SURVIVAL OF STRIPED MAPLE FOLLOWING SPRING PRESCRIBED FIRES IN PENNSYLVANIA

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Abstract—Survival of striped maple (*Acer pensylvanicum* L.) was assessed after three spring prescribed fires in Pennsylvania mixed oak (*Quercus* spp.) stands. Portions of two stands were prescribe-burned in spring 2002 and the part of a third in spring 2004. Following the fires, each stand was divided into burned and unburned units. Striped maple sapling counts were done one and three growing seasons after the fires in both units of each stand to determine whether the fires had reduced the density of stems. In all stands, fire initially reduced density of striped maple by 25 to 50 percent. Delayed mortality pushed this rate to over 90 percent in two of the stands. These data suggest that prescribed fire appears to be a viable means of controlling striped maple in mixed oak forests.

INTRODUCTION

There is growing appreciation and understanding of the important role periodic, low-intensity, surface fires played in the historic dominance of mixed oak (*Quercus* spp.) forests throughout the eastern North America, including the mid-Atlantic region (Abrams 1992, Brose and others 2001, Yaussy 2000). This fire regime was largely the result of American Indian burning practices and, in conjunction with other environmental factors, helped perpetuate mixed oak forests on a wide variety of soils, especially mesic upland sites. The advent of effective fire control policies and practices ended the periodic surface fire regime of the mid-Atlantic region, like they did in the Southeast and the Interior West. However, unlike those other regions, the lack of fire did not translate into an increased loading of hazardous fuels that contributed to catastrophic, stand-replacing wildfires. Rather, the cessation of periodic surface fires in the mid-Atlantic region led to a new forest succession pathway; one in which fire-sensitive, shade-tolerant shrubs and trees invade and eventually impede successful oak regeneration in mixed oak forests.

One beneficiary of the cessation of periodic surface fires is striped maple (*Acer pensylvanicum* L.). Striped maple is a small- to medium-sized, shade tolerant tree found from Nova Scotia west to the Great Lakes region and south along the Appalachian Mountains to North Carolina (Gabriel and Walters 1990). Within that range, it generally occurs in northern hardwood forests and is most common on cool, moist slopes. However, it is being found more frequently and abundantly in mixed oak forests, an environment from which it was historically absent or sparse.

Striped maple is not a long-lived tree, about 40 years, but can subsist as a small seedling for another 40 years (Hibbs 1979). It is a rather prolific seeder and, in conjunction with its seedling banking strategy, can develop high density populations in forests. When such populations develop, striped maple becomes a serious silvicultural problem as it casts a dense shade on the forest floor that impedes oak seedling survival and growth. In Pennsylvania, striped maple is considered the most troublesome woody interference that precludes successful oak regeneration (Personal communication. 2005. Gary Rutherford, Silviculture Section Chief, Pennsylvania Bureau of Forestry, P.O. Box 403, Rothrock Lane, Huntington, PA 16652).

Glyphosate-containing herbicides are often used to control striped maple when its density becomes an obstacle to forest regeneration (Horsley and Bjorkbom 1983, Marquis and others 1992). However, there are times and places when herbicide use is not possible so there is growing interest in using prescribed fire as an alternative control method. Striped maple exhibits several attributes that suggest it is quite sensitive

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to fire. Striped maple bark is quite thin, regardless of stem diameter, its root collar (the location of dormant buds) is relatively high in the litter layer, and its root system is small and shallow. Striped maple leaves also emerge earlier in the spring than many other species. As a result, root carbohydrate reserves are depleted earlier thus rendering striped maple susceptible to surface fires for a longer period of time.

Surprisingly, there is little published literature on the effects of fire on striped maple. Swan (1970) compared burned and unburned northern hardwood stands in southern New York. He found unburned sites to have five times more striped maple than those that had been burned. Unfortunately, fire behavior was unknown and pre-fire striped maple density between stands was not documented. Conversely, Collins and Carson (2003) reported that striped maple was a strong sprouter following prescribed fires in West Virginia and actually benefited from them. Again, fire behavior was poorly described.

