USDA FOREST SERVICE FARM WOODLANDS CASE STUDY—50 YEAR RESULTS FROM WEST VIRGINIA

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ABSTRACT.–Recognizing that fire, grazing, and poor cutting practices had compromised much productivity in farm woodlots in the early 1900s, USDA Forest Service personnel established a demonstration on the Fernow Experimental Forest (FEF) to show the feasibility of two harvesting systems that could be used to maintain or enhance stand productivity and provide private forest land owners with biennial revenue. Beginning in 1950, treatments were applied to create single-tree selection and 4 percent diameter limit cutting in two compartments. In this paper we document a shift in species composition, relatively equal volumes in removals, and generally increasing growing stock levels over the course of the intervening 50 years.

During the latter part of the 19th century and the first half of the 20th century, forests in the United States—particularly in the east—underwent landscape scale heavy cutting. In virtually all regions this cutting often resulted in hundred or even thousands of contiguous acres being cut without regard to the environmental consequences of these actions.

This widespread cutting, grazing, and burning, that took place during this period of forest exploitation drew the attention of conservationists throughout the United States. Fifty years ago, a group of foresters concerned with deleterious logging practices they were seeing in West Virginia, established a demonstration area in Tucker County, at what was then the recently established Fernow Experimental Forest. The intent of the demonstration area was to show farmers and other woodland owners the economic value of managing their tracts of timber, and to demonstrate silvicultural methods that could be used to provide biennial or annual revenue while assuring sustained wood production.

Today, now that the cutover stands of past centuries have regenerated and have developed into stands with valuable hardwood sawtimber, harvesting is again progressing through the forests of West Virginia and other states in the central Appalachians. Over the past decade three mills, each requiring over a million tons of hardwood pulpwood per year for composite wood products, have been established in central and southern West Virginia adding to the demand for wood products. A "mid-cycle" inventory, sponsored by the West Virginia Division of Forestry (WVDOF 1997) found that between 1989 and 1995 the growth to drain ratio—a metric that describes the proportion of wood volume growing in the forest to that cut from the forest—decreased from 3.41 in 1989 to 1.34 in 1995. Growth to drain ratios below 1 indicate harvests exceed growth and would not be sustainable for long.

These indications of accelerated timber harvesting are of particular concern in light of the 1995 timber harvest inventory reported by Fajvan and others (1998). In their assessment of 101 harvest areas, the researchers document the seeming lack of silvicultural prescriptions and intent for future stand conditions. Despite the resiliency of the forest that was seen over the past century, changing social and environmental conditions may have more negative impacts to the productivity of the forest today than in the past.

Given our current social and environmental setting, conveyance to forest land owners of information that expresses the benefits of forest management is crucial for promoting renewable natural resources production from

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the forests of today. This paper documents the 50-year productivity of two demonstration areas in order to improve understanding of long-term uneven-aged silviculture in the central Appalachian region. While the individual practices in each demonstration unit were not replicated, the case study as presented here can serve as an example of long-term management for new and experienced forest land owners, and can also stimulate hypotheses regarding possible stand trajectories and volume production under these and alternative scenarios.

STUDY AREA

Data for this case study have been collected since 1950 from Compartments 13 and 21 on the Fernow Experimental Forest (39.03º N, 79.67º W) in north-central West Virginia. The Fernow is located in the Allegheny Mountains section of the Central Appalachian Broadleaf Forest (McNab and Avers 1994). The vegetation is classified as mixed-mesophytic (Braun 1950) and dominant overstory species often include northern red oak (*Quercus rubra* L.), yellow-poplar (*Liriodendron tulipifera* L.), and sugar maple (*Acer saccharum* Marsh.) on mesic sites and red maple (*A. rubrum* L.) and chestnut oak (*Q. prinus* L.) on more xeric sites. Compartments 13 and 21 have characteristics of both mesic and xeric conditions, but overall are classified as good growing sites and have red oak site indices 50 of about 70.

In the original study plan, Holcomb and Weitzman (1950) described Compartment 13 (31 acres) as an unmanaged forest which had been high-graded and burned but retained some of the old residuals not removed in the original logging (c. 1905–1912). Compartment 21 represented even poorer starting conditions than 13 according to the initial investigators. They described Compartment 21 (31 acres) as essentially clearcut during the original logging and severely burned following logging. Consequently, in 1950 it was in an earlier stage of development with noticeably less stocking than that found in Compartment 13. These two compartments were selected for this case study because they were fairly representative of the range of farm woodland conditions found throughout the area in the early 1950s, and both were readily accessible for demonstration.

