Two-Age Silviculture on the Monongahela National Forest—Managers and Scientists Assess 17 Years of Communication

Gary W. Miller, James E. Johnson, John E. Baumgras, and R. Gary Bustamente[1]

Abstract.—This report describes the development of two-age silviculture on the Monongahela National Forest and provides an assessment of the practice as it is applied today. Silviculturists at each ranger district provided a chronology of the communication process between managers and scientists that led to current stand treatment prescriptions. In addition, data were collected from a total of 20 recently treated stands on four ranger districts. This information was used to assess two-age systems in terms of current stand conditions and the implications for future species composition and stand structure. Comments obtained from land managers and the accompanying field data are used to illustrate how the ongoing communication process helped to provide feedback, clarify objectives, motivate useful research, define feasible options, and produce a flexible land management tool.

INTRODUCTION

For many years, clearcutting was an important silvicultural practice for harvesting and regenerating new stands of central Appalachian hardwoods on the Monongahela National Forest (MNF). Public opposition to the visual impacts of clearcutting led land managers to seek alternatives that provide adequate light and seedbed conditions for tree regeneration, but are more aesthetic after cutting while the new stand becomes established (Smith and others 1989). Since 1991, clearcutting has been prescribed on a decreasing number of acres on the MNF and is being replaced in part by two-age silvicultural systems, alternative regeneration methods that show promise in sustaining multiple forest benefits such as aesthetics, species diversity, high-quality wood products, and habitat for many wildlife species.

This paper describes an ongoing partnership between land managers on the MNF and scientists at the Northeastern Forest Experiment Station (NEFES) that led to the expanded use of two-age silvicultural systems to meet emerging management objectives. First, background information is provided to clarify silviculture terminology and to chronicle the history of two-age silviculture as it has been applied on the MNF. Second, the process of communication between managers and scientists is summarized to demonstrate a possible model for others to use in developing and implementing innovative silvicultural practices. Third, results from a recent study of 20 two-aged stands located throughout the MNF are provided to illustrate the current status of this practice in three forest cover types.

BACKGROUND

Two-aged stands resemble those treated with a seed-tree or shelterwood practice in that a given number of overstory trees are retained while all other trees are cut (Fig. 1). However, to maintain a two-age stand structure, the residual trees are not cut once the reproduction becomes established as in even-age practices. Instead, the harvest of the residual trees is deferred until new reproduction is between 40 and 80 years old, generally one-half to a full sawtimber rotation. The result is a two-age stand structure. Once the two-age stand structure is established, similar practices can be repeated at intervals of 40 to 80 years to maintain this condition for many years. Management of some stands on the MNF is based on a 200-year rotation, so two-age cuts could be applied several times per rotation.

Silviculturists use several terms to describe regeneration methods that effectively create a two-age stand structure. These terms include deferment cutting, clearcutting with reserves, shelterwood with reserves, and irregular shelterwood. Deferment cutting and clearcutting with reserves are used to describe practices in which residual trees are retained for an entire sawtimber rotation to achieve goals other than reproduction. The other terms describe practices in which residual trees are retained to achieve goals other than regeneration, but not necessarily for an entire rotation. Thus, the terms used to describe two-age regeneration methods are defined by how long the residual trees are to be retained. In practice, residual trees can be retained for different periods of time to achieve different goals. For this reason, two-age silviculture is a general term that describes a host of regeneration methods designed to maintain and regenerate a stand composed of two distinct age classes that are separated by more than 20 percent of the planned rotation.

Silvicultural systems that promote a two-age stand structure have been initiated on national forests, state forests, industrial forests, and to a lesser degree on nonindustrial private forests in many eastern states. A similar practice called "insurance silviculture" was applied in Pennsylvania to retain a seed source in the event of a regeneration failure (Bennett and Armstrong 1981). The reasons for using two-age silvicultural methods are twofold: to regenerate a variety of species, particularly those that are shade-intolerant, and to mitigate the perceived negative visual impacts of clearcutting. Similar to clearcut stands, natural regeneration that follows two-age regeneration methods includes a variety of both shade-tolerant and shade-intolerant commercial hardwoods (Trimble 1973; Miller and Schuler 1995). Unlike

[1]Research Forester, USDA Forest Service, Northeastern Forest Experiment Station, Parsons, WV; Associate Professor, Virginia Polytechnic Institute and State University, Blacksburg, VA; Research Forest Product Technologist, USDA Forest Service, Northeastern Forest Experiment Station, Morgantown, WV; Forest Silviculturist, USDA Forest Service, Monongahela National Forest, Elkins, WV, respectively.