The objective of this study was to determine whether striped maple densities increased or decreased following prescribed burning. Understanding this aspect of striped maple ecology will help foresters deal more effectively with the species when it poses a regeneration obstacle.

METHODS

Study Sites

This study was conducted on three Pennsylvania State Forests (Bald Eagle, Clear Creek, and Moshannon) between 2002 and 2005. The Bald Eagle State Forest is located in eastern Centre County in the Ridge and Valley region of central Pennsylvania. The study site was a 10-acre stand situated at the bottom of an 18-percent, north-facing slope. Elevation was approximately 1400 feet. Soil was a stony loam (Typic Fragidult) formed from sandstone alluvium (Braker 1981). Consequently, it was moderately acidic, fertile, and well drained. Severe gypsy moth (*Lymantria dispar* L.) defoliation had occurred there in the late 1980s and early 1990s, resulting in substantial overstory mortality and salvage logging occurred shortly thereafter. The remaining overstory trees resembled a shelterwood stand and relative density, i.e., stocking, was 50 percent as per SILVAH criteria (Marquis and others 1992). Common canopy species were chestnut oak (*Quercus prinus* L.), northern red oak (*Q. rubra* L.), and red maple (*A. rubrum* L.). A dense sapling layer of striped maple, sweet birch (*Betula lenta* L.), red maple, and witch-hazel (*Hamamelis virginiana* L.) was present. The forest floor contained abundant late low blueberry (*Vaccinum angustifolium* Ait.), black huckleberry (*Gaylussacia baccata* (Wang.) K. Koch.), mountain laurel (*Kalmia latifolia* L.), and seedlings of several hardwood species, especially chestnut and northern red oak.

The Clear Creek State Forest is located in northern Jefferson County on the Allegheny Plateau region of northwestern Pennsylvania. The study site was an 8-acre stand found at midslope of a 5-percent, east-facing hill. Elevation was approximately 1800 feet. Soil was a loam (Typic Dystrochept) formed in place by the weathering of sandstone and shale parent material (Zarichansky 1964). Consequently, it was moderately acidic, fertile, and well drained. The stand had only experienced light gypsy moth defoliation with little attendant overstory mortality (relative density was 100-percent). Dominant canopy species included northern red oak, sugar maple (*A. saccharum* Marsh.), black cherry (*Prunus serotina* Ehrh.), and yellow-poplar (*Liriodendron tulipifera* L.). The sapling layer was quite dense and consisted almost entirely of striped maple with a few American beech (*Fagus grandifolia* Ehrh.). The regeneration layer was dense with northern red oak seedlings because of a bumper acorn crop in fall 2001. Otherwise there were few hardwood seedlings and some scattered pockets of hay-scented fern [*Dennstaedtia punctilobula* (Michx.) Moore] comprised the herbaceous community on the forest floor.

The Moshannon State Forest is located in northern Clearfield County in the Allegheny Mountians region of north-central Pennsylvania. The study site was a 12-acre stand situated on an upperslope bench with a northwest aspect and slope of 2 percent. Elevation was approximately 2100 feet. Soil was a loam (Typic Fragiudult) formed in place by the weathering of sandstone and shale parent material (Hallowich 1988). Consequently, it was moderately acidic, fertile, and moderately drained. The stand had experienced light to moderate gypsy moth defoliation and mortality but relative density was nearly 100 percent. Dominant canopy species included northern red oak, sugar maple, black cherry, and yellow-poplar. The sapling layer was quite dense and consisted almost entirely of striped maple with a few American beech. The regeneration layer was dense with northern red oak seedlings due to a bumper acorn crop in fall 2001. Otherwise there were few hardwood seedlings and some scattered pockets of hay-scented fern comprised the herbaceous community on the forest floor.