SILVICULTURAL TREATMENTS

The original intent of silvicultural treatments for both compartments was to determine the economic and silvicultural feasibility of annual harvest cuts from small areas. The initial cuts were designed to remove primarily cull trees and the most defective merchantable trees. Succeeding cuts were designed not to exceed growth until the desired structure and stocking were achieved, then removals would approximate growth. Goal diameter distributions were to approximate uneven-age and uneven-size class characteristics, although explicit silvicultural guidelines were deemed secondary to mimicking practices thought feasible by small landowners. For example, one year the harvest might remove material deemed suitable for mine timbers by removing low quality stems of less desirable species. Preferred species for retention included sugar maple, northern red oak, white oak (*Q. alba* L.), yellow-poplar, white ash (*Fraxi-nus americana* L.), and black cherry (*Prunus serotina* Ehrh.). Less desirable species were red maple, chestnut oak, birch (*Betula* sp.), beech (*Fagus grandifolia* Ehrh.), hickory (*Carya* sp.), and cucumber-tree (*Magnolia acuminata* L.). Undesirable species included blackgum (*Nyssa sylvatica* Marsh.), sassafras (*Sassafras albidum* (Nutt.) Nees), sourwood (*Oxydendrum arboreum* (L.) DC.), and black locust (*Robinia pseudoacacia* L.).

During the 1960s, each compartment was further divided into five sub-compartments of approximate equal size. Compartments were cruised on 10-year intervals where all stems greater than 5 inches in diameter at breast height (dbh) were recorded by species and sampled for hardwood tree grade. Cutting guidelines for the next 10 years would then be based on this inventory. The cutting cycle for each subcompartment was 10 years but the dates were scheduled so that one subcompartment from either Compartment 13 or 21 was marked and harvested annually. Annual harvests alternate between the two main compartments. The small size of the annual harvests was desirable, in part, because the scale would approximate the level of work the initial investigators thought some farmers could do working independently. The annual cut would also allow woodland owners to respond to changing market conditions and provide an annual cash flow.

After the initial salvage logging objectives were met, silvicultural guidelines became more explicit. Since 1974, Compartment 13 has been managed using a single-tree selection system. Initially, residual stand structure goals following harvesting were defined by inherent differences in site productivity. By 1981, a single standard was applied using a Q of 1.3 (which refers to the number of trees in successively smaller two inch diameter classes) (Nyland

1996), a residual basal area of 85 ft^2 ac^{-1} for trees 5 inches dbh and larger, and a maximum dbh of 32 inches.

Beginning in 1998, each sub-compartment was cruised separately so that more realistic marking guidelines could be determined for each sub-compartment. Consequently, we found some sub-compartments to be substantially above stand structure goals and others to be in deficit. One sub-compartment (13B1) was not harvested as scheduled after the 2000 growing season because most diameter classes were slightly below residual stand structure goals. This was a result of previously using compartment-wide characteristics to determine surplus trees in each sub-compartment. Growth projections indicate the 13B1 will have adequate volume above the residual stand structure goal at the next cutting cycle in the year 2010.

Since the early 1970s, Compartment 21 has been managed using a procedure for selection marking based on variable rates of return that are influenced by tree quality, species, and size (Trimble and others 1974). Compartment 21 is managed using the guidelines for site index 70 using a 4 percent rate of return. In essence, yellow-poplar, beech, white oak, and chestnut oak are marked when they reach the 18 inch dbh class, black cherry and white ash are marked when they reach the 20 inch dbh class, and red oak and red and sugar maple are marked when they reach the 22 inch dbh class. Additionally, this system prioritizes removal of smaller trees that are of low quality or vigor, and all short-lived species. Hereafter, we refer to this procedure as the 4 percent diameter limit. In practice, the forester can adjust rates of return with each cutting cycle to control residual stocking, although that was not done in this case (Miller and Smith 1993).

Volume estimates used in our analysis were generated from local volume tables developed from sites throughout the Fernow Experimental Forest. Originally volume tables were constructed for each compartment. In 1971, board foot volume tables were revised based on site index and species. All board foot volumes presented in this analysis were calculated based on the 1971 tables.

RESULTS

Fifty years of measurement and observation in the two experimental management compartments have provided an image of long-term potential of forest stands in the Central Hardwood region. From the standpoint of providing sustained wood production and periodic income for farm woodland owners, the two systems have similarities and some differences.

Single-Tree Selection System

Initial Composition

At the outset of this study, Compartment 13 contained an estimated total volume of 10,444 bf ac^{-1}. Two-thirds of the stems measured, however, were poletimber-sized trees ($5 \leq$ dbh ≤ 11 inches); consequently, stand structure was well characterized by a negative exponential diameter distribution. Absolute stem density (dbh ≥ 5 inches) was 153 trees per acre, comprised predominately of yellow-poplar (19 percent), beech (12 percent), birch (12 percent), and red oak (12 percent). Volume in the stand was dominated by yellow-poplar (18 percent), beech (16 percent), sugar maple (15 percent), and red oak (11 percent).

