EFFECTS OF PRE- AND POST-HARVEST SITE PREPARATION TREATMENTS ON NATURAL REGENERATION SUCCESS IN A MIXED HARDWOOD STAND AFTER 10 YEARS

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Abstract—Advance regeneration, sprouts and seeds are sources of reproduction in the regeneration of mixed hardwood stands following harvest. The control of undesirable, non-commercial, competing vegetation is a common technique in site preparation to promote the establishment and growth of desirable species. This study was designed to evaluate the effectiveness of pre- and post-harvest site preparation treatments in the regeneration of an upland hardwood stand near Oak Ridge, TN. Four site preparation treatments (pre- and post-harvest slashing, with and without herbicide stump treatment) and a control (no slashing or herbicide treatment) were implemented. Each set of five treatments was replicated six times. The regeneration harvest was conducted during the winter of 1996-1997. After ten growing seasons, there was little statistical difference in species composition between treatments. Even though many undesirable existing stems were controlled by the pre- and post-harvest site preparation treatments, the proliferation of light-seeded species, primarily yellow-poplar (*Liriodendron tulipifera*), red maple (*Acer rubrum*), black cherry (*Prunus serotina*), and Virginia pine (*Pinus virginiana*) overcompensated for the various site preparation treatments.

INTRODUCTION

Ensuring adequate regeneration of preferred species in mixed hardwood stands following a harvest is often a concern to forest managers. A myriad of different species with different site requirements and growth habits and varying sources of reproduction (seed, sprouts, advance regeneration) make prediction of regeneration complex and sometimes unreliable. Often competition from undesirable trees is too great for the commercially important species to overcome.

One means of encouraging growth of preferred, regenerating species is by limiting competing trees through site preparation either before or after the harvest operation. Slashing and/or the use of herbicide are two methods of site preparation. Little information is available to assess the relative effectiveness of these various site preparation alternatives. Loftis (1978, 1985) evaluated the effectiveness and costs associated with preharvest treatments on Appalachian hardwoods. The results suggest that after clearcutting, preharvest treatments reduce the number of stems of undesirable species and increase the proportion of desirable species in the stand. After ten years, stands that received preharvest treatments were well-stocked with single stems of desirable species.

Loftis (1978, 1985) only used a post-harvest treatment as a check on the effectiveness of the preharvest treatments. A herbicide application was only used with the preharvest operation; no herbicide was used in post-harvest treatments. Our study considers how a stand develops after a regeneration harvest when a variety of pre- and post-harvest site preparation treatments is applied.

OBJECTIVES

The purpose of this study was to evaluate the effect of pre- and post-harvest slashing and herbicide stump treatment of non-commercial stems on species composition following a silvicultural clearcut. Ten-year results are presented. Hodges and others (2002) reported two-year results on species composition and the costs associated with the pre- and post-harvesting treatments.

METHODS

The study was located on a 17-acre watershed at the University of Tennessee Forest Resources Research and Education Center near Oak Ridge, TN. Elevations in the south-facing drainage range from 970 to 1100 feet above sea level. Site index (base age of 50 years) for upland oaks ranged from 65 to 75 feet (Olson 1959). The harvested sawtimber stand was comprised primarily of oaks (*Quercus* spp.) (69 percent) by volume, yellow-poplar (*Liriodendron tulipifera*) (14 percent), miscellaneous hardwoods (10 percent), and pines (*Pinus* spp.) (6 percent).

Five treatments were implemented:

1. Preharvest slash only
2. Preharvest slash with herbicide stump treatment
3. Post-harvest slash only
4. Post-harvest slash and herbicide stump treatment
5. Control (no slashing or herbicide)

The five treatments were applied to 120 by 120 foot (0.33-acre) plots. This plot size was large enough to distinguish individual treatments from adjacent treatments while allowing for replications. Each set of five treatments was replicated six times for a total of 30 treatment plots. All treatment plots were located adjacent to each other.

Within each plot, four 1/100 acre subplots were established for sampling. Each subplot was located at a corner of a 60 by 60 foot square contained within the plot. The first subplot was established by running a line bisecting the northern corner of each plot for 42.5 feet. The remaining three subplots were

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positioned by running a 60-foot line parallel to the boundaries of the plot.

Plots were assigned to different replications by establishing groups of plots that were similar in terms of species composition, density, and location. A computer-generated design for incomplete blocks was used to assign treatments to plots.

The initial inventory before the harvest was conducted in June 1996. All trees above one foot in height were measured in the subplots during September 1996. Data were collected in several designated classes: 1 foot height classes to 4 feet tall, above 4 feet tall but less than 1.5 inches at diameter breast height (d.b.h., 4.5 feet), and by 1 inch diameter class above 1.5 inches. This methodology follows the regeneration prediction model designed and being tested by the USDA Forest Service, Southern Research Station, Bent Creek Experimental Forest near Asheville, NC.

Preharvest treatments were conducted on the designated plots during October 1996. The number of stems cut per plot was recorded as stems greater than or less than 1.5 inches d.b.h. Garlon 3A in a 50:50 mix with water and red dye was used on all non-commercial stumps, primarily red maple (*Acer rubrum*), blackgum (*Nyssa sylvatica*), sourwood (*Oxydendrum arboreum*), dogwood (*Cornus florida*), sweetgum (*Liquidambar styraciflua*), elms (*Ulmus* spp.), and beech (*Fagus grandiflora*). Herbicide was applied to the stump directly after cutting.

The timber harvest was conducted from February through April 1997. Approximately 118.9 million board feet of hardwood sawtimber, 7.0 million board feet of pine sawtimber, 29.2 cords of hardwood pulpwood and 9.0 cords of pine pulpwood were harvested.

Post-harvest treatments were conducted in August 1997 in the same manner as the preharvest treatments.

All subplots were measured after the second growing season (1999) and the results were reported by Hodges and others (2002). Measurements after ten growing seasons (2006) were collected during December 2006 and January 2007. Since the general canopy level after 10 years was 30 to 35 feet and the canopy was closed, data collected on each subplot were stem counts by species for all stems more than 4 feet in height. The most dominant tree on each subplot was identified and tallied by species and d.b.h.

RESULTS AND DISCUSSION

Few statistical differences were detected in the number of stems per acre by species and treatment (table 1). The only significant species component was the miscellaneous species category. Yellow-poplar comprised 43 to 50 percent of the total number of stems in each treatment, red maple 13 to 23 percent, black cherry 7 to 13 percent, oaks 5 to 7 percent and miscellaneous species 9 to 24 percent. Even though the site preparation treatments were conducted to control undesirable residuals and promote regeneration present, species that regenerate from light, wind-blown seed such as yellow-poplar, black cherry, red maple and Virginia pine had greater number of trees than oaks and hickories.

In addition, many of these species that regenerate readily from seed maintain seed viability on the forest floor for several years: yellow-poplar, four to seven years (Clark and Boyce 1964); black cherry, three or more years (Wendel 1977); and red maple, two or more years (Marquis 1975). Virginia pine seed remain viable for only one year. The viable seed accumulate in the forest floor after seed dissemination each year forming a seed bank ready to germinate when conditions are favorable, especially after a harvest. The wind-blown seed and the numerous seeds in the seed bank probably overburdened the regeneration present on the site prior to the harvest shifting the species composition toward these light-seeded species.

Red maple seed is different from other species that usually disseminate their seed in the fall. Red maple is one of the first species to flower in the spring. Its fruit ripens just before leaf development is complete. Seeds are dispersed in April through June, depending on location and climate. The seed are not dormant and do not require any pre-germination treatment. Seeds of red maple germinate within a few weeks of ripening and dispersal (Walters and Yawney 1990). Unlike most species that disseminate seed in the fall and germinate in the spring, red maple can actually regenerate and grow within the current growing season giving it an advantage or head start on other species, especially during spring and summer harvests. Red maple seed also stays viable in the forest floor for several years, increasing its regeneration advantages.

Preharvest treatments compared to post-harvest treatments had little effect on species composition (table 1). More than three times as many stems were treated in the preharvest plots than were recorded in the post-harvest plots (table 2). The harvesting operation resulted in many of the stems in the post-harvest plots being severed before the treatment was applied. The preharvest treatments were more costly to conduct than the post-harvest treatments (Hodges and others 2002). However, safety during slashing operations is also a concern. Slashing stands before harvest is much safer than slashing after the harvest when tree tops and other harvesting debris is on the ground. A balance between safety and cost should be considered during site preparation activities.

Effects of the herbicide treatment were varied. Miscellaneous species, primarily the midstory species of sourwood, blackgum and dogwood were impacted most during the preharvest slash and herbicide treatment (table 1). No definitive judgments can be made about the herbicide treatment and red maple. We observed that the herbicide treatment did kill many of the red maple residuals, but red maple was still prolific on the harvested area after 10 years, presumably from new and stored seed and some sprouting.

Table 1—Stems per acre by species and treatment (n = 24 subplots per treatment) after 10 years for the pre- and post-treatment site preparation regeneration study at the Forest Resources Research and Education Center, Oak Ridge, TN. Treatment differences by individual species were only found for the miscellaneous species category at the *alpha = 0.05* **level (Tukey's procedure)**

Species	Trmt #1[a]	Trmt #2	Trmt #3	Trmt #4	Trmt #5
Yellow-poplar	2733	2683	2383	2367	2770
Red maple	1073	1210	940	715	969
Black cherry	391	387	553	470	403
Oaks	295	265	382	340	424
Hickories[b]	75	104	79	129	91
Virginia pine	108	58	70	116	66
Miscellaneous species[c]	806 ab	480 b	775 ab	1285 a	1040 a
Total	5435	5187	5182	5422	5763