The Prescribed Fires

The objective of all three fires was to remove the sapling layer that was competing with the oak regeneration. Personnel of the Pennsylvania Bureau of Forestry conducted the prescribed burns on April 19, 2002 at Clear Creek State Forest, May 23, 2002 at Bald Eagle State Forest, and May 3, 2004 at Moshannon State Forest. Fuel, weather, and fire behavior data are presented in table 1. Fires were lit by hand with drip torches in a strip-headfire pattern commencing at the downwind or uphill side of each burn unit. The Clear Creek fire barely burned as it had only compacted leaf litter as a fuel. Observed flame lengths were only a few inches. Conversely, the Bald Eagle fire produced flame lengths of four to eight feet because that site had an abundance of ericaceous shrubs for fuel. The Moshannon burn displayed widely varying fire behavior. Some areas barely burned due to a paucity of fuel while other areas produced enough heat to damage and kill overstory trees. Leaf expansion of the striped maples was as follows; Clear Creek – swollen buds, Bald Eagle – fully expanded, Moshannon – half expanded.

Study Design and Sampling Procedures

Because the Bald Eagle and Clear Creek fires occurred with little advance notice to us, collecting pre-burn data was not possible. However, approximately 50 percent of each stand was excluded from the fires, thus providing a valid source of data for evaluating the effect of the fires on striped maple survival. Ten to twelve 1/40 acre circular plots were systematically located in each burn and control unit to ensure uniform coverage of the area. In these plots, all saplings (five feet tall to six inches dbh) were identified to species and tallied as alive, i.e., not top-killed by the fires, dead, or sprouting. Inventories were conducted in fall 2002 and 2004 (one and three growing seasons post-burn) at the Bald Eagle and Clear Creek stands and in spring 2005 (one growing season post-burn) at the Moshannon site.

Table 1—Environmental conditions and fire behavior at the time of the prescribed fires

Fuel and weather data	Bald Eagle	Clear Creek	Moshannon
Burn date	May 23, 2002	April 19, 2002	May 3, 2004
Time of burn	13:00–15:00	11:00–12:00	14:00–15:00
Burn size (acres)	5	4	6
Aspect	N	E	NW
Slope (percent)	18	5	2
Slope position	Lower 1/3	Middle 1/3	Upper 1/3
Air temperature (F)	72–78	65–67	71–74
Rel. Humidity (percent)	23–27	35–40	42–48
Wind direction	West	West	West
Wind speed (miles per hour)	1–3	1–2	2–5
Cloud cover (percent)	0	0	25
Fuel model	6	8	8
Fuel description	Heath shrubs	Compact litter	Litter, slash
Fuel moisture (percent)	10	15	16
Flame length (feet)	4–8	< 0.5	0.5–3
Rate-of-spread (feet per minute)	3–6	1–2	1–4

Statistical Analysis

A randomized complete block design was used to test for differences in the number of living, dead, and sprouting striped maples between treatments. Each stand was considered a block to account for differences in site quality, fire behavior, and degree of leaf expansion. Burned and unburned were the treatments and the number of living, dead, and sprouting striped maples was the dependant variable. Analysis of variance with the Student-Keuls mean separation test (SAS 2002) was used to determine whether there were any differences in the number of living, dead, and sprouting striped maple between treatments. Residuals were analyzed to ensure ANOVA assumptions were met and alpha was 0.05 for all tests.

RESULTS

The mean density (stems per acre) of the striped maple understories varied among stands but was reasonably equivalent between treatments within each stand (fig. 1). Moshannon had the most striped maple, 1466, while Bald Eagle and Clear Creek had 700 and 913, respectively. Striped maple densities were equal between the burned and unburned treatments at all sites. Bald Eagle had striped maple densities of 709 and 691 stems per acre in the burned and unburned portions while Moshannon had 1400 and 1533 and Clear Creek had 871 and 754, respectively, for their burned and unburned portions.

There were clear differences between the burn and unburned treatments after the first post-burn growing season (fig. 2). In the unburned treatment, virtually all the striped maple saplings were alive. Conversely, the burn treatment, regardless of the study stand, always had more dead and sprouting striped maples and fewer living ones than the unburned plots. Densities of dead, sprouting, and alive striped maple were 548, 331, and 46 stems per acre, respectively, in the burn treatment while the corresponding unburned densities were 11 dead, 23 sprouting, and 961 alive. Striped maple density data were available for the third post-burn growing season (2004) from the Bald Eagle and Clear Creek stands. Again, the burned portions had more dead, sprouting, and alive striped maple saplings than the unburned portions.

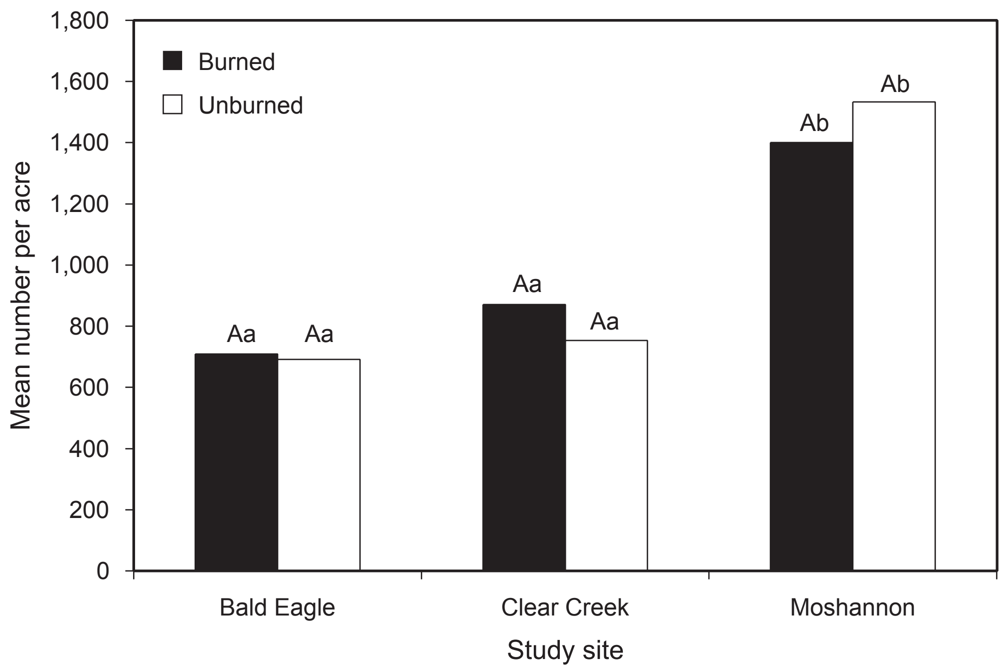

Figure 1—Mean number of striped maple saplings per acre at the three sites at the beginning of the study. Columns with the same uppercase letter are not significantly different at the 0.05 level for that stand. Columns with the same lowercase letter are not significantly different at the 0.05 level for that treatment.

