EFFICIENT SILVICULTURAL PRACTICES FOR EASTERN HARDWOOD MANAGEMENT

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ABSTRACT

Eastern hardwood forests are now managed to meet a wide range of objectives, resulting in the need for silvicultural alternatives that provide timber, wildlife, aesthetics, recreation, and other benefits. However, forest management practices must continue to be efficient in terms of profiting from current harvests, protecting the environment, and sustaining production of desired benefits in the future. This paper evaluates four major silvicultural practices used to manage eastern hardwoods: single-tree selection, group selection, two-age management, and even-age management. The analysis focuses on defining variations of these practices that can be applied economically in current markets, and that result in sustainable forests that can be managed economically in the future. In general, results indicated that in many cases current harvests can provide sufficient stumpage revenues to apply each of the practices evaluated. However, market conditions and changes in species composition can have a dramatic effect on the economic efficiency of future harvests.

INTRODUCTION

Eastern hardwood forests are managed to produce a wide range of woodland resources, including timber products, wildlife habitat, aesthetics, and recreation opportunities. As production objectives become more complex, forest managers often try to sustain output of several resources simultaneously within a given stand. Conflicting objectives call for the use of silvicultural practices that differ greatly from the more common clearcutting or diameter-limit practices used in the past. While traditional forest cutting practices focused mainly on economic efficiency of the current timber harvest, alternative practices are needed to address the growing demand for continuous nontimber benefits and the importance of sustaining yields of quality timber in the future.

Numerous silvicultural practices have been developed to meet a variety of needs on a sustainable basis. For example, single-tree selection practices can result in minimal disturbance of the landscape, while providing periodic timber yields in stands where commercial shade-tolerant species regenerate successfully. Practices such as group selection that entail making small openings in the forest canopy provide periodic timber yields with slightly more disturbance, but allow shade-intolerant species to regenerate because more sunlight reaches the forest floor after harvest.

Forest managers must conduct stand management operations within existing timber product markets, and, to some degree, with an eye on future markets. Current silvicultural treatments must be economical but also result in sustainable growth and development of products that will have commercial value decades later. Traditional forest management practices such as diameter-limit cutting are driven by the economic efficiency of the current timber harvest. In the past, little attention was given to how such practices might conflict with other woodland resources, or reduce the potential quality of future harvests. In this paper, we provide information about four major silvicultural practices that can be used to manage eastern hardwoods and discuss the efficiency and impact of each practice. Guidelines are provided to help forest managers determine which practices can be applied economically in a given stand.

The four silvicultural practices evaluated in this report include: 1) single-tree selection, 2) group selection, 3) two-age management, and 4) even-age management. Data were obtained from stands on the Fernow Experimental Forest and the Monongahela National Forest near Parsons, West Virginia. All stands contained second-growth central Appalachian hardwoods that were regenerated for the most part following early logging from 1905 to 1910. Each stand is on a good growing site, northern red oak site index 70, base age 50 years.

BACKGROUND

Each of the four silvicultural practices evaluated has certain impacts on the economic efficiency of current harvest operations as a result of the species, volumes, and sizes of roundwood products removed and their values in current markets. Each practice also influences future stand characteristics and the economic feasibility of future harvests. A brief description of each practice is provided to clarify the key factors that determine the marked cut. The implications of each practice in terms of future species composition, growth, stand quality, and frequency of harvest operations are discussed.

Single-tree selection

On the basis of stand characteristics and management objectives, a residual stand goal is established in terms of residual basal area (RBA), largest diameter residual tree (LDT), and q-value, which defines how residual trees are distributed among diameter classes (Smith and Lamson 1982). Single-tree selection has been applied in central Appalachian hardwood stands since the early 1950's on the Fernow Experimental Forest. Selection stands on site index 70 have been cut four times on a 10-year cutting cycle using the following residual stand goals:

RBA = 65 ft^2 (5.0 inches d.b.h. and larger)
LDT = 26 inches d.b.h.
q-value = 1.3

In the example stand, the first periodic cut resulted in heavy volume removals to condition the stand and remove many large, old residual trees left after the original logging of the early 1900's. Later periodic cuts removed roughly one-third of the merchantable volume. The most recent cut, the fourth so far, removed about 14 trees per acre, mostly red oak, black cherry, maples, and other commercial hardwood species (Table 1).

Table 1.--Per-acre stand attributes for four silvicultural practices

Silvicultural practice		Number of trees			Basal area			Avg. d.b.h
		6-10 in.	12 in.+	Total	6-10 in.	12 in.+	Total	12.0 in.+
		No. trees/acre			Ft^2/acre			Inches
Single-tree selection	Initial	87.2	57.1	139.8	27.4	97.6	125.0	
	Cut	1.8	11.7	13.5	0.5	23.2	23.7	19.1
	Residual	85.4	45.4	126.3	26.9	74.4	101.3	
Group selection	Initial	104.3	68.3	172.6	30.6	110.9	141.5	
	Cut	13.8	11.6	25.4	4.2	21.3	25.5	18.3
	Residual	90.5	56.7	147.2	26.4	89.6	116.0	
Two-age management	Initial	104.3	68.3	172.6	30.6	110.9	141.5	
	Cut	103.1	55.5	158.6	29.9	91.3	121.2	17.4
	Residual	1.2	12.8	14.0	0.7	19.6	20.3	
Even-age management	Initial	104.3	68.3	172.6	30.6	110.9	141.5	
	Cut	104.3	68.3	172.6	30.6	110.9	141.5	17.3
	Residual	0.0	0.0	0.0	0.0	0.0	0.0	

As future cuts remove shade-intolerant and intermediate shade-tolerant species from the sawtimber-size classes, shade-tolerant species will replace them (Miller 1993). To evaluate single-tree selection over long planning horizons, the value of future harvests must be estimated based on future species composition and growth rates. An important impact of repeated partial cuts using single-tree selection is that shade-tolerant species eventually will dominate future stands. In the central Appalachians, such stands will contain mostly sugar maple, red maple, and American beech.

Group selection

Volume control and residual stand density are used to regulate periodic cuts, which include trees removed in groups to regenerate new trees and individual trees removed to improve quality and distribution of the residual stand. Group selection entails making small openings with each periodic 10- to 20-year cut to provide suitable light conditions to perpetuate a variety of commercial hardwoods, including desirable shade-intolerant species (Miller and Smith 1991; Leak and Filip 1977). In the example stand, a recent periodic harvest removed all trees (1.0 inch d.b.h. and larger) within seven group openings that were approximately one-half acre in size (Table 1). Some poor-quality sawtimber trees also were removed between openings to improve the residual stand. Although the stand is actually 31 acres, the cut focused on clearing parts of the stand where trees were mature or high risk/poor quality to provide growing space for new regeneration. Species composition was a mixture of species characteristic of second-growth forests in the central Appalachians.

In the near future, species composition of periodic harvests will continue to be a mixture of shade-tolerant maples, intermediate shade-intolerant oaks, and shade-intolerant black cherry and yellow-poplar. However, oaks do not regenerate successfully on better sites by any known practice except where advanced oak seedlings can be developed before harvest. In general, group selection will regenerate a much wider variety of species compared to single-tree selection, though oaks eventually will be replaced by other species in either practice. Thus, to evaluate group selection over long planning horizons, the values of future harvests must be estimated for a variety of shade-intolerant and shade-tolerant commercial species. Oaks removed in current harvests will be replaced by maples, yellow-poplar, black birch, and black cherry--the major components of successful regeneration in newly created group openings.

Two-age management

Two-age stands in second-growth central Appalachian hardwoods are created by retaining 10 to 20 desirable dominant or codominant residual trees per acre and cutting all other trees 1.0 inch d.b.h. and larger (Smith and Miller 1991). Periodic regeneration harvests are applied every one-half rotation to maintain a two-age stand structure. In the central Appalachians, the rotation length for sawtimber production is 80 years on red oak site index 70. In most cases, the residual trees retained to maintain a two-age stand structure will be high-quality sawtimber trees that are expected to live at least 40 years. The initial two-age harvest in a second-growth Appalachian hardwood stand removed about 56 sawtimber trees per acre, leaving 14 residual sawtimber trees per acre (Table 1). The logging operations and sale preparations are similar to those for clearcutting except for marking and protecting the reserve trees. Special care is required during logging to avoid damaging these stems. Windthrow is possible on sites with shallow soils.