Volume Production

By the end of the first decade, standing merchantable volume had increased 811 bf ac^{-1} (9 percent) from an initial 9,240 bf ac^{-1}, and attained 10,051 bf ac^{-1} despite the relatively heavy cutting over the decade that was necessary to remove unproductive culls. During the second and third decades removals diminished, but standing volume continued to increase to 12,045 bf ac^{-1} (20 percent) and 14,209 bf ac^{-1} (18 percent), respectively. The remeasurement data from the end of the fourth decade shows that standing volume decreased 176 bf ac^{-1} (-1 percent), but again increased 991 bf ac^{-1} (7 percent) to 15,024 bf ac^{-1} by the end of the fifth decade.

Cull and Merchantable Removals

Management of this compartment under the silvicultural regime described above resulted in five decades of wood production that generated about 2,600 bf ac^{-1} per decade in merchantable removals. In reality, merchantable removals varied by decade, with less volume removed in the second and third decades than greater volumes removed in the subsequent two decades as stand structure goals were met and surpluses were removed (fig. 1).

In this compartment, initially 1,204 bf ac^{-1} of cull wood were present in the stand and through the first decade 1,249 bf of cull material were removed (table 1). At the 10-year remeasurement, only 169 bf ac^{-1} of cull and 77 bf ac^{-1} of dead material were recorded, illustrating the intent to improve growing-stock quality. The

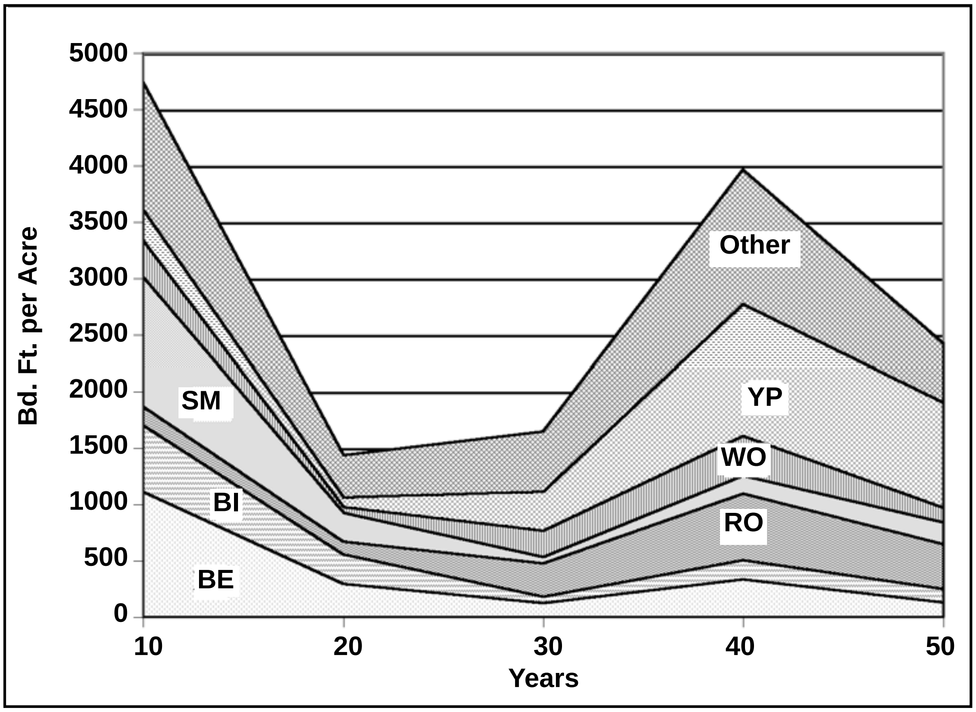

Figure 1.—*Total board foot per acre removals from single-tree selection treatment by species group and years following establishment of the Farm Woodlands Study areas at the Fernow Experimental Forest. "Years" represents the decade that the removals were made, e.g., 10 is the first 10 years of the study, 20 is the second 10 years, and so on. Legend codes are: YP=yellow-poplar, WO = white oaks, SM = sugar maple, RO = red oaks, BI = birch, BE = American beech, Other = composite of species described in methods.*

unmerchantable material that was cut throughout the first decade represented 26 percent of the removals and 12 percent of the initial standing volume in this period. The relatively high proportion of culls removed permitted the more valuable stems to acquire main canopy growing space and to accelerate their growth. This process of cull removal consequently increased potential merchantable volume production at the stand level; by the end of the second decade there were few cull trees occupying productive growing space.

Beech, birch, and sugar maple comprised the bulk of the volume removed in the first decade from the single-tree selection area (fig. 1). Of this total volume, beech was the dominant cull species (48 percent of cull volume) and sugar maple dominated the merchantable class (30 percent of merchantable volume). Sugar maple was not a preferred species during the initial logging (c. 1905–1912), which explains its importance in merchantable classes during the 1950s.

Over the next several decades this cutting pattern changed (fig. 1). With time, removals became increasingly comprised of the oaks and yellow-poplar, reflecting the intent to manage for these species by retaining vigorous individuals and giving them additional growing space. By the fourth and fifth decades, at least 30 percent of merchantable removals were yