AN ASSESSMENT OF RESIDUAL STAND CONDITIONS FOLLOWING SHELTERWOOD-WITH-RESERVES CUTS IN APPALACHIAN HARDWOODS[1]

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Abstract—In recent years foresters managing hardwoods in the Southern Appalachians have been investigating a variety of regeneration methods that lead to the development of a two-aged stand. The reserved trees that make up the older age class usually meet a variety of objectives such as timber, wildlife food and cover, and aesthetic values. A series of 20 operational cuts in Appalachian hardwood stands was evaluated 2 to 5 years post-logging. Residual stand characteristics such as species composition, density, volume, grade, and damage were investigated to determine the early fate of the reserve trees. Residual stand density across the 20 stands averaged 39 ft^2/ac, the number of residual trees per acre averaged 47, and the residual stand volume averaged 3,210 bd. ft./ac (Int. ¼"). Most of the residual stands were classified as low-risk (69 percent), and only 8 percent of the trees per ac were either standing dead or blown down 2 to 5 years following the harvest.

INTRODUCTION

For many years, foresters have recommended the use of clearcutting as a method of regeneration for Central Appalachian hardwoods. Clearcutting, followed by site preparation to remove residual small or noncommercial stems, results in a high light environment favorable for the regeneration of many commercial species such as yellow-poplar (*Liriodendron tulipifera*), northern red oak (*Quercus rubra*), and black cherry (*Prunus serotina*). However, public dissatisfaction with the aesthetics of clearcutting, coupled with the desire to manage forests for multiple objectives or on an ecosystem basis, have led to the investigation of alternative practices (Bartuska 1994, Heissenbuttel 1996).

In recent years, a method of cutting that leaves a light, residual overstory of 15 to 20 codominant trees occupying 10 to 20 ft^2 of basal area per ac has emerged. This method has been called deferment cutting (Smith and others 1989), and leads to the development of a two-aged stand (Beck 1986). The cut is heavy enough to stimulate seed germination and sprouting so that regeneration resembles, in both species composition and numbers, that which would be expected following clearcutting (Miller and Schuler 1995, Miller and others 1998). The residual overstory trees mitigate the visual impact of the logging, provide a continuing source of seed, provide food and cover for wildlife, and continue to grow into larger and more valuable trees for future harvest. The regeneration eventually develops into a second age class, hence the term "two-aged stand." The residual overstory may remain in place for as long as the entire next rotation, typically 80 years, or may be gradually removed along with regular thinnings when the younger age class develops to a merchantable size, typically 40 years. This practice, by current definition, is known as shelterwood-with-reserves.

A recent inventory of commercial timber harvests in West Virginia has shown that, while partial cuts are common, planned shelterwood seed or removal cuts are not (Fajvan and others 1998). In a random survey of 99 harvests, only about 20 percent were associated with a planned silvicultural application. Nevertheless, shelterwood-with-reserves is being used by the U.S. Forest Service Monongahela National Forest, and to a lesser extent on forest industry and private nonindustrial lands. This study was established to investigate the residual stand characteristics and regeneration following 20 such operational cuts on the Monongahela National Forest in West Virginia. This paper will report only the stand-level characteristics, individual tree quality characteristics and regeneration having been reported elsewhere (Johnson and others 1998).

METHODS

Study Area

During 1996, 20 tracts were identified on the Monongahela National Forest in West Virginia (table 1). The stands had all received a shelterwood cut two to five growing seasons prior to measurement. Previous studies have shown that butt log epicormic branches and logging wounds appear within two years after cutting, and change little over the next eight years (Smith and others 1994, Miller 1996); thus, it was felt that an evaluation after two growing seasons would be sufficient to evaluate residual quality. The study tracts were located on four ranger districts, and were part of the ongoing timber sale program on the forest. Tracts ranged from 8 to 33 ac in size and occurred in two physiographic provinces and three forest cover types (table 1). Residual stands were generally left to meet aesthetic, timber, and wildlife objectives. Site preparation, which entailed cutting all stems greater than 1 in dbh, but less than 5 in dbh, was completed during or soon after logging in each stand.

Residual Stand Measurements

Both stand level and individual tree measurements were made in each stand. In each stand, BAF 10 prism points were systematically established, at a density of one per ac up to a maximum of 25 per stand. All trees 5.0 in dbh and larger were tallied. From the point sampling data, number of trees per ac, basal area per ac, and International ¼" bd. ft.

