on the xeric ridges where stands of Table Mountain pine occur. Ground layer cover in loblolly and shortleaf pine stands was reduced by an average of 19 percent with a fire interval of three years when compared with intervals of six and nine years and unburned areas (Cain and others 1998). This study also showed a reduction in vertical cover percentage with the frequency of burning.

The purpose of this study was to determine effects of multiple, low-intensity fires on (1) structure and composition of vegetation, (2) fuel loading and arrangement, and (3) regeneration of Table Mountain and pitch pine.

METHODS

Study Areas

The study was located in western North Carolina on the Green River and Thurmond-Chatham gamelands of the North Carolina Wildlife Resources Commission. Forest overstories on the sites were in mixed pine (Table Mountain/Pitch Pine)-hardwood with an understory dominated by mountain laurel.

Plot Layout and Burning

Six to ten sample plots, each 10x20 meters, were installed along the ridge line of each treatment area. There were five treatments: Areas burned 1, 2, 3, and 4 times since 1988, as well as unburned controls. All treatments were burned on a three- to four-year interval. Treatment areas burned two and four times were unreplicated because only one of each of these areas was available. All other burned areas were replicated twice and the control was replicated four times.

[1]Graduate Research Assistant,Clemson University,261 Lehotsky Hall, Clemson, SC 29634; Professor,Clemson University; Research Forester,US Forest Service, Clemson University,233 Lehotsky Hall,Clemson, SC 29634; Wildlife Forester, NC Wildlife Resources Commission, 8676 Will Hudson Road, Lawndale, NC 28090, respectively.

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Table 1—Bark char height as an index of fire intensity (Average of max. scorch height after each burn)

	Mean Bark Char Height (m)	
Number of Burns	Thurmond-Chatham	Green River
0	0.00	0.00
1	1.52	1.52
2	N/A	2.29
3	4.06	3.05
4	7.62	N/A

Table 2—Species richness and diversity indices of herbaceous plants for each treatment

Treatment	Species Richnes (# Spp/200 sq. m)		Diversity (Shannon-Weiner)	
Control	12.3	A	.959	A
1 Burn	13.6	A	.875	A
2 Burn	10.2	A	.394	A
3 Burn	12.5	A	.840	A
4 Burn	19.5	B	2.00	A

One source of variation which could neither be accounted for nor controlled was fire intensity. For the most part, burns were of similar intensity; however, fires in the four-burn treatment on Thurmond-Chatham were of considerably higher intensity than the others (Personal Communication. 1999. Dean M. Simon)(table 1). All burns were dormant season burns conducted between January and March.

Vegetative Composition and Structure

Within each sample plot, twenty-one 1 square meter points were sampled along three transects extending the length of the plot. These points were sampled for frequency and percent cover of herbaceous species and *Vaccinium* spp. less than 1 meter in height. Importance value (IV(200)) for each species or species group was calculated using the equation IV(200) = (relative frequency plus relative cover)/2. This value was used to calculate a Shannon-Weiner diversity index (h' = (sum(Pi))ln(Pi))for herbaceous plants at each site.

All trees greater than 2 meters tall within each plot were tallied by species and DBH. It was noted whether they were living or dead. Trees less than 6 centimeters DBH were classified as understory trees, those between 6 and 12 centimeters were midstory, and all greater than 12 centimeters were overstory. These arbitrary classifications were based on the general canopy position of trees in these diameter ranges.

The shrub layer was sampled in two 5x10 meter subplots at the ends of each sample plot. Within these subplots species with multiple woody stems were sampled by number of individuals and number of stems for each individual. *Vaccinium* spp. greater than 1 meter in height were included with the shrub sampling. Width of each crown was measured at the widest point and perpendicular to that point and averaged to obtain crown diameter and percent cover of each individual. Maximum height of the shrub was also recorded for each individual.

Fuel Loading

Within each plot, Brown's planar intersect method (1971, 1974) was applied to three 15.24 meter (50 feet) transects to obtain a fuel loading for surface fuels. One hour fuels (0-.6 centimeters diameter) and ten hour fuels (.6-2.5 centimeters diameter) were counted over the first 2.4 meters (8 feet) of each transect. Both 100 hour (2.5-7.6 centimeters diameter) and 1000 hour (greater than 7.6 centimeters diameter) fuels were counted over the entire length of the transect, recording the diameter of any 1000 hour fuels. The depth of litter (L layer) and duff (F and H layers) was determined at .3, 1.8, 2.7 and 3.6 meters (1, 6, 9 and 12 feet) along each transect.

Height of down woody fuels was recorded at 3.0, 6.1, 9.1, 12.2 and 15.2 meters (10, 20, 30, 40 and 50 feet). This information was entered into the equation derived from Brown (1974) to calculate fuel loading. Vertical fuel height was measured as the mean height of vertical fuels (trees excluded) along each transect at 3.0, 6.1, 9.1, 12.2 and 15.2 meters (10, 20, 30, 40 and 50 feet).

Pine Regeneration

Pine regeneration was sampled concurrently with the 21 points described in the vegetation sampling section. However, the area sampled for pine regeneration at each point was 2x2 meters. Pine seedlings were counted and the height of each was recorded. Pines which had resprouted following a previous fire were measured in a similar manner.

Statistical Analysis

Data were analyzed using an incomplete block design with site as a block and number of burns as a treatment. An analysis of variance was performed sing PROC MIXED in Statistical Analysis Software. In cases where the variance was not uniform a square root transformation was performed to reduce the error (Kuehl 2000). Significance was determined at alpha equal to .05.

RESULTS AND DISCUSSION

Vegetative Structure and Composition

Herbaceous Composition and Diversity—Species richness on the four-burn treatment was significantly higher than the control and each of the other treatments (table 2). There were no significant differences in species richness among the other treatments or controls. Since the four-burn treatment burned more intensely than the other stands during each burn, greater species richness can likely be attributed more to fire intensity than number of burns. Shannon-Weiner diversity indices did not differ among treatments and controls (table 2). The low abundance of many species found in the four-burn treatment may offer an explanation for the lack of significance in the diversity index even though the species richness is higher.

Importance values (IV(200))for *Andropogon* spp., low panic grass (*Dichanthelium* spp.), and sweet fern (*Comptonia peregrina*) were higher in the four-burn treatment than in the other burns and control. Species found exclusively in the four-burn treatment included Indian grass (*Sorghastrum nutans*), fireweed (*Erictites hieracifolia*), and sweet fern (*Comptonia peregrina*). Species reduced in importance by burning included *Smilax* spp., which were reduced in each burn, and *Galax urceolata* which decreased in the two- and four-burn treatments (table 3).

Stand Structure—Understory tree density was significantly reduced in the two, three, and four-burn treatments compared to control areas (figure 1). Understory density in the four-burn treatment was also lower than that of the one-burn treatment. This pattern suggests that multiple burns are more effective in reducing understory density than single burns, although a single, high-intensity fire could theoretically fires.

Midstory and overstory densities were also significantly reduced in the four-burn treatment compared to other treatments and controls. However, the fire at this site actually crowned in some overstory trees due to the unusually high intensity during all four burns. There was little overstory mortality in any of the other burned areas because fire intensities were lower. Total basal area was reduced in the four-burn treatment compared to other treatments. Basal area in the two-burn treatment was lower than that in the control and one-burn area. Basal area reductions could be a result of the single replication of the two- and four-burn treatments as well as fire intensity in the four-burn treatment.

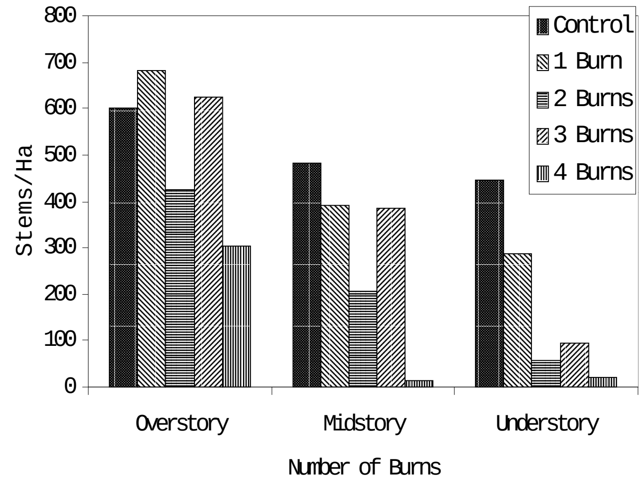

Figure 1—Canopy strata density (stems/ha) for burn treatments and control.

