STRIP THINNING YOUNG HARDWOOD FORESTS: MULTI-FUNCTIONAL MANAGEMENT FOR WOOD, WILDLIFE, AND BIOENERGY

Jamie Schuler and Ashlee Martin[1]

Abstract—Upland hardwood forests dominate the Appalachian landscape. However, early successional forests are limited. In WV and PA, for example, only 8 percent of the timberland is classified as seedling and sapling-sized. Typically no management occurs in these forests due to the high cost of treatment and the lack of marketable products. If bioenergy markets come to fruition, these young forests can be managed in ways that promote improved forest growth, increased wildlife habitat, and biomass feedstocks. We will demonstrate how strip thinning in young stands can simultaneously provide (1) long-term wood products (sawtimber), (2) the maintenance of early successional habitat that many wildlife species require, and (3) a woody feedstock that can be repeatedly harvested and requires no establishment costs.

INTRODUCTION

Forests continue to dominate the landscape throughout the eastern U.S. However, they are increasingly utilized for multiple uses and functions. While forests are commonly managed for wood and wildlife, their role in providing biomass for energy is expected to increase. The goal of this study was to examine the opportunities to simultaneously manage forests for wood, wildlife and bioenergy.

Deciduous hardwoods are a predominant cover type across the eastern U.S. landscape. In the central Appalachian region, oaks (*Quercus*), maples (*Acer*), hickories (*Carya*), yellow-poplar (*Liriodendron tulipifera*), and birch (*Betula*) are represented in most forested stands. The age class distributions across the region show most of these forests are heavily skewed to older stands. For example, Pennsylvania and West Virginia each have less than 8 percent of their forested landscape as younger forests (i.e., <20 years old, fig. 1) (FIA 2007). As a consequence, early successional habitat and its associated wildlife species are declining.

Recently harvested stands can provide for early successional habitat, providing a mixture of grasses, herbaceous plants, shrubs and tree species (Greenberg and others 2011). However, after a decade or two, trees dominate and shade out most other vegetation. As these forests develop, the high stem densities that occur during this period also constrain tree growth, thereby prolonging suboptimal growth and the time until commercial products are available. While studies have documented positive growth responses resulting from treatments that reduced stem density at young ages (Trimble 1973, Schuler and Robison 2006, Robison and others 2004, Pham 1985; Smith and Lamson 1983), the operational challenge has been that these activities are pre-commercial which produce no immediate return at a considerable cost.

When implemented, pre-commercial thinning treatments in hardwood stands are generally applied as individual tree release treatments, that select the best 50-75 stems/acre and discriminate against poorly formed stems and less desirable species (Miller and others 2007). The drawback of these “crop tree” treatments is that they are expensive, time consuming and labor intensive. Additionally, the crop tree approach does not allow for the collection of harvested material. As an alternative, strip-thinning could be applied in a cost-effective and efficient manner in young stands; however, there is little a priori knowledge to predict the quality and growth rate of stands treated in this fashion. The few published studies generally indicate accelerated stand development and improved growth following strip thinning in young stands, (e.g., Bella and DeFranceschi 1982, McCreary and Perry 1983, Cain 1993, Schuler and Robison 2009), but they offer very little insight as to the magnitude of the response in young Appalachian hardwoods stands.

The feasibility of strip thinning relies on the availability of equipment and markets for small diameter stems. Recently, many prototypes and some commercially available harvesting machines have been marketed for operating in forest conditions characterized as having high-density, small diameter stems (Dykstra 2010, Roise and others 2009). Certainly, without a suitable

[1]Jamie Schuler, Assistant Professor, and Ashlee Martin, Graduate Student, West Virginia University, Division of Forestry and Natural Resources, Morgantown, WV 26506

Citation for proceedings: Schweitzer, Callie J.; Clatterbuck, Wayne K.; Oswalt, Christopher M., eds. 2016. Proceedings of the 18th biennial southern silvicultural research conference. e–Gen. Tech. Rep. SRS–212. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 614 p.