Species composition of future harvests in two-age stands will be similar to that found in even-aged stands. At low residual stand density, basal areas ranging from 20 to 40 ft^2/acre in residual sawtimber-size trees, a variety of species including a large component of shade-intolerant stems will continue to develop into codominant trees of the future. Without sufficient advance regeneration, oaks removed in current harvests will be replaced by maples, yellow-poplar, black birch, and black

cherry. Once the two-age stand structure is established in one or two cuts, harvests will occur every 40 years. The periodic 40-year marked cut will include 80-year-old sawtimber trees retained in the previous cut, plus 40-year-old saplings, poletimber, and several small sawtimber trees cut to favor residual codominant trees and prepare the site for establishment of a new age class. The residual stand will include 25 to 35 codominant trees per acre, ranging from 10 to 14 inches d.b.h. The residual basal area in 40-year-old codominant trees should range from 20 to 40 ft^2/acre. Thus, future cuts will differ from the initial cut made in a second-growth stand to create the two-age structure.

Even-age management

Even-age management in this analysis is defined by an 80-year rotation. At rotation age, all trees 1.0 inch d.b.h. and larger are cut. Merchantable sawtimber 11.0 inches d.b.h. and larger and perhaps merchantable poletimber to a 4-inch diameter outside bark (d.o.b.) are removed, while the remaining unmerchantable trees are felled and left on the site. In the example stand, the even-age harvest removed 68 sawtimber trees per acre ranging in size from 12 to 28 inches d.b.h. (Table 1).

The initial and future periodic even-age cuts will yield approximately equal volumes of roundwood products depending on site productivity and rotation age. However, as with other practices discussed, if advance oak regeneration is not present on good sites (site index 70+), oaks will be replaced by other commercial species. Future even-aged stands will contain a mixture of maples, yellow-poplar, birch, black cherry, and other commercial hardwoods.

METHODS

The GB-SIM simulation model was used to estimate harvesting system production rates and product yields based on the marked cut in each silvicultural practice (Baumgras and others 1993). Cut tallies from existing studies of each silvicultural practice were used to determine the efficiency of harvests in current markets. It was assumed that cut tallies for current and future harvests were similar in size-class distributions. However, the efficiency of future harvests was determined on the basis of observed changes in species composition associated with each silvicultural practice over a 40-year period on similar stands in the study area.

The harvesting simulation model estimates the stump-to-truck production rate, machine operating times, and roundwood product yields. These factors were used to calculate net harvesting revenue per acre associated with each practice in current and future harvests. The model uses a stochastic process to predict machine performance as a function of cut-stand attributes that include individual trees by size class and location in relation to other cut trees. These predictions are based on machine cycle-time equations and productive delay-time distributions sampled from West Virginia logging operations. The simulated production rate reflects those of each system component and the product-flow interactions that occur between system components. The simulation also estimates roundwood product yields using tree-taper functions (Martin 1981), tree grade-distribution equations (Dale and Brisbin 1985), and equations estimating sawlog yields by log grade (Yaussy and others 1988).

The simulated harvesting system was one common to the Appalachian hardwood region that included manual chain saw felling and limbing, a 90-hp rubber-tired skidder, and a hydraulic loader/slasher combination. Harvesting was simulated over a standardized 25-acre tract with skid trails on a 200-foot spacing. The stand tables representing trees harvested were obtained from actual stand data for each silvicultural practice. The control variables that calibrate the model were selected to represent relatively efficient operations. In other words, the model assumes that the feller works to maintain an adequate inventory of felled trees and that the skidder operator attempts to maximize payloads each turn within the capacity of the machine. With these assumptions in place, productivity is largely the result of the silvicultural prescriptions and associated cut-stand attributes.

Marked trees smaller than the merchantable d.b.h. were assumed to be felled but not skidded. By definition for some silvicultural practices, trees as small as 1.0 inch d.b.h. must be felled. GB-SIM provides the flexibility to simulate several tree-harvesting and utilization options. The options evaluated in this study included: 1) skidding trees 8 inches d.b.h. and larger to a 4-inch top d.o.b., 2) skidding trees 12 inches d.b.h. and larger to a 4-inch top d.o.b., and 3) skidding trees 12 inches d.b.h. and larger to a 10-inch top d.o.b.

The cost rates applied to the simulation results include reported machine operation costs (Burgess and Cubbage 1988), wages and benefits averaging $9.80 per hour, and system fixed costs that allowed the system owner-operator to earn wages, plus an after-tax cash flow representing a 12-percent return on invested capital. Costs were inflated to 1994 levels using the Producer Price Index for all commodities.

The cash-flow analysis included three price levels for each of three roundwood product classes: sawlogs, sawbolts, and pulpwood-fuelwood (Table 2). Sawlog prices by tree species and log grade were obtained from published reports (Pa. State Univ. 1990-93). Sawbolts represent sawable roundwood suitable for the manufacture of wooden pallets, other low quality sawn products, or fencing material. Haul distance was factored into estimates of net revenue by estimating the haul cost for 20, 40, and 80 miles. Prices represent the range of market conditions to illustrate the sensitivity of results to regional and cyclical price fluctuations. Obtained from cumulative frequency distributions for four regions of Pennsylvania, low prices represent the 10th percentile, medium prices represent the 50th percentile, and high prices represent the 90th percentile.

RESULTS

Two key factors in determining the efficiency of silvicultural practices are the average tree volume and the average volume yield per acre associated with periodic harvests. Harvesting system production generally increases and costs decrease with increasing volume per tree and volume per acre. The average sawtimber tree (11.0 inches d.b.h. and larger) was 19.1 inches d.b.h. in the single-tree selection cut compared to 18.3 inches d.b.h. in the group selection cut (Table 1). For both selection practices, the cut included about 12 sawtimber-size trees per acre, averaging 340 bf/tree in single-tree selection and 310 bf/tree in group selection. For both the two-age and even-age management practices, the average sawtimber tree cut was similar, about 17 inches d.b.h. containing

270 bf/tree. The even-age practice removed 68 sawtimber trees per acre compared to 55 sawtimber trees per acre in the two-age practice.

Table 2.--Net roundwood product prices delivered to mills for period 1990 to 1993

Grade sawlogs[a]		Price level		
		High	Medium	Low
			$/Mbf	
White oak	Grade 1	600	325	240
	Grade 2	280	185	140
	Grade 3	150	100	70
Red oak	Grade 1	610	485	320
	Grade 2	350	285	230
	Grade 3	175	125	90
Black cherry	Grade 1	800	520	295
	Grade 2	445	330	215
	Grade 3	240	125	85
Yellow-poplar	Grade 1	290	175	135
	Grade 2	180	125	95
	Grade 3	125	85	65
Sugar maple	Grade 1	460	260	170
	Grade 2	280	170	120
	Grade 3	150	95	65
Other hardwoods	Grade 1	280	190	135
	Grade 2	205	140	100
	Grade 3	125	85	60
Below grade products			$/100 ft^3	
	Sawbolts[b]	80	50	35
	Pulpwood[c]	65	45	35

[a]Factory grade sawlogs, USDA Forest Service grades 3 or better, scaling diameter ≥ 10 inches.

[b]Sawable roundwood not meeting the quality or dimension requirements for sawlogs, scaling diameter ≥ 8 inches.

[c]Roundwood with diameter inside bark ≥ 4 inches, not meeting the quality or dimension requirements for sawlogs or sawbolts.

Single-tree and group selection practices produced similar volumes per acre, 3.9 and 3.6 Mbf per acre, respectively (Table 3). These yields are approximately equal to periodic merchantable-volume growth for central Appalachian hardwood stands managed with partial cutting on a 10-year cutting cycle (Trimble 1968). The group selection volume (Table 3) represents the average yield over the entire 25-acre unit, though yields from the groups actually cut exceeded 24 Mbf/acre. The even-age practice removed 18.1 Mbf/acre and the two-age practice removed 14.9 Mbf/acre. In the two-age

practice, there were 13 residual sawtimber trees per acre averaging 16.8 inches d.b.h. and 250 bf/tree.

Table 3.--Summary of volume yields and production rates for various marketing options

Silvicultural practice	Product		Volume yield					Production rate
	D.b.h.	D.o.b.	Sawlogs	Sawlogs	Sawbolts	Pulpwood	Total	
	---- Inches ----		- Bf/ac -	---------- Ft^3/ac ----------				- Ft^3/hr -
Single-tree selection	8[a]	4[b]	3,933	660	193	119	972	524
	12	4	3,933	660	195	117	972	540
	12	10	3,933	660			660	482
Group selection	8	4	3,602	613	195	167	975	542
	12	4	3,602	613	165	109	886	527
	12	10	3,602	613			613	425
Two-age management	8	4	14,943	2,564	862	915	4,341	486
	12	4	14,943	2,564	706	499	3,769	445
	12	10	14,943	2,564			2,564	348
Even-age management	8	4	18,181	3,109	1,027	1,034	5,170	506
	12	4	18,181	3,109	857	611	4,577	474
	12	10	18,181	3,109			3,109	374

[a]Merchantable tree d.b.h.; trees removed as products.