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Table 1—General description for 20 shelterwood cuts on the Monongahela National Forest

Stand	Ranger District	Area	Physiographic Province	Forest cover type	Site index[a]	Year of harvest	Management objectives[b]
		Acres					
1	Greenbrier	15	Allegheny Mts.	Beech-cherry-maple	78	1993	TWA
2	Greenbrier	13	Allegheny Mts.	Beech-cherry-maple	89	1994	TWA
3	Greenbrier	15	Allegheny Mts.	Beech-cherry-maple	80	1992	TWA
4	Greenbrier	10	Allegheny Mts.	Beech-cherry-maple	70	1993	TWA
5	Greenbrier	10	Allegheny Mts.	Beech-cherry-maple	89	1993	TWA
6	Greenbrier	13	Allegheny Mts.	Beech-cherry-maple	81	1992	TWA
7	Greenbrier	22	Allegheny Mts.	Beech-cherry-maple	69	1993	TWA
8	Greenbrier	13	Allegheny Mts.	Beech-cherry-maple	74	1992	TWA
9	Greenbrier	25	Allegheny Mts.	Mixed Appal. hdwds.	72	1995	TWA
10	Potomac	24	Allegheny Mts.	Mixed Appal. hdwds.	85	1993	TA
11	Potomac	14	Ridge & Valley	Mixed oaks	60	1993	T
12	Potomac	14	Ridge & Valley	Mixed oaks	65	1992	T
13	Potomac	13	Ridge & Valley	Mixed oaks	60	1992	T
14	Potomac	8	Allegheny Mts.	Beech-cherry-maple	58	1992	WA
15	Potomac	33	Ridge & Valley	Mixed oaks	54	1994	TA
16	Potomac	13	Allegheny Mts.	Beech-cherry-maple	58	1992	W
17	Potomac	9	Allegheny Mts.	Beech-cherry-maple	58	1992	W
18	Cheat	10	Allegheny Mts.	Mixed Appal. hdwds.	65	1994	T
19	Cheat	10	Allegheny Mts.	Mixed Appal. hdwds.	75	1994	W
20	Marlinton	24	Allegheny Mts.	Mixed Appal. hdwds.	58	1994	WA

[a] Site index is average ht. in ft of dominant and codominant trees at 50 yrs of age.

[b] Management objectives are timber (T), wildlife (W), and aesthetics (A).

volume per ac were computed by species, risk class, and potential use. Risk classes used were: 1 = low risk of death or blowdown within 10 years; 2 = moderate risk; 3 = high risk of death or blowdown within 10 years; 4 = standing dead with death occurring after the cut; and 5 = blown down after the cut. Trees with low forks, severe lean, weak crowns, and/or advanced decay were generally classed as high risk. Potential use classes were timber or wildlife/aesthetic. Wildlife/aesthetic trees were residual trees of non-commercial species or commercial species that were of such poor quality before logging as to render them non-merchantable. Timber trees were of a commercially desirable species and contained merchantable volume for pulpwood or sawtimber.

RESULTS

Four of the ranger districts on the Monongahela National Forest have adopted the shelterwood-with-reserves method as a standard practice. The oldest of the cuts surveyed was completed in 1992, while the most recent were completed in 1995 (table 1). Harvest tracts ranged from 8 to 33 ac in size, and occurred in three primary forest cover types — beech-cherry-maple, mixed Appalachian hardwoods, and mixed oaks. The beech-cherry-maple cover type occurs at the higher elevations in the Allegheny Mountains, and consists of American beech (*Fagus grandifolia*), black cherry, sugar maple (*Acer saccharum*), sweet birch (*Betula lenta*), yellow birch (*B. alleghaniensis*), and red maple (*A. rubrum*). Lesser amounts of white ash (*Fraxinus americana*) and eastern hemlock (*Tsuga canadensis*) occur. Site index averaged 73 feet at base age 50 years. The mixed Appalachian hardwoods also occur west of the Allegheny Front, but at lower elevations. Typical species include yellow-poplar, northern red oak, sugar maple, white ash, and American basswood (*Tilia americana*), and site index averages 71 feet. The mixed oaks occur on the drier sites in the Ridge and Valley Physiographic Province east of the Allegheny Mountains. Site index for the mixed oak stands surveyed in this study averaged 60 ft. at 50 years (table 1). Typical species include white oak (*Q. alba*), chestnut oak (*Q. prinus*), black oak (*Q. velutina*), scarlet oak (*Q. coccinea*), and various hickories (*Carya* spp.). Management objectives for the harvested tracts varied somewhat by ranger district (table 1). For example, on the Greenbrier Ranger District, the multiple objectives of timber production, wildlife habitat, and aesthetic concerns controlled the selection of reserve trees. Timber production alone was an objective for three stands on the Potomac Ranger District, and one stand on the Cheat Ranger District (table 1). The decision to adopt the shelterwood-with-reserves method and create two-aged stands was mainly driven by wildlife and aesthetic concerns, but was made easier because the method had been researched from a timber management perspective (Miller and others 1997).