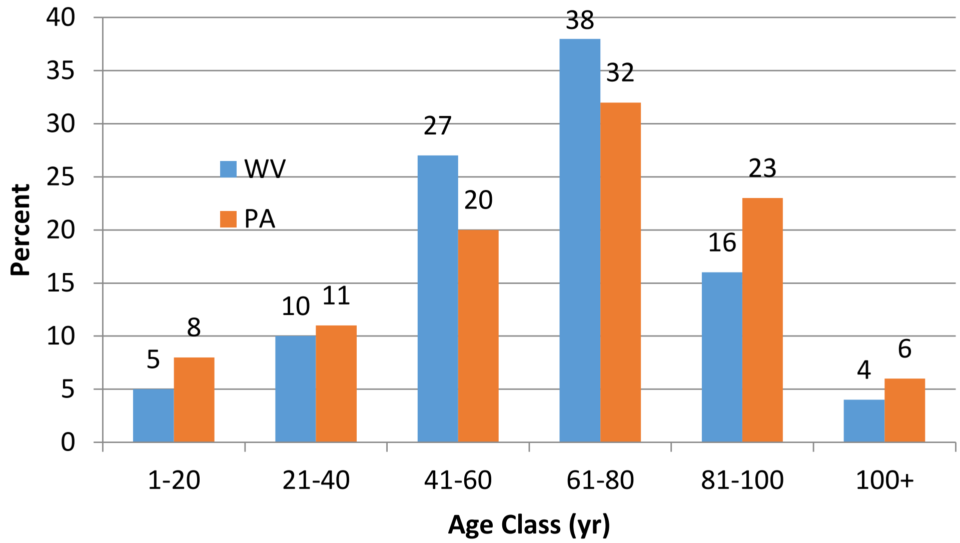

Figure 1—Age class distribution among forest stands in PA and WV (FIA 2007).

market for small diameter biomass, these strip thinning treatments will result in a significant expense to the landowner. The largest potential use for this biomass is for energy production. Interest in utilizing trees as a woody feedstock for bioenergy development remains high as the U.S. attempts to reduce fuel imports and reduce foreign reliance for its energy needs. Utilizing this technology, harvesting previously non-merchantable trees from natural stands for use as a bioenergy feedstock would alleviate the marketing constraints and increase the number of silvicultural management options for stands with high numbers of small diameter stems, poorly formed or defective trees, and non-merchantable species.

Once considered a drawback to managing young stands (Trimble 1973), the significant sprouting potential of Appalachian hardwoods can offer a considerable opportunity when managing for woody feedstocks and wildlife. Coppicing is a management strategy that relies on the development of new stems from stump sprouts or root suckers. Coppicing young stands allows for the repeated harvests on short rotations (e.g., 3-5 years). This sequence of activities can be repeated for a long period of time. The result is a sustainable system of forest management which is capable of producing a large amount of biomass. The coppice system has been widely promoted in the parts of the northeastern US for growing short rotation woody crops biomass using shrub willows grown under a 3 year harvest cycle (Heller and others 2003). Historically, this method has been in practice throughout Europe for centuries, where woodlands are repeatedly harvested for fuelwood.

A variant of the coppice system includes *standards*, which allows for the retention a few non-coppiced stems for other values such as timber production, mass production, and aesthetics. This modified coppice system that includes standards can achieve a suite of desired commodity and non-commodity objectives and diversify the forest landscape in the Appalachians by providing opportunities to manage young stands, generate additional income through woody feedstock production, and enhance wildlife habitat, all while maintaining the traditional sawtimber forest products for which the Appalachian hardwood forests are well known.

The coppice with standards method is untested in natural stands under the scenario envisioned here. This study will address the feasibility of such systems for improving growth rates of trees in residual strips, as well as providing yield estimates for each coppice cycle. Short rotation coppice systems can persist 5-7 cycles until significant reductions in yield occur. In the proposed system, the width of the coppiced strips will affect the long-term production, since canopy encroachment from the uncut residual strips will shade the coppice regrowth. Our objective was to determine the effect of cut strip width and position within the cut strip on the development and quantity of woody biomass produced.

METHODS

Strip thinning occurred on three upland sites located on the West Virginia University Research Forest (Monongalia Co., WV) in March and April 2014. Each stand was regenerated using shelterwood methods, with the final removal cut occurring 10 years prior to this study. Species composition on this site were representative of other forests in the Allegheny Plateau. The most common species included black cherry (*Prunus serotina*), red oak (*Q. rubra*), red maple (*A. rubrum*), yellow-poplar, and black birch (*B. lenta*) at 33, 13, 12, 12, and 9 percent of stand density, respectively. At the time this study was initiated, the developing stands averaged 3,000 stems/ac and 1.8 inches d.b.h.