[b]Merchantable top diameter outside bark.

Productivity is determined to a lesser degree by the number of saplings and poletimber trees that must be cut to properly apply a particular silvicultural practice. With even-age, two-age, and group-selection, trees as small as 1.0 inch d.b.h. are cut to prepare the sites for desired regeneration. However, single-tree selection involves cutting only merchantable trees after the initial periodic cut. Once a residual tree goal is achieved with single-tree selection, subsequent cuts simply remove surplus trees in each merchantable size class. While single-tree selection required cutting only 2 poletimber trees per acre and no saplings, group selection required cutting 14 poletimber trees and 50 saplings per acre. The two-age and even-age practices both required cutting more than 100 poletimber trees and nearly 300 saplings per acre.

Production rates varied by silvicultural practice and by the marketing option used to simulate harvesting. For each practice, harvesting production rates were determined for three merchantability

limits for d.b.h. and top diameter. For each option, all trees marked to apply the practice were cut, but only trees that met the merchantability requirements for each option were skidded to the landing. For the sawtimber only option, the logging production rate ranged from 348 to 482 ft^3/hour, lowest for two-age management and highest for single-tree selection (Table 3). In general, the production rate increased as the volume per tree increased. Total yield in the even-age practice increased from 3,109 to 5,170 ft^3/acre by skidding trees 8 inches d.b.h. with a 4-inch top diameter compared to skidding trees 12 inches d.b.h. with a 10-inch top diameter. For each of the silvicultural practices, the additional yield was in roughly equal proportions of sawbolts and pulpwood. Also, skidding smaller trees increased estimated production rates by 10 to 40 percent, with the greatest increase observed for the two-age management practice.

Stumpage revenue available to the landowner was calculated for each silvicultural practice and product option using a range of prices and a haul distance of 40 miles (Table 4). These cash flows are residual values, determined by subtracting felling, skidding, and hauling costs and profit margins from reported delivered prices for various roundwood products. As a result, these residual values represent maximum stumpage revenue given estimated harvesting costs and delivered roundwood prices. The available stumpage revenues also would apply to landowners who own and operate the harvesting system, and do not include sale administration costs such as inventories, marking, consultation and legal fees, or the cost of truck-road and skid-trail construction. The average cost of minimum-standard truck roads is $8,000/mile (Kochenderfer and others 1984). Total sale-related cost, including roads and other costs, could range from $50 to $200/acre depending on road requirements.

Stumpage revenues were computed for both present species composition and expected future species composition as a result of each silvicultural practice. For example, species composition in stands managed under single-tree selection eventually will be dominated by shade-tolerant species such as sugar maple, red maple, and American beech. Depending on product prices, future stumpage revenues can be reduced by as much as 83 percent due to anticipated changes in species composition (Table 4). Similar reductions in stand value are associated with other partial harvest practices such as diameter-limit cutting (Miller 1993).

For other silvicultural practices, changes in species composition are less pronounced in their effect on net revenues. Northern red oak is a major component of current cut volumes for the example stands. Once oaks are harvested, species composition will shift to a mixture of species such as yellow-poplar, black cherry, and maples. As a result, future stumpage revenues will reflect the loss of the valuable oak component and, with the exception of black cherry, its replacement by lower value species. Under group selection, two-age management, and even-age management, expected future harvest revenues can be reduced from 5 to 70 percent depending on specific circumstances.