[a]Treatment #1 = Pre-harvest slash only
Treatment #2 = Pre-harvest slash and herbicide
Treatment #3 = Post-harvest slash only
Treatment #4 = Post-harvest slash and herbicide
Treatment #5 = Control (no slash or herbicide)
[b]Hickories (*Carya* spp.)
[c]Miscellaneous species includes beech, blackgum, dogwood, elms, hollies (*Ilex* spp.) sassafras (*Sassafras albidum*), sourwood, sweetgum, sumac (*Rhus* spp.), and white ash (*Fraxinus americana*)

Further evidence, beyond the number of stems, that yellow-poplar was the most common regenerating species is that 38 percent of the subplots had a yellow-poplar as the most dominant tree (table 3). Although oaks comprised the majority of the volume of the harvested stand, oaks represent a minority of the stems in the regenerating stand. Approximately, the same number of oaks is present in the regeneration after 2 years (Hodges and others 2002) as was observed after 10 years. Oaks were not affected by the treatments. However, 200 to 400 oaks per acre were present across treatments, with some dominating the subplots (table 3). Oaks will probably continue to be a component of the new stand, albeit at lower volumes and probably fewer trees compared to the harvested stand.

Table 2—Site preparation treatment applied (n = 24 subplots) for the pre- and post-treatment site preparation regeneration study at the Forest Resources Research and Education Center, Oak Ridge, TN

Treatment	Slashed	Herbicide
	(# of trees/acre)	
Pre-harvest	948	na[a]
Pre-harvest/ Herbicide	1383	607
Post-harvest	308	na
Post-harvest/ Herbicide	426	387

[a]na = not applicable

FUTURE CONSIDERATIONS

This long-term study on stand development will continue to be monitored. These comments are based on observations while collecting data for this study and experience with other harvests in similar forests in this area. We anticipate yellow-poplar to continue to dominate on the better sites, but some density-dependent, self-thinning will occur. On the poor productivity sites that are more stressful, yellow-poplar will probably diminish compared to other species. Oaks and hickories are better suited to these sites and probably will be able to persist and become a greater proportion of the overstory component replacing many of the yellow-poplar. Black cherry in this area is susceptible to pitch pockets, black

Table 3—Most dominant tree by species on each subplot (n = 120) after 10 years regardless of treatment for the pre- and post-treatment site preparation regeneration study at the Forest Resources Research and Education Center, Oak Ridge, TN

Species	Number of Subplots	Percent of Total
Yellow-poplar	46	38
Black cherry	27	22
Virginia pine	19	16
Red maple	8	7
Hickories	7	6
Oaks	6	5
Miscellaneous species[a]	7	6

[a]Sweetgum, sourwood, elms, white ash.

rot and crown breakage from wind and ice damage. We do not expect black cherry to be a formidable component of the overstory.

The role of red maple is unknown. There are twice as many stems of red maple compared to oaks. However, sawtimber red maple was an infrequent component of the harvested stand. Although the number of subplots with dominating oaks and red maple was similar, our observations and experiences are that red maple rarely assumes a dominant position in mixed hardwood stands in TN. Most of the red maple and the miscellaneous species are below the main canopy comprising the midstory and will minimally influence the overstory species.

Future work is to use this dataset of initial preharvest measurements and 10 year post-harvest measurements for the various site preparation treatments to evaluate the predictive ability of the hardwood regeneration model developed for the Appalachian forests by forest researchers at the Bent Creek Experimental Forest and to modify the model for application to forests in east Tennessee.

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LITERATURE CITED

Clark, F.B.; Boyce, S.G. 1964. Yellow-poplar seed remains viable in the forest litter. Journal of Forestry. 62: 564-567.

Hodges, D.G.; Evans, R.L.; Clatterbuck, W.K. 2002. Comparing alternative slashing techniques on a mixed hardwood forest: 2-year results. In: Outcalt, K.W. (ed.) Proceedings of the eleventh biennial southern silvicultural research conference. Gen. Tech. Rep. SRS-48. U.S. Forest Service, Southern Research Station, Asheville, NC: 412-414.

Loftis, D.L. 1978. Preharvest herbicide control of undesirable vegetation in southern Appalachian hardwoods. Southern Journal of Applied Forestry. 2: 51-54.

Loftis, D.L. 1985. Preharvest herbicide treatment improves regeneration in southern Appalachian hardwoods. Southern Journal of Applied Forestry. 9: 177-180.

Marquis, D.A. 1975. Seed storage and germination under northern hardwood forests. Canadian Journal of Forest Research. 5: 478-484.

Olson, D.J., Jr. 1959. Site index curves for upland oak in the southeast. Res. Note SE-125. U.S. Forest Service, Southeastern Forest Experiment Station, Asheville, NC: 2 p.

Walters, R.S.; Yawney, H.W. 1990. *Acer rubrum* L., red maple. In: Burns, R.M.; Honkala, B.H. (tech. coords.) Silvics of North America: 2 Hardwoods. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC: 60-69.

Wendel, G.W. 1977. Longevity of black cherry, wild grape and sassafras seed in the forest floor. Res. Pap. NE-375. U.S. Forest Service, Northeastern Forest Experiment Station, Upper Darby, PA: 6 p.