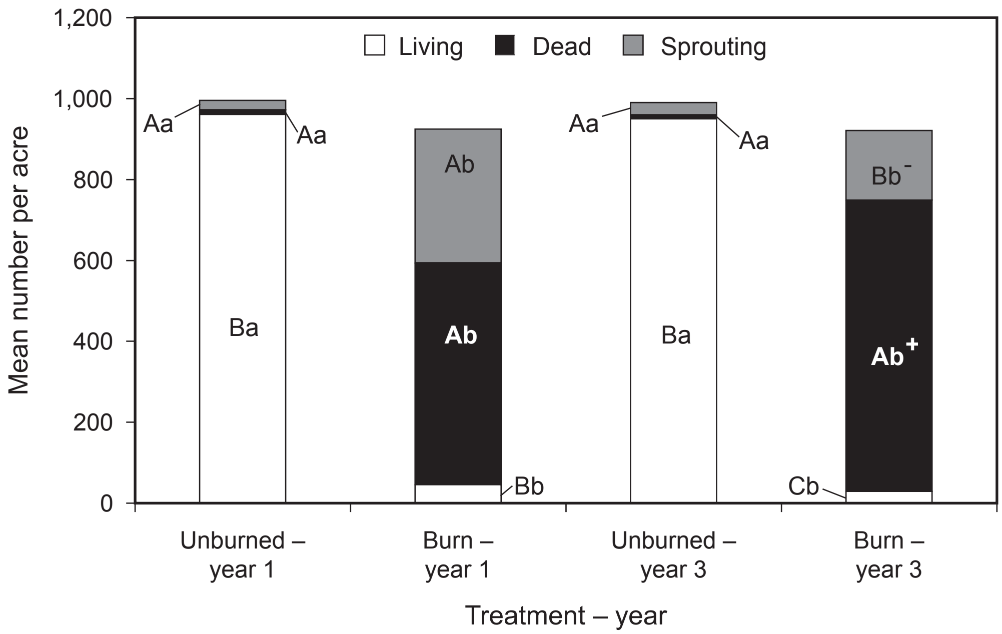

Figure 2—Mean number of living, dead, and sprouting striped maple saplings by treatment and year. Different uppercase letters within a column indicate significant differences at the 0.05 level. Different lowercase letters indicate significant differences between treatments within the same year at the 0.05 level. The plus (+) and minus (-) superscripts in the Burn–YR3 column indicate a significant increase and decrease, respectively, from the Burn–YR1 column.

Comparing the first- and third-year data, the mean number of dead striped maples in the burned portions increased from 548 in 2002 to 717 saplings per acre in 2004 (fig. 2). This additional mortality appears to have come from previously sprouted stems as those densities declined from 331 in 2002 to 172 in 2004. The number of living striped maples in the burned units did not significantly decrease from 2002 to 2004 nor did any of the striped maple densities in the unburned portions change during that period.

DISCUSSION

One obstacle to using more prescribed fire in the mixed oak forests of the eastern states is the lack of knowledge regarding fire effects on important competing hardwoods. Striped maple certainly falls under that heading as evidenced by the contradictory results reported in the few fire studies that included the species. This study helps clarify the picture, at least in term of spring fires.

Striped maple is extremely sensitive to spring fires, regardless of fireline intensity. Its paper-thin bark offers little or no protection against fire as even the small flames at Clear Creek top-killed over 80 percent of the saplings. The slightly more intense fire at Moshannon pushed the top-kill rate to over 93 percent and less than 5 percent of the striped maple at Bald Eagle was not top-killed. In fact, striped maples surviving the fire at Bald Eagle were only able to do so if they were growing in protected microsites that precluded burning.

Not only were striped maples easily top-killed, substantial numbers of rootstocks were also killed by fire. Over 50 percent of the striped maples at Bald Eagle and Clear Creek failed to sprout the first year after the fires. This was apparently due to the fires being able to scorch the root collars, thereby killing the dormant basal buds. While this was not unexpected at Bald Eagle given its relatively high fireline intensity, it was surprising at Clear Creek where the fire barely burned. In fact, after that fire all the striped maples expanded their leaves as if there had been no fire. However within a few weeks, they began wilting in large numbers. Apparently the fire was sufficient to girdle these saplings and prevent carbohydrate and water flow through the cambial tissue. Given the sensitivity to fire displayed by striped maple in this study, it probably was not the major component of the understory when periodic surface fires occurred that it is now in the absence of fire.

It is unclear why there was delayed mortality at Bald Eagle and Clear Creek. Both stands showed an increase in the number of dead striped maples in the burn units from 2002 to 2004. The intervening two growing seasons were exceptionally cool and wet leading to a major outbreak of anthracnose. This foliar pathogen may have caused the additional mortality because many of the dead stems were sprouts close to the ground. *Armillaria mellea* Vahl., a root pathogen, may also be the causal agent as this fungus is ubiquitous in eastern forest soils and routinely attacks trees weakened by a stress. Whatever the mechanism was, between it and the fires, over 80 percent of the striped maple saplings were dead within three years after the fires.

From this study, it appears that prescribed fire is another means to control striped maples when they become a silvicultural obstacle. Fire can be used in lieu of herbicides when the latter is not feasible due to policy constraints or site restrictions, i.e., too steep or rocky for equipment, striped maple is too tall, it's a drought year, etc. Or fire and herbicides can be used in tandem with fire initially removing some stems and spot application of herbicide finishing the job.

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