Table 4.--Estimated stumpage revenue for each silvicultural practice at three price levels and three market options

Silvicultural practice	Product		Product prices					
			High		Medium		Low	
	D.b.h.	D.o.b.	Present	Future	Present	Future	Present	Future
	---- Inches ----		---------- Stumpage revenue $/acre ----------					
Single-tree selection	8[a]	4[b]	1,431[c]	971	993	508	625	279
	12	4	1,409	932	978	488	614	265
	12	10	1,245	772	887	393	557	206
Group selection	8	4	1,164	1,144	732	666	462	368
	12	4	1,119	1,102	709	646	449	359
	12	10	937	902	598	523	374	275
Two-age management	8	4	4,457	4,465	2,668	2,533	1,636	1,357
	12	4	4,165	4,140	2,506	2,355	1,539	1,254
	12	10	3,355	3,266	2,008	1,820	1,197	888
Even-age management	8	4	5,507	5,474	3,360	3,132	2,095	1,698
	12	4	5,205	5,176	3,193	2,969	1,996	1,602
	12	10	4,204	4,101	2,582	2,310	1,579	,152

[a]Merchantable tree d.b.h.; trees removed as products.

[b]Merchantable top diameter outside bark.

[c]Revenue based on medium haul cost, 40 miles.

DISCUSSION

The economic feasibility of initial-entry silvicultural treatments in many second-growth Appalachian hardwoods is enhanced by the presence of high-value oaks. However, oaks are difficult to regenerate on more productive growing sites (red oak site index 70+), and future revenues can be reduced dramatically as oaks are replaced by other commercial hardwoods. The four silvicultural practices evaluated in this analysis usually provide desirable reproduction other than oak species following cutting treatments. This analysis indicates that under a range of market conditions, future harvests can continue to be economical even if oaks are replaced by other commercial species. However, if an oak component could be maintained, future revenues and nontimber benefits can be increased dramatically.

In each of the silvicultural practices evaluated for these well-stocked example stands, positive stumpage revenues were observed for all market options, price levels, and haul cost assumptions. For "worst case" scenarios, where low prices, high haul costs, and lower value species composition drive potential revenues to their lowest level, stumpage revenues remained positive (Table 5). Stumpage prices for sawtimber ranged from $36 to $312/Mbf depending on the silvicultural practice, market conditions, and haul distance. Recall that revenues presented here do not include road or administrative costs. Lowest returns were associated with single-tree selection, while highest returns were observed for even-age management.

Table 5.--Minimum and maximum potential periodic net revenues in future harvests

Silvicultural practice	Cut frequency	Minimum	Maximum
	---Years -------	---------- $/acre	---------
Single-tree selection	10	141[a]	1,013[b]
Group selection	10	212	1,184
Two-age management	40	655	4,638
Even-age management	80	866	5,681

[a]Based on low prices, high haul cost.

[b]Based on high prices, low haul cost.

Commercial thinnings are feasible in the even-age management practice once the stand reaches age 60 to 70 years (Baumgras 1992). Similar to results in this analysis, roundwood markets affect the net revenues available to the landowner and are major factors in determining the timing and intensity of commercial thinnings. Strong markets allow thinnings as early as 50 years, while weaker markets tend to delay thinnings and require heavier removals for feasible operations.

Net revenue estimated for most scenarios was maximized by skidding cut trees 8 inches d.b.h. and larger and including pulpwood and sawbolts in the product mix. This indicates that the added cost of harvesting trees 8 to 12 inches d.b.h. and using polewood 4 to 10 inches d.o.b. was less than the added revenue from pulpwood and sawbolts. Of course, gains from multiproduct harvesting are dependent on product prices and the stand attributes that affect product yields. Revenue gains from multiproduct harvesting were lowest for single-tree selection with low prices ($57/acre) and greatest for even-age management with high prices ($1,303/acre). Without accessible sawbolt markets, this roundwood could be allocated to the pulpwood market with only a small price reduction. Without markets for either sawbolts or pulpwood, the sawlog-only harvest would be the sole option. However, the revenue gains shown for multiproduct harvesting indicate the potential advantage of having access to a variety of markets.

Four silvicultural practices were evaluated in terms of economic feasibility of current and future cutting treatments. Current stand entries, where species composition is mixed and includes some component of valuable oaks, can be economical even when markets are relatively weak. Single-tree

selection, which leads to future stands dominated by shade-tolerant maples and beech, can become a marginal practice if markets for these products are weak in the future. Group selection, two-age management, and even-age management, which regenerate a variety of commercial hardwood species, are more likely to remain feasible practices over a range of future market conditions.

This analysis indicates that several major silvicultural practices can be economical in managing Appalachian hardwoods. While nontimber management objectives may influence the choice of a particular silvicultural practice, it is apparent that forest managers will continue to have several viable management options in the future.

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