There are usually several objectives to be met by the shelterwood-with-reserves method. The cut must be heavy enough to allow for adequate regeneration of desirable species, the residual stand must be dense enough to insure that visual quality is maintained, and the residual trees should remain healthy to maintain visual quality and satisfy future timber and wildlife needs. It is important, therefore, that the cut lead to adequate regeneration of a new age class, and the residual stand remain intact with minimal mortality, blowdown, or grade loss. General characteristics for the 20 stands measured in this study are presented in Tables 2 and 3. Residual basal area ranged from 6 to 75 ft^2 per ac, and averaged 39 ft^2 per ac. Current guidelines call for two-aged residual basal areas to range from 10 to 40 ft^2 of basal area per ac. Half the stands in this study fell within that range, with most of the rest above. The residual trees per ac numbered, on average, 47, with a range of 8 to 74. This total includes both pulpwood and sawtimber-sized

Table 2—Residual stand characteristics for 20 shelterwood cuts on the Monongahela National Forest

Stand	Basal area	Number of trees	Volume/acre
	Ft^2 per acre	*Trees per acre*	*Int. ¼" bf*
1	58	63	5,920
2	75	74	6,020
3	40	43	3,540
4	47	48	3,640
5	29	46	1,330
6	39	32	3,600
7	31	40	2,190
8	70	66	6,250
9	58	67	5,220
10	32	38	2,520
11	46	58	3,790
12	51	72	3,730
13	23	26	2,090
14	12	21	570
15	42	47	3,400
16	14	22	750
17	6	8	520
18	44	81	3,250
19	35	34	3,770
20	31	59	1,880
Means	39	47	3,210

Table 3—Residual basal area, number of trees, and volume by risk classes following two-aged cutting of 20 tracts on the Monongahela National Forest

	Basal area			Number of trees			Volume per acre		
Risk class[a]	Mean	Standard error	Range	Mean	Standard error	Range	Mean	Standard error	Range
	------ Ft^2 per acre -------			*----- Trees per acre -----*			*-------- Int. ¼" bf --------*		
1	26.9	3.0	4.0-48.8	30.4	3.2	5.1-53.2	2,490	336	1,280-3,150
2	5.9	.7	.0-12.0	8.4	1.0	.0-19.4	380	59	130- 550
3	3.4	.8	.0-14.0	4.5	.9	.0-14.0	160	37	50- 170
4	1.5	.4	.0- 6.0	1.8	.5	.0- 6.1	80	24	0- 130
5	1.4	.4	.0- 6.0	2.1	.7	.0-11.7	100	32	0- 160
Total	39.1	—[b]	—	47.2	—	—	3,210	—	—

[a] Risk classes: 1 = low; 2 = moderate; 3 = high; 4 = standing dead with death occurring after cut; 5 = blown down after cut.
[b] No value.

trees. Volumes ranged from 520 to 6250 bd. ft. per ac, with an average of 3210. Across all stands the dominant risk class was low. For example, 69 percent of the basal area and 64 percent of the trees were classified as low-risk. Loss due to standing mortality and blowdown was also low. On average, only 7 percent of the basal area and 8 percent of the trees per ac fell into these classes. If high-risk trees eventually die, mortality may rise to 16 percent (table 3).

As trees were sampled, any that had commercial value due to size, species, and quality, were classified as timber trees. Culls, trees with cavities, and noncommercial trees with hard or soft mast potential are examples of trees that were classified as wildlife trees. The distribution of trees by use class is presented in Table 4. A relatively small proportion of the residual trees did not have commercial value. For example, the basal areas and volumes shown for wildlife trees in Table 4 represent only 9 to 20 percent of the residual basal area, and 9 to 11 percent of the residual board foot volume. It is also important to point out that many trees, such as all the oaks, can meet both objectives.

The species distribution of reserve trees is shown in Table 5. In the beech-cherry-maple type, American beech comprised the majority of the residual basal area. This species, while having low commercial value, has a high wildlife value due to hard mast production. Additionally, many of the larger, old beech trees also have cavities. Interestingly, 18 percent of the residual basal area in this type is comprised of black cherry, the highest-value species. In the mixed Appalachian hardwood type, northern red oak and sugar maple dominated the residual stand, while in the mixed oak type northern red oak and chestnut oak comprised the majority of the residual basal area (table 5). The mast-producing oaks, important to wildlife, comprised 41 percent of the residual basal area in the mixed Appalachian hardwood stands and 45 percent in the mixed oak stands in the Ridge and Valley.

Table 4—Distribution of basal area, number of trees, and volumes by use classes for 20 residual stands following two-aged cutting on the Monongahela National Forest

		Basal area		Number of trees		Volume	
Ranger District	n	Timber	Wildlife	Timber	Wildlife	Timber	Wildlife
		- - - *Ft² per acre* - - -		- - *Trees per acre* - -		- - *Bd. ft. per acre* - -	
Greenbrier	9	39.7	9.7	43.2	9.9	3,770	420
Potomac	8	24.2	4.0	31.9	4.6	1,930	250
Cheat	2	35.9	3.7	54.1	3.3	3,190	320
Marlinton	1	27.8	3.7	52.1	9.4	1,710	180

Table 5—Dominant species composition, expressed as a percentage of basal area, in 20 residual stands following two-aged cutting on the Monongahela National Forest

	Physiography and forest cover type		
Species	Allegheny Mountains beech-cherry-maple (n = 11)	Allegheny Mts. mixed Appalachian hardwoods (n = 5)	Ridge & Valley mixed oaks (n = 4)
	- - - - - - - - - - *Percent* - - - - - - - - - -		
American beech	36	5	0
Black cherry	18	3	0
N. red oak	1	26	19
Sugar maple	21	20	8
Red maple	12	7	9
Yellow-poplar	1	2	6
American basswood	0	8	0
White oak	0	8	8
Chestnut oak	0	7	18
Other species[a]	11	15	31

[a] Other species include red spruce (*Picea rubens*), eastern hemlock, white ash, sweet birch, yellow birch, misc. hickories, serviceberry (*Amelanchier arborea*), scarlet oak, black oak, black walnut (*Juglans nigra*), blackgum (*Nyssa sylvatica*), black locust (*Robinia pseudoacacia*), slippery elm (*Ulmus rubra*), and pitch pine (*Pinus rigida*).

DISCUSSION

The purpose of this study was to evaluate reserve shelterwood stands from a timber perspective. This is still a relatively new practice, and future applications will depend upon knowledge and experience developed by the current practitioners. Nine of the 20 stands, or 45 percent, were left with a residual overstory above the original goal, indicating that foresters are reluctant to mark the stands heavily. In some stands, clumps of trees were left for wildlife purposes. In these areas the potential for regenerating shade-intolerant species is relatively low. Maintaining a large residual overstory is likely to be detrimental in the long run, and certainly the 40 ft^2/ac basal area should be considered an upper limit. For example, if 40 trees, each 14" in dbh, were left per acre as a residual, the stand would be at the upper limit of 40 ft^2/ac basal area. Assuming no mortality and an average growth rate of two inches per decade, after 40 years each tree will have a dbh of 22 in, or a basal area of 2.64 ft^2. This represents a stand basal area of 106 ft^2/ac, a fully stocked condition with no room for a younger age class struggling to reach the main canopy. In a case like this, it is obvious that some intermediate treatments in the residual stand will be necessary to create more growing space for the new age class of trees.

Although the intent of this study was not to evaluate the wildlife or aesthetic values of the stands, subjective observations indicate that these goals will be met as well. Large proportions of the residual stands are comprised of soft and hard mast-producing species like black cherry, American beech, northern red oak, white oak, and chestnut oak. A recent evaluation of several 10- to 15-year-old two-aged stands in West Virginia has shown that the practice results in a diversity of woody species and vertical structures. Songbird density counts were higher in the two-aged stands than in adjacent even-aged stands over a two-year observation period (Miller and others 1995). Further evaluation of the wildlife implications of two-aged cuts is progressing.

Two-aged cuts appear to mitigate the visual impact of timber harvesting, at least after several years. Figure 1 shows a background, middleground, and foreground sequence of a two-aged cut on the Potomac Ranger District, taken during late spring. The area is not highly visible from a distance, and has the appearance of a heavily thinned area up close. Figure 2 shows an interior view of a two-aged stand four years following the cut. Site preparation, which removes stems from 1 to 5 in dbh, increases the visual penetration.

A

B

C

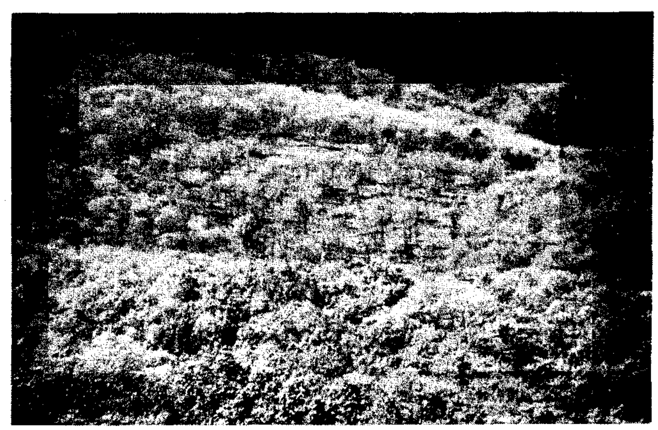

Figure 1—(A) A two-aged cut on the Potomac Ranger District viewed from background; (B) A two-aged cut on the Potomac Ranger District viewed from middleground; (C) A two-aged cut on the Potomac Ranger District viewed from foreground.

Figure 2—Interior view of a two-aged stand 4 years following the cut.

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