Figure 1.—A two-aged central Appalachian hardwood stand 3 years after treatment.

clearcutting, however, the presence of residual overstory trees improves aesthetics and maintains a more diverse vertical stand structure that may benefit certain wildlife species (Pings and Hollenhorst 1993). As the new cohort develops beneath the large overstory residuals, the stand has two distinct height strata. These strata provide a diverse habitat for songbirds that forage in high canopy trees (Wood and Nichols 1995), as well as those that require a brushy cover characteristic of a young even-aged stand (DeGraaf and others 1991). Two-age silvicultural practices also provide an opportunity to retain species that produce hard mast for wildlife food.

Early History

During the 1970's, forest managers on the MNF began considering alternative regeneration methods in response to public criticism of clearcutting. An employee of the USDA Forest Service visited Europe and learned of deferment cutting, a two-age regeneration practice used to manage larch, pine, and oak-beech stands (Kostler 1956; Troup 1966) to improve the aesthetics of even-age practices that remove the overstory over a relatively short interval. In 1979, an experimental deferment cut was applied on the Greenbrier Ranger District in cooperation with NEFES scientists at Parsons, West Virginia. Five additional experimental deferment cuts were applied on the Cheat and Marlinton Ranger Districts and the Fernow Experimental Forest by 1983. These study sites, which range from 10 to 15 acres, have since provided preliminary silvicultural information on two-age regeneration methods for forest managers who are interested in alternatives to clearcutting.

After the experimental deferment cuts were applied, the study sites served as valuable demonstration areas where students and forest managers from the forest industry and various public agencies were able to see two-age silviculture in action. As these two-aged stands developed through the 1980's, preliminary reports were published on residual tree growth and the development of regeneration (Beck 1986; Smith 1988; Smith and others 1989). In addition, forest managers on the MNF were able to visit these stands over the course of several growing seasons to monitor the progress of the new reproduction and to evaluate their potential as an alternative to clearcutting.

Recent History

In 1990, a team was organized on the MNF to define and evaluate possible alternatives to clearcutting. This team included experts from many disciplines: wildlife biology, landscape architecture, silviculture, and forestry research. Two-age management was included as a viable alternative for regenerating shade-intolerant species and improving aesthetics. The first operational two-age cuts were applied on the Potomac and Greenbrier Ranger Districts in 1991. These stands also served as demonstration areas for managers from other districts.

Since then, clearcutting has been prescribed on a decreasing number of acres. Since 1990, regeneration treatments were prescribed on an average of 1,500 acres/year on the MNF. The proportion of acres on which clearcutting was prescribed declined from 98 to 45 percent from 1990 to 1995. In most situations, two-age regeneration treatments were prescribed instead of clearcutting, and this trend is expected to continue.

In 1995, personnel from the MNF, NEFES (Parsons, WV), and Northeastern Area State and Private Forestry (Morgantown, WV) collaborated on a Marker Training Workshop for timber marking crews on the MNF. Silviculturists and marking crews from each district attended a 2-day training session that focused on proper residual stand stocking levels and criteria for identifying leave-trees to meet various management objectives. This workshop included hands-on marking exercises in various forest cover types. An important result of this workshop was that the concerns of district silviculturists, specialists from non-timber disciplines, and administrators on the forest were included in the marking guidelines. As a result, timber marking became more consistent throughout the forest, and marking crews were better prepared to implement the intended prescriptions.

The process of evaluating two-age practices and improving application methods on the MNF is continuing. The aesthetics of residual stands were compared to those resulting from other silvicultural methods (Pings and Hollenhorst 1993). A study of songbird density and nesting success in two-aged stands was conducted from 1992-1996 (Wood and Nichols 1995; Miller and others 1995). Logging economics and product market options also have been investigated (Miller and Baumgras 1994; Baumgras and others 1995). New studies are planned to develop improved methods for increasing the proportion of oak regeneration that develops before and after two-age cuts are applied.

COMMUNICATIONS

The following sections describe highlights in the ongoing partnership between land managers and scientists that led to increased use of two-age silviculture as an alternative to clearcutting on the MNF. The first two sections describe how management objectives and stand treatment prescriptions evolved during this process, followed by recommendations from forest managers for future research needed to improve the effectiveness of two-age regeneration methods. Finally, some suggestions on useful communication tools are offered that might assist other forest management partners in developing and implementing innovative silvicultural practices.

Defining Forest Management Objectives

An important first step in the development of two-age silviculture on the MNF was to narrowly define the problem and to clarify the management objectives so that specialists from a variety of resource management disciplines could work toward a common end. Initially, the problem was defined as the need for practical alternatives to clearcutting. The objectives were to identify alternative regeneration methods that provide for adequate desirable regeneration after harvest operations and improve the aesthetics of treated stands compared to clearcutting.