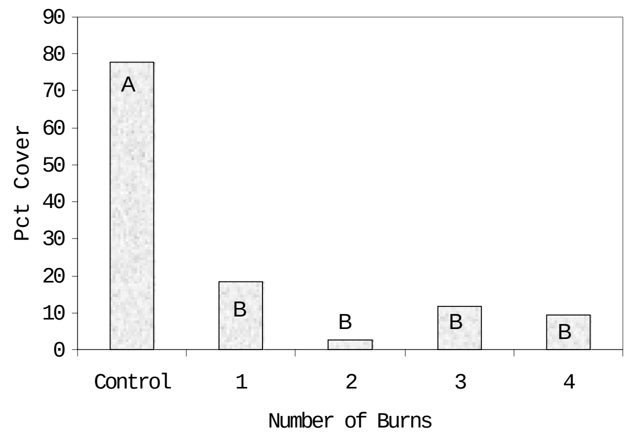

Figure 2—Shrub cover (predominantly mountain laurel) in treatments and control.

Table 3—Importance values (IV200) by species for each treatment

	Number of Burns				
Species	0	1	2	3	4
Andropogon spp.	0.38	0.08	0.31	0.68	11.28
Chimaphila maculata	2.70	0.43	0.54	0.05	0.05
Comptonia peregrina	0.00	0.00	0.00	0.00	10.40
Coreopsis major	0.16	0.08	0.20	0.06	1.25
Dichanthelium spp.	0.24	0.46	0.40	0.58	9.67
Epigaea repens	0.21	0.36	0.31	0.36	0.28
Erichtites hieracifolia	0.00	0.00	0.00	0.00	0.56
Galax urceolata	29.34	29.56	0.85	40.25	6.77
Vaccinium spp.	40.35	63.78	91.58	53.27	39.51
Polygonium convolvulus	0.17	0.61	0.00	0.15	0.00
Pteridium aquilinum	2.36	0.23	5.59	1.40	13.73
Smilax glauca	15.05	2.37	0.21	1.87	4.29
Smilax rotundifolia	8.34	1.78	0.00	1.06	0.11
Sorghastrum nutans	0.00	0.00	0.00	0.00	0.98
Other	0.53	0.32	0.00	0.29	3.28

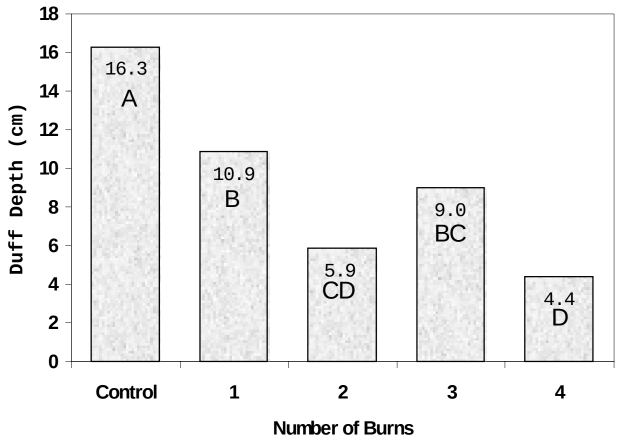

Figure 3—Duff reduction with burningc.

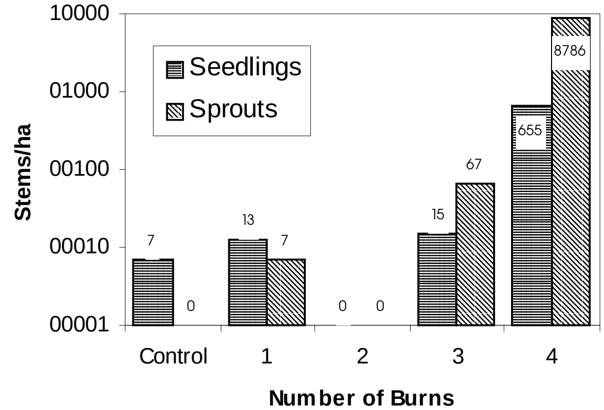

Figure 4—Log-scale of number of pine stems/ha for seedling and sprout regeneration.