For each treatment plot, five pairs of alternating cut and leave strips were established using chainsaws to harvest stems (fig. 2), with strips oriented in a N-S direction. Three different cut strip widths (8, 12, and 16 feet) were examined. Leave strips were 8 feet wide regardless of cut strip width. The measurement plots were restricted to the center three cut strips and two residual strips. Stump height in the cut strips was approximately 4 inches. Each treatment was repeated once on each of the three sites.

The first year re-growth of woody vegetation was estimated on 3 subplots per measurement strip using a 5 feet wide plot with a length equal to the cut strip width. In each subplot, the woody vegetation was clipped and samples were dried at 65 degrees C, and the weight recorded. In addition, samples were separated based on position (west edge, center, east edge) to assess the impact of edge. A 2.6 feet x 5 feet plot was delineated within each subplot to partition biomass growth on the east and west edges of the cut strip as well as for the center of the cut strip. Browse was recorded as present/absent for each stem.

All stems >1 inch d.b.h. in the residual uncut strips were tagged on two, 60 feet long measurement plots per treatment plot. In addition, three 1/100 ac plots were assigned to a uncut area to serve as control plots that were not impacted by the strip thinning. All stems within the control plots were also tagged and measured. All tagged stems were remeasured at the end of the first growing season following release.

Biomass and residual tree diameter growth were compared by cut strip width treatment using ANOVA with subsampling. Overall treatment effects and Tukey mean separation tests were assessed at $P \leq 0.05$. SAS 9.3 (SAS, Inc, Cary, NC) was used for statistical analyses.

RESULTS

Woody biomass was recorded separately for stem sprouts and new seedlings. Sprout biomass varied by cut strip width (P=0.02), with each successively wider strip producing statistically greater biomass. Sprout biomass averaged 1.52, 3.00, and 5.97 oven dried (od) tons per cut ac for 8, 12, and 16 feet strips, respectively. Sprout biomass was greatest in the center of each strip. Biomass on east and west edges were significantly less (56 and 73 percent, respectively) of the biomass present on the center plots (P=0.001). New seedlings represented a very small fraction of the overall biomass. On cut strips, new seedling biomass was 0.019 ton/ cut

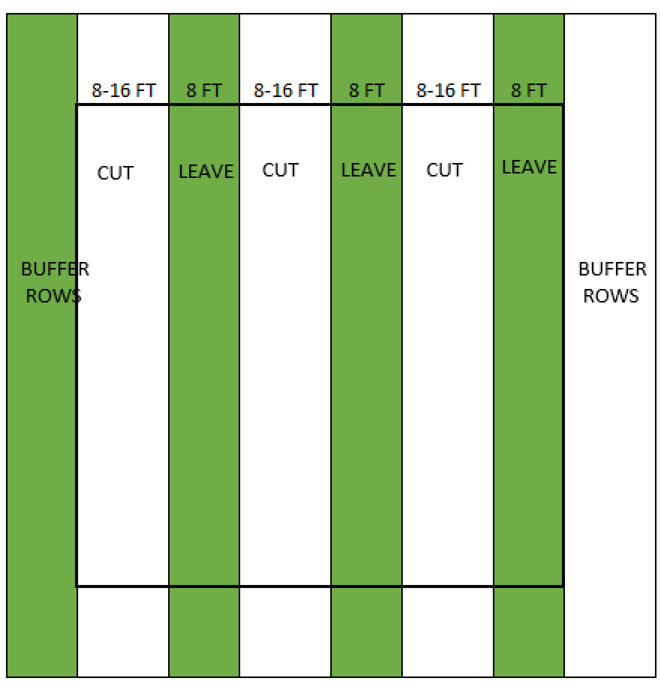

Figure 2—Illustration of plot layout for strip thinning treatment layout. Measurement plots were located in the center plot.

ac on 8 feet strips, 0.013 ton/ cut ac on 12 feet strips, and 0.009 ton/ cut ac on 16 feet strips.