A range of regeneration methods was evaluated based on their effectiveness in providing the light and seedbed conditions necessary to regenerate desirable species, while improving the post-harvest aesthetics compared to clearcutting. In evaluating potential alternatives, additional management objectives became apparent. For example, group selection, which results in small clearings (0.5-2.0 acres) where desirable regeneration can develop and aesthetics are improved compared to clearcutting, is a viable alternative. However, this alternative would require a dramatic increase in the number of sale acres to regenerate the same number of acres as would be possible through clearcutting. Another objective for alternative harvest methods called for silvicultural practices that would not involve sale acres beyond practical limits. While group selection is a sound silvicultural practice, other regeneration methods (in addition to group selection) were needed to address concerns about sale acreage.

The implications for wildlife habitat also were considered in evaluating potential alternatives to clearcutting. Several options such as seed tree, shelterwood, and two-age practices, which entail the retention of residual trees, were recognized as improvements over clearcutting because residual trees provide mast, dens, perches, and habitat for foraging and nesting for many wildlife species. Moreover, two-age practices were superior because residual trees are retained for a relatively long time compared to seed tree and shelterwood practices. As a result, improved wildlife habitat also emerged as one of the management objectives used to define suitable alternative harvest methods.

As resource management specialists and scientists worked toward defining a suitable alternative to clearcutting, various silvicultural options also were evaluated in terms of their potential effect on Forest Plan goals and management prescriptions. For example, each alternative was evaluated in terms of its effect on recreation, aesthetics, harvest volumes and acreages, and economics. The interaction among the various resource specialists, scientists, and administrators that occurred during this process resulted in a valuable exchange of ideas and a more integrated approach to land management that continues today. Through this process, land managers at the district level became better prepared to prescribe stand treatments that account for many management objectives involving multiple forest resources.

Stand Prescriptions Then and Now

Based on information provided by forest managers at each of the ranger districts, stand prescriptions for two-age regeneration methods have changed since 1991 as individual silviculturists build on their experience with this relatively new practice. The initial prescriptions called for residual basal areas ranging from 20 to 40 ft^2/acre, with the residual stand composed of mostly sawtimber trees (Smith and Miller 1991). Actual residual stocking levels after harvest operations were greater than intended because marking crews were accustomed to leaving more trees as is done in thinnings or selection cuttings. There also was a tendency to remove most of the larger, high-quality sawtimber and retain the smaller, low-quality sawtimber and poletimber. This was due in part to the perceived risk of grade loss, logging damage, or grade reductions from epicormic branching to residual trees during and after harvest operations.

As silviculturists and marking crews on the districts gained more experience with this practice, and additional information about the response of residual trees was provided by scientists, stand prescriptions have changed accordingly. In general, the more recent stand presciptions reflect an increased emphasis on enhancing the long-term species composition of the regeneration and quality of the residual trees. More recent prescriptions require lower residual stand density, ranging from 20 to 30 ft^2/acre with about 15 to 20 sawtimber trees/acre. These prescriptions also call for cutting all other stems 1.0-inch d.b.h. and larger. Lower residual densities are more favorable to the reproduction of desirable shade-intolerant species, particularly over long periods of time when crown expansion of residual trees may interfere with reproduction. Current prescriptions also call for leaving larger, high-quality, long-lived sawtimber trees because vigorous codominant trees are less likely to die or suffer grade loss after treatment than trees in weaker crown positions (Miller 1996).

Guidelines for choosing residual trees to improve wildlife habitat also have improved as forest managers gain experience with two-age regeneration methods. This improvement is the result of continued interaction among personnel of several resource disciplines, since the first two-age cuts were applied on an experimental basis in 1979. Desirable residual trees for mast production include American beech, black gum, hickory, and the oaks. For example, white oaks are preferred residual trees for wildlife and timber because they are long-lived and produce acorns for a relatively long time. For habitat diversity, residual trees also include cull trees with large cavities, standing dead trees, and conifers such as hemlock, pines, and spruces.

Research Results and Future Needs

Two-age regeneration practices were applied on an experimental basis in six central Appalachian hardwood stands on the MNF and the Fernow Experimental Forest from 1979 to 1983. These areas ranged from 10 to 15 acres on site index 70 and 80 for northern red oak and provided preliminary results on the growth and development of the residual overstory trees and the species composition and quality of reproduction that became established after the treatments were applied. Such results were shared with silviculturists on the MNF over the years and later published. The following sections provide a brief review of research results that were helpful in developing stand prescriptions in use today, followed by a summary of new research that forest managers need for the future.

A Review of Research Results

D.b.h. Growth.—In general, residual trees after two-age regeneration harvests exhibited faster diameter growth compared to control trees in uncut stands over the 10-year study period, though growth response varied by individual species (Miller and others 1995) (Table 1). Residual trees were free-to-grow with an average crown growing space of 20 feet to adjacent residual tree crowns after treatment (Miller and Schuler 1995). Control trees also were codominant, but they had crown competition on all sides during the study period. For black cherry, average d.b.h growth of untreated controls exceeded that of released trees, though the difference was not statistically significant (P = 0.48). For all other species tested, released trees had greater average d.b.h. growth compared to that for control trees.

Table 1.—Ten-year d.b.h. growth for central Appalachian hardwoods released by deferment cutting versus unreleased controls

Species	Treatment	Number of trees	Initial d.b.h.	10-year d.b.h. growth	P[a]
			- - - - - - -*Inches*- - - - - - -		
White oak	Release	59	14.5	2.89	<0.01
	Control	14	19.6	1.02	
Chestnut oak	Release	12	14.4	2.18	0.13
	Control	6	17.2	1.57	
Red oak	Release	200	16.7	3.34	<0.01
	Control	58	19.9	1.92	
Yellow-poplar	Release	193	17.8	3.65	<0.01
	Control	46	17.3	1.95	
Black cherry	Release	66	14.2	2.30	0.48
	Control	47	16.9	2.21	
Basswood	Release	18	15.1	2.93	<0.01
	Control	9	18.6	1.47	

[a]P= probability of a larger F for 10-year growth; analysis of covariance means adjusted for initial dbh.

D.b.h. growth of released trees was 45 to 134 percent faster than controls, led by white oak, yellow-poplar, basswood, and red oak. White oak, chestnut oak, red oak, and basswood grew faster the second 5 years compared to the first 5 years after treatment. For yellow-poplar, residual trees grew faster during the first 5 years after treatment, though growth during the second 5 years continued to exceed that of controls.

Survival and Quality of Residual Trees.—A total of 667 residual trees were monitored for survival and quality after two-age cuts were applied (Miller 1996). After 10 years, 89 percent of residual trees had survived. A total of 6 trees (1 percent) were destroyed or removed due to inadvertent damage during logging. After logging, 22 trees (3 percent) died within 2 years, and an additional 38 trees (6 percent) died between the 2nd and the 5th year. Mortality after the 5th year was greatly reduced; only an additional 7 trees (1 percent) died by the end of the 10th year. Mortality was greatest for black cherry (more than 20 percent), least for yellow-poplar (less than 5 percent).

The risk of residual trees developing new epicormic branches increases as the intensity of the cut increases (Trimble and Seegrist 1973). Epicormic branching increased for all species within 2 years after two-age cuts compared to pretreatment levels. Between year 2 and 10 there was no significant increase in the number of epicormic branches on the butt 16-foot log sections. Epicormics continued to increase on the second 16-foot log section for black cherry, red oak, and yellow-poplar. The net effect on quality was that 12 percent of residual trees exhibited a reduction in grade (Hanks 1976) due to new epicormic branches over the 10-year study period. Of the few grade reductions observed, white oak, northern red oak, and black cherry were most susceptible, while less than 1 percent of yellow-poplar trees had lower grades due to epicormic branching.

Logging operations resulted in bark wounds (exposed sapwood) on about one-third of residual deferment trees. Half of wounded trees had wounds less than 50 in^2, and half had larger wounds. Most of the wounds were located on the lower portions of the bole and were caused by skidding logs too close to residual trees. More than 95 percent of logging wounds that were less than 50 in^2 in size callused over and were closed within 10 years after logging. Based on the observed rate of closing over a 10-year period, Smith and others (1994) estimate that larger wounds up to 200 in^2 in size will close within 15 to 20 years after logging.

Reproduction.—Reproduction observed after two-age cuts was similar to that observed after clearcutting (Miller and Schuler 1995). Before two-age cuts were applied, small reproduction (less than 1.0 inch d.b.h.) averaged 3,019 stems/acre, with 50 percent in shade-tolerant species (maples and American beech), 37 percent in shade-intolerant species (black cherry and yellow-poplar), and 13 percent in intermediate-shade-tolerant species (oaks and white ash). More than 80 percent of survey plots (0.001-acre) had at least one commercial hardwood species present, and more than 60 percent of survey plots had sugar maple or American beech present.

Two years after harvest, small reproduction (< 1.0 inch d.b.h.) in the study areas averaged 9,100 stems/acre of commercial species composed of 60 percent seedling-origin stems. There also were more than 14,000 stems/acre of noncommercial woody species. More than 95 percent of survey plots had a commercial stem present. Five years after harvest, the canopy of the new age class developing beneath the residual overstory had not closed. Large woody reproduction (≥ 1.0 inch d.b.h.) after 5 years included more than 300 stems/acre of commercial species and 100 stems/ acre of noncommercial species.

After 10 years, the canopy of the new age class developing beneath the deferment trees was nearly closed, and codominant trees averaged 35 feet tall. Large reproduction included 991 stems/acre of commercial species, with 450 good, codominant stems/acre exhibiting the potential to become high-quality crop trees in the future. On excellent growing sites, northern red oak reproduction was sparse, averaging only 10 potential crop trees/acre. Other codominant, commercial species reproduction included a variety of both shade-tolerant and shade-intolerant species distributed over 74 percent of the stand area.

Songbird Density and Nest Success.—Songbird density and nest success in clearcut and two-aged stands were compared 10 years after cutting treatment (Miller and others 1995; Wood and Nichols 1995). Songbird density estimates were greater (649 vs. 522 birds/ 40 ha; P< 0.001) in the two-aged stands. Interior-edge (359 vs. 320 birds/40 ha; P<0.001) and edge (83 v. 12 birds/40 ha; P<0.001) species were more abundant in two-aged stands. The abundance of interior species was similar (207 vs. 190 birds/40 ha; P >0.10) for two-aged and clearcut stands, respectively. Nest survival (151 nests) was not significantly different between the two-age and clearcut treatments (50% vs. 54%; P>0.10), and predation by mammals was the most common cause of nest failure.

Future Research Needs

As silviculturists on the MNF gained experience in prescribing two-age regeneration treatments and considered the implications of such practices for the future, the following questions arose.

Harvesting systems and economics.—For unconventional logging operations based on cable and helicopter systems, what is the optimal pattern of residual trees to minimize logging cost and damage to residual trees? How do local markets influence the cutting cycle and product mix for harvests in two-aged stands? How can two-age regeneration methods be applied in stands where there is limited merchantable volume and value?

Regeneration.—How does residual stand density and structure affect species composition and quality in the future? What silvicultural treatments are needed before two-age cuts are applied to increase the reproduction of target species such as northern red oak? How does the logging system and season of logging operations affect reproduction? What impact do residual trees have on the genetics of reproduction in the future? What impact do deer have on reproduction?

Residual trees.—How does increased diameter growth affect tree quality for veneer products? How do logging wounds affect the quality and vigor of residual trees? How do tree age and species affect growth, survival, and seed production? What is the rate of crown expansion for residual trees of different species?

Non-timber Issues.—How do two-age stand structures affect aesthetics in middle-ground views (0.25-4 miles)? How do residual tree species, vertical structure, and density affect aesthetics? How do aesthetics change as the new stand develops and vertical structure becomes more diverse? How do residual stand structure and density affect songbirds, small mammals, and game species over time?

As two-age regeneration methods are used to meet emerging forest management objectives, additional research is needed to better understand the implications of this innovative practice. It is important to define linkages among abiotic and biotic ecosystem components that may be affected by maintaining two vertical strata of woody vegetation over extended periods of time. For example, additional studies are needed to determine the relationship between stand density and structure on game and nongame wildlife communities. And because the forest is always changing, more research is needed to define the susceptibility of residual trees to attacks by insects and pathogens over much longer time periods. This practice may also affect product options in the future. Residual trees grow rapidly after two-age regeneration cuts, and such growth rates may influence product quality and utilization options.

Suggested Communication Tools

Land managers and scientists utilized several communication tools during the last 17 years to improve and develop two-age stand management prescriptions. The following suggestions are four possible strategies that might be helpful to others who are considering the use of unconventional silvicultural methods: the use of demonstration areas, holding meetings in the field, conducting forest-wide training sessions, and sharing preliminary information.

The stands in which experimental two-age cuts were applied served as valuable demonstration areas for sharing information. Initially, forest managers had the opportunity to evaluate the general appearance of a two-aged stand and ask important questions about the long-term implications of such treatments. The initial visits prompted numerous questions about the fate of residual trees and the new reproduction. As a result, the demonstration areas challenged land managers and scientists to better understand the implications of two-aged stands. As the stands developed, these areas also provided a medium for presenting and interpreting preliminary results.

The demonstration areas were located throughout the forest on three ranger districts, so forest management personnel had "ownership" and were able to visit these areas and monitor development with minimal investment of time and expense. Later, these areas served as a place to hold meetings, train personnel, and educate the public about the objectives of two-age silviculture. Thus, it is important that demonstration areas are accessible and inexpensive to visit for maximum impact on communications.

Another successful communication strategy entailed holding meetings among resource specialists, district silviculturists, and the forest leadership team in the field, against the backdrop of one or more of the demonstration areas. These sessions were two-way exchanges of questions and answers for personnel at different levels of management. The outdoor forum promoted an open dialog of ideas and reduced confusion about the management objectives and/or the long-term implications of using two-age regeneration methods. In particular, such meetings were an efficient use of time because participants usually could direct their questions and answers to tangible issues such as epicormic branching on residual trees, characteristics of forest roads, or vertical structure of the residual stand that are visible on the site. In addition, scientists often were invited to such meetings to provide updated research results and to stay abreast of new research needs.

Table 2.—Percent of trees reduced in grade due to logging wounds or epicormic branching after deferment cutting[a]

Species	Small sawtimber (12-16 inches d.b.h.)				Large sawtimber (18 inches d.b.h. and larger)			
	n	Number of trees	%	95% CI[b]	n	Number of trees	%	95% CI
Yellow-poplar	23	1	4	<1-34	11	0	0	0-46
Black cherry	59	3	5	<1-11	38	3	8	1-22
Northern red oak	43	2	5	<1-19	32	1	3	<1-16
White oak	19	0	0	0-20	9	1	11	<1-48
Chestnut oak	22	0	0	0-11	15	0	0	0-33
Sugar maple	61	4	7	<1-12	20	0	0	0-17
Red maple	49	1	2	<1-12	10	0	0	0-49
White ash	41	4	10	<1-18	20	0	0	0-17
American basswood	17	0	0	0-26	3	0	0	0-71

[a]Data from 20 stands on the MNF where operational two-age cutting was applied.
[b]95% confidence interval.

The forest-wide training for marking crews helped to make two-age stand treatment prescriptions more consistent across the forest. Marking crews and silviculturists from all districts had the opportunity to interact with each other through hands-on marking exercises in the field. Participants practiced selecting residual trees, asked questions of each other, and resolved confusion about management objectives associated with two-age systems. These activities clarified the criteria for selecting residual trees for a range of objectives. As a result, the 2-day training session prepared each marking crew to better implement a stand prescription as intended by the silviculturist.

Scientists also made an effort to share preliminary research information with land managers as it became available. This was accomplished through preliminary written reports (before the formal publication of results), telephone conversations, and field visits to the demonstration areas. Obtaining preliminary research results at frequent intervals helped the silviculturists make more rapid progress toward developing appropriate stand prescriptions. Similarly, presenting such information and obtaining feedback helped the scientists focus on the high-priority needs of the land manager. This exchange of preliminary information is ongoing.

There also are opportunities to communicate the implications of innovative silvicultural practices through existing channels within the Forest Service. For example, two-age silviculture is now part of the Program of Advanced Studies in Silviculture (PASS) throughout Regions 8 and 9. At the forest level, the forest planning process provides an opportunity to involve outside groups in fine-tuning the objectives of silvicultural treatments, which in turn clarifies guidelines for writing stand treatment prescriptions.

ASSESSMENT OF CURRENT PRACTICES

In 1996, data were collected on 20 two-aged stands on the MNF that had been treated two to five growing seasons before the study. This survey was conducted to assess current conditions and to shed light on the implications of two-age cutting on future species composition and wood product quality. Thus, the results presented here on residual tree response and reproduction are preliminary findings that do not necessarily represent the long-term implications of this practice (Johnson and others 1997).

Residual stand quality

A total of 768 individual trees representing nine commercial species were evaluated for tree grade (Hanks 1976), epicormic branches, and logging damage. In general, deferment cutting did not result in significant changes in grade distributions in the first 2 to 5 years after treatment. Among large sawtimber (17.0 inches d.b.h. and larger), 11, 8, and 3 percent of white oak, black cherry, and northern red oak, respectively, exhibited grade reductions due to logging wounds or epicormic branches. Large sawtimber of other species did not exhibit grade reductions. Among small sawtimber (11.0 to 16.9 inches d.b.h.), grade reductions were more common compared to those for large sawtimber (Table 2). The development of epicormic branches was most prevalent on white oak. Suppressed and intermediate trees developed more epicormic branches and had more reductions in tree grade compared to those for codominant and dominant trees. In all of the 20 stands, logging wounds were found on 45 percent of residual trees, and 21 percent of trees had severe wounds larger than 100 in^2. However, the number of trees wounded and the severity of wounds were related to the months in which logging occurred (Fig. 2). Logging damage was greatest during the spring (March-June) and least during the dormant season (November-February). The data indicate that logging damage can be reduced by 50 percent if operations are conducted in the fall and early winter months.