Shrub Composition and Structure—Mountain laurel cover was reduced by 59 to 75 percent in the burned treatments but did not significantly differ among burn treatments (figure 2). Repeated winter burns at intervals of several years apparently do not further reduce percent cover of shrubs; rather, the first burn greatly reduces shrub cover and subsequent periodic burns simply maintain this state. Growing season burns might further reduce or even eliminate shrub cover because sprouting vigor is less at this time of year due to lower root reserves.

The height of shrub cover in each burn was significantly lower than that of the controls by 66–91 percent but did not vary from one burn treatment to the next. Mountain laurel was the only shrub found consistently within each area. Other shrubs noted were *Vaccinium* spp., flame azalea (*Rhododendron calendulaceum*), and rosebay rhododendron (*Rhododendron maximum*); however, these shrubs were scattered individuals with little effect on overall cover.

Fuel Loading—Down woody fuel loadings were essentially the same in each of the treatments suggesting frequent burning did not create, or reduce fuel loading. With the exception of the four-burn treatment, burns were generally not of sufficient intensity to kill trees, or if killed, they had not fallen and become surface fuels at the time of sampling. Coarse woody debris on the ground was apparently not consumed by the fires.

Duff depth in each treatment was lower than in the controls, and in most cases, each burn reduced the duff further (figure 3). The exception is the three-burn treatment, which had a mean duff depth slightly, but not significantly, greater than the two burn site. Lack of replication in the two-burn treatment may account for the lower duff depth. Vertical fuel height did not vary in relation to number of burns.

Pine Regeneration—Pine regeneration (seedlings and sprouts) was significantly higher in the four-burn treatment (9440 stems/hectare) than the control (7 stems/hectare) and other burn treatments (avg. 34 stems/hectare) (figure 4). Pine sprouts outnumbered seedlings by a margin of about 13:1 on the four-burn treatment. This pattern suggests that regeneration in this case is not due to the number of fires but rather to intensity of the fires. Had pine regeneration density been due to the number of times the site was burned, a progression in the number of seedlings would likely have been more evident.

Lack of regeneration in the other burn treatments could be caused by the amount of duff remaining on each of the sites after the burns (figure 3), as well as the degree of shading on the one- to three-burn treatments. Waldrop and Brose (1999) suggest that duff depths less than 7.5 centimeters provide a higher probability of germination and seedling survival if a seed source exists. Duff in the three-burn treatment averaged 9.0 centimeters which is still higher than the recommended depth. Results of the two-burn treatment are a bit surprising in that the mean depth was 5.9 centimeters and yet there was no regeneration on sample plots. This depth is not significantly different from the three-burn treatment which is higher than the suggested limit. Growing season burns would likely reduce duff depths more than winter burns and may be more productive in preparing seedbeds. Further study is needed to test this hypothesis. Unfortunately no measure of seed rain or seed viability was conducted so it is unsure how much seed was produced and whether that seed was viable.

Pines are shade-intolerant species and the amount of light reaching the forest floor influences seedling survival. The four-burn treatment had significantly more light reaching the forest floor than the control or any of the other treatments. Reduced shading reflected the intensity with which this stand had been burned on multiple occasions. The type and amount of litter present at seed fall also affects regeneration of Table Mountain pine (Williams, 1990). Most of the litter in these stands was hardwood litter, which reduces the establishment and survival of pine seedlings.

CONCLUSIONS

Multiple understory burns in Table Mountain/pitch pine stands create a more open forest with less cover of shrubs and saplings than unburned forests. Low intensity, dormant-season fires such as those in the one-, two-, and three-burn treatments, however, have little effect on fuel loading and had no quantifiable benefit to the regeneration of Table Mountain and pitch pines. Higher intensity fires such as those in the four-burn treatment created conditions (such as reduced shading and duff depth) that greatly enhanced pine regeneration.

The use of fire to regenerate Table Mountain-pitch pine stands needs further study. Various techniques should be investigated including combinations of thinning and burning, as well as different burning regimes, to develop effective regeneration methods.

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