Browsing was very common across the sites. On average, 45 percent of the stems were browsed during the first growing season following treatment. Although browse was widespread, certain species were preferred (Table 1). Sourwood was the most frequently browsed species with 88 percent of stems browsed, although red maple and northern red oak were also browsed more than 70 percent of the time.

Diameter growth for tagged trees in the residual uncut strips ranged from 0.18-0.20 inches for the three strip widths. By contrast, the seedlings on the control plots grew 0.12 inches. However, this difference among treatments was not significant (P=0.11).

DISCUSSION

The coppice yields reported here compare favorably with those reported for commercial plantations (3 to 6 tons/acre/year) in the north central region of the U.S. (Zalesny and others 2011). While bioenergy markets are expected to increase in the future, it is possible that suitable biomass outlets could fail to develop in this region. The advantage of our strip thinning treatments is that they were designed to provide other benefits. As mentioned, young developing stands are infrequent across the landscape (fig. 2). From a wildlife perspective, the browse available in stands past canopy closure is low, and the lack of early succession habitat has been identified for the decline in certain wildlife populations (Litvaitis 2001). By harvesting strips of trees within these younger stands (with closed canopies), the silvicultural objective of reducing stem density can be achieved, while also increasing the availability and persistence of early successional habitat as the cut stems re-sprout. Over time the cut strips will grow and form a closed canopy again. Subsequent harvesting of these stems can perpetuate the cycle again until at some time in the future when the shading from the residual strips prevents regrowth.

In many parts of the central Appalachian region, deer populations can be very high (exceeding 40 deer/ square mile), which is far greater than pre-European settlement estimate of 8-20 deer/sq. mi. Harvesting forest stands in areas with excessive deer pressure often results in regeneration problems. In fact, fencing is a frequent prescription to ensure re-establishment of woody vegetation (Steiner and others 2008). While deer populations at the WVU Research Forest are not considered high, almost one-half of the seedlings were still browsed (table 1), suggesting limited available food sources. Strip thinning existing young stands

Table 1—Occurrence of browsing on coppiced stems

Species	Scientific name	n	% Browsed
sourwood	*Oxydendrum arboreum*	32	88
red maple	*Acer rubrum*	113	75
northern red oak	*Quercus rubra*	108	70
witch hazel	*Hamamelis virginiana*	35	69
spicebush	*Lindera benzoin*	141	67
white oak	*Quercus alba*	9	67
sassafras	*Sassafras albidum*	28	64
devil's walking stick	*Aralia spinosa*	5	60
yellow-poplar	*Liriodendron tulipifera*	50	52
chestnut oak	Quercus montana	12	42
white ash	*Fraxinus americana*	27	37
black birch	*Betula lenta*	52	31
pin cherry	*Prunus pensylvanica*	4	25
black cherry	*Prunus serotina*	282	7
black locust	*Robinia pseudoacacia*	8	0
cucumbertree	*Magnolia acuminata*	1	0

may also serve a secondary benefit in that besides fencing, managers may be able to disperse the deer population across the landscape so to not allow them to overwhelm any one area. Again, an integrated forest management plan that includes strip thinning of young stands (coppice with standards) at appropriate spatial positions and temporal periods to coincide with forest regeneration activities, will improve the overall sustainability of the forested landscape.

The silvicultural treatment of young age classes provides a convenient mechanism to transform the landscape without negatively impacting the future value and sustainability of forest stands. By focusing management efforts earlier in the rotation, future commercial operations can be much more valuable and provide valuable benefits that would otherwise not be available (Siry and others 2004). While the treatments employed in this study did not statistically affect diameter growth of saplings in the residual strips, the first year change in diameter for saplings remaining in the residual strips was more than 1.5 times the average diameter growth on control plots. The limitation to this method of reducing densities in young stands is the inability to alter species composition, as strip thinning does not allow for selection of individual stems.

In order for a system like the one describe here to become practical, managers must have reasonable predictions concerning effects on the residual stand, the amount of biomass/browse being produced, and the expected longevity of the system. The experiment described here was designed to address these questions.

LITERATURE CITED

Bella, I.E.; DeFranceschi, J.P. 1982. Growth of lodgepole pine after mechanical strip thinning in Alberta: 15-year results. *Forestry Chronical.* 58(3): 131-135.

Cain, M.D. 1993. Ten-year results from precommercial strip-thinning: paradigm lost or reinforced? Southern Journal of Applied Forestry. 17(1): 16-21.