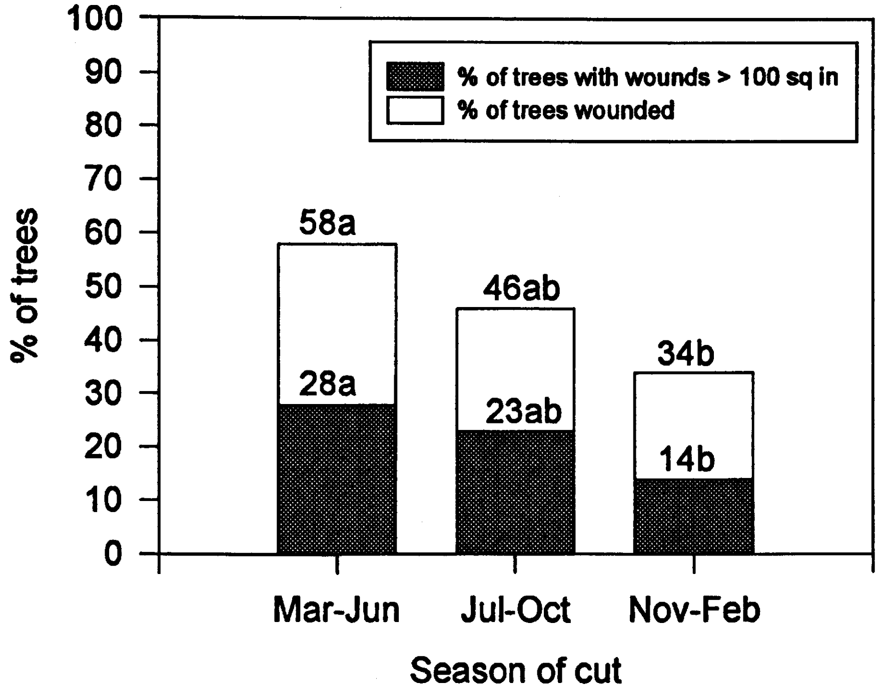

Figure 2.—Mean percent of residual trees with logging wounds. For bars of the same shade, means followed by the same letters are not significantly different at the 0.10 level based on analysis of variance followed by Tukey HSD.

The total number of noncommercial stems was relatively small, representing only 5, 12, and 28 percent of stems present in the beech-cherry-maple, mixed Appalachian hardwood, and mixed oak cover types, respectively. Noncommercial stems included striped maple, dogwood, pin cherry, sassafras, serviceberry, and American hornbeam. These stems are not expected to interfere with the growth and development of commercial species (Miller and Schuler 1995).

As these stands continue to develop, the trees in the new age class will form a height stratum distinct from the larger overstory trees left after logging. Stems present when data were collected will compete for crown position until the canopy of the new age class closes from 10 to 15 years after logging. At this point, most areas have adequate density and distribution of desirable reproduction. However, it is too soon to predict the eventual species composition. Trees that attain a codominant position at crown closure will determine the species composition of these stands for many years to come. Soon after crown closure, preferred crop trees can be given a crown release to assure their survival and competitive position within the stand.

Regeneration

Very small (< 1.0 ft tall) and small (≥ 1.0 ft tall and < 1.0-inch d.b.h.) reproduction was tallied within 1/1,000-acre circular plots, and large reproduction (1.0-inch d.b.h. and larger) was tallied within 1/100-acre circular plots. From 25 to 50 reproduction plots were located along systematic grids within each stand. For very small and small reproduction, stem counts and heights were recorded for each stem observed on a plot. For large reproduction, species, d.b.h., stem origin, quality, and crown class were recorded for each stem observed on a plot.

Stands were grouped by three forest cover types before regeneration results were summarized: beech-cherry-maple at the higher elevations in the Allegheny mountains, mixed Appalachian hardwoods in the coves of the Allegheny Mountains, and mixed oaks in the Ridge and Valley province east of the Allegheny Front. Most of the reproduction present on the survey plots was less than 1.0 ft tall (Table 3). In the beech-cherry-maple stands, reproduction was dominated by American beech, black cherry, and the birches, though many other species also were present. The mixed Appalachian hardwood stands contained the greatest diversity of species, though birches, maples, black cherry, and white ash were most abundant. Reproduction in the mixed-oak stands was dominated by red and sugar maple, birches, and northern red oak, though oak reproduction is difficult to sustain on high-quality growing sites. These results are consistent with other studies of two-age and even-age regeneration practices (Trimble 1973; Miller and Schuler 1995; Beck 1986).

Summary of Results

Results of this study were evaluated by land managers on the MNF and the following preliminary conclusions were drawn:

- Two-age silvicultural systems met the goals for timber, many wildlife species, and aesthetics.
- Residual basal area averaged 39 ft²/acre; 82 percent of residual trees met timber objectives.
- Residual stands contained a mix of species, and 64 percent of residual trees were considered to be low-risk—expected to live more than 20 years after treatment.
- Only 8 percent of residual trees had died or blown over 2 to 4 years after treatment.
- Tree grades were not seriously reduced after treatment.
- The average size of logging wounds and the proportion of trees wounded was greatest for operations conducted from March through June, least from November through February.
- Regeneration was similar in composition and abundance to that observed after clearcutting.

DISCUSSION

Experience with two-age cutting since 1979 indicates that desirable reproduction can be established and will develop into an acceptable new crop for sustained production of

Table 3.—Summary of reproduction present 2-5 years after deferment cutting by forest cover type

Species	Beech-Cherry-Maple		Mixed Appalachian Hdwds		Mixed oaks	
	Very small[a]	Small[b]	Very small	Small	Very small	Small
	Number of stems/acre (% of plots stocked)					
Birches[c]	8,464(62)	1,989(31)	3,502(39)	2,324(24)	2,886(25)	137(9)
Maples	1,717(50)	641(16)	1,116(39)	516(19)	2,259(50)	556(14)
Red oaks	9(1)	3(1)	410(24)	203(11)	582(18)	100(7)
White oaks	0(0)	0(0)	80(8)	254(1)	103(6)	140(3)
Am. beech	2,268(55)	4,591(63)	83(4)	162(4)	20(1)	0(0)
Black cherry	6,357(68)	3,825(44)	820(25)	466(14)	40(2)	45(2)
Hemlock	68(3)	0(0)	0(0)	4(1)	0(0)	0(0)
White ash	38(3)	30(1)	829(22)	499(12)	30(30)	0(0)
Yellow-poplar	404(12)	70(4)	3,271(35)	62(3)	367(13)	18(2)
Am. basswood	0(0)	0(0)	4(1)	12(1)	0(0)	0(0)
Others	305(16)	68(5)	185(14)	396(17)	299(16)	520(20)
Total[d]	19,628	11,217	10,300	4,898	6,586	1,516

[a]Very small reproduction = all stems < 1.0 ft in height
[b]Small reproduction = stems $\geq$ 1.0 ft in height and < 1.0 inch dbh.
[c]Birches include sweet and yellow birch; maples include red and sugar maple; red oaks include northern red, scarlet, and black oak; white oaks include white and chestnut oak; others include blackgum, aspen, and cucumbertree.
[d]Data from 20 stands on the Monongahela National Forest where operational applications of deferment cutting were applied.

many forest benefits. The species composition includes a wide variety of shade-intolerant and shade-tolerant species that is similar to that observed after clearcutting. Cultural practices, such as crop-tree release, can be applied once the canopy of the new age class closes to favor the growth and development of the most desirable stems such as northern red oak.

Residual basal area in the early, experimental deferment cuts averaged 20 ft²/acre. In early operational two-age cuts on the MNF, the target residual basal area ranged from 20 to 40 ft²/acre, with actual residual basal area averaging 39 ft²/acre. More recently, new prescriptions call for 20 to 30 ft²/acre. Although residual trees in the experimental cuts were all potential high-quality sawtimber, residual trees in the operational cuts also included trees to help meet wildlife habitat objectives. In practice, residual trees may be selected by many criteria to help the forest manager achieve a wide range of objectives.

Where residual tree quality is a concern, trees in weaker crown positions or trees that show evidence of stress before treatment are most likely to lose quality. For most species, the strong codominants will not suffer grade reductions after deferment cutting. To reduce logging damage, operations should be conducted during the dormant season from November through January. To reduce windthrow, residual trees should not be selected above skid roads close to the cut bank where roots are disturbed.

To meet regeneration goals, residual basal area should range from 20 to 40 ft²/acre. However, if small sawtimber or poles are retained, maximum residual basal area will be reduced to allow for crown expansion as the overstory trees mature. It also is important to cut all stems 1.0 inch d.b.h. and larger other than the desired residual trees. Cutting these stems during logging eliminates low shade that interferes with regeneration and provides suitable growing conditions for the valuable shade-intolerant species.

Two-age regeneration harvests should be applied no more frequently than one-half the recommended economic sawtimber rotation for local conditions. In the central Appalachians, economic sawtimber rotations are 90, 80, and 70 years for northern red oak SI 60, 70, and 80, respectively. As a result, two-age harvests could be applied every 40 to 50 years to maintain a two-age stand structure, and some individual trees can be retained indefinitely to satisfy goals for longer rotations. A concern with relatively frequent harvests is that many large poles and small sawtimber need to be cut at short intervals in order to provide adequate light for regeneration of a new age class. At age 40, even-aged stands in the region contain 75 to 100 codominant stems per acre, with an average d.b.h. of only 10 inches. To maintain a two-age stand structure, 20 to 30 of the best codominant trees need to be retained to reach maturity, while the remaining trees will be cut. A disadvantage of short cutting intervals is that many cut trees will be removed at a time when their potential growth and value increase are at a maximum.

Due to differences in the timing and frequency of harvest cuts, economic returns from silvicultural alternatives are seldom directly comparable on the basis of returns from a single entry. However, estimates of harvesting costs and roundwood values indicate that implementing deferment cuts versus conventional clearcuts can reduce net cash flows from the initial regeneration cuts by $459 to $1,171/acre, or 18 to 26 percent, depending on site quality and roundwood price levels (Miller and Baumgras 1994; Baumgras and others 1995). These revenue reductions were estimated for fully stocked stands at age 80 years, and reflect the assumption that the residual trees were low-risk, dominants and codominants. These residual trees can make significant contributions to economic returns from future harvests, but diminish short-term returns to provide the desired non-timber amenities.

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