Dykstra, D.P. 2010. Extraction and utilization of saltcedar and Russian olive biomass. In: Shafroth, P.B.; Brown, C.A.; Merritt, D.M., eds. Saltcedar and Russian olive control demonstration act science assessment. Scientific Investigations Report 2009-5247. Fort Collins, CO: U.S. Geological Survey: 103-116.

Forest Inventory and Analysis. 2007. http://nrs.fs.fed.us/futures/current_conditions/states/?state=WV. [Date accessed: January 17, 2013].

Greenberg, C.H.; Collins, B.; Thompson III, F.R.; McNab, W.H. 2011. Introduction: What are early successional habitats, why are they important, and how can they be sustained? In: Greenberg, C.; Collins, B.S.; Thompson III, F., eds. Sustaining young forest communities. Managing Forest Ecosystems, Vol. 21. The Netherlands: Springer: 1-10.

Heller, M.C.; Keoleian, G.A.; Volk, T.A. 2003. Life cycle assessment of a willow bioenergy cropping system. Biomass and Bioenergy. 25(2): 147-165.

Litvaitis, J.A. 2001. Importance of early successional habitats to mammals in eastern forests. Wildlife Society Bulletin. 29(2): 466-473.

McCreary, D.D.; Perry, D.A. 1983. Strip thinning and selective thinning in Douglas-fir. Journal of Forestry. 6(1): 375-377.

Miller, G.W.; Stringer, J.W.; Mercker, D.C. 2007. Technical guide to crop tree release in hardwood forests. University of Tennessee Extension Publication PB-1774. Knoxville, TN: University of Tennessee. 24 p.

Pham, C.H. 1985. Thinning of young natural hardwood regeneration in southeastern West Virginia. In: Dawson, J.O.; Majerus, K.A., eds. Proceedings of the 5th central hardwood forest conference. Urbana-Champaign, IL: University of Illinois: 25-34.

Robison, D.J.; Schuler, J.L.; Jervis, L. [and others]. 2004. Individual tree release and enrichment planting in young natural upland hardwoods. In: Conner, K., ed. Proceedings of the 12th biennial southern silvicultural research conference. Gen. Tech. Rep. SRS-71. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station: 283-286.

Roise, J.P.; Hannum, L.C.; Catts, G.P. 2009. Machine system for harvesting small diameter woody biomass and reducing hazardous fuels: a developmental report. In: Proceedings of the 2009 ASABE Bioenergy Engineering Conference. Bellevue, WA: 1-15.

Schuler, J.L.; Robison, D.J. 2006. Stand development and growth response of 1 to 6 year old natural upland hardwoods to silvicultural treatments. Forest Ecology and Management. 232 (1/3): 124-134.

Schuler, J.L.; Robison, D.J. 2009. Response of reproduction and residual overstory trees to even-aged regeneration methods in southern hardwoods. In: Columbus, F., ed. Forest regeneration: ecology, management and economics. New York: Nova Publishers: 71-86.

Siry, J; Robison, D.J.; Cubbage, F.W. 2004. Economic returns model for silviultural investments in young hardwood stands. Southern Journal of Applied Forestry. 28(4): 179-184.

Smith, H.C.; Lamson, N.I. 1983. Precommercial crop-tree release increases diameter growth of Appalachian hardwood saplings. Res. Pap. NE-534. Broomall, PA: U.S. Department of Agriculture Forest Service, Northeastern Forest Experiment Station. 5 p.

Steiner, K.C.; Finley, J.C.; Gould, P.J. [and others]. 2008. Oak regeneration guidelines for the central Appalachians. Northern Journal of Applied Forestry. 25(1): 5-16.

Trimble, G.R. 1973. Response to crop-tree release by 7-yr-old stems of yellow-poplar and black cherry. Res. Pap. NE-253. Broomall, PA: U.S. Department of Agriculture Forest Service, Northeastern Forest Experiment Station. 10 p.

Zalesny, R.S.; Cunningham, M.W.; Hall, R.B. [and others]. 2011. Woody biomass from short rotation energy crops. In: Zhu, J. [and others], eds. Sustainable production of fuels, chemicals, and fibers from forest biomass. American Chemical Society Symposium Series. Washington, DC: American Chemical Society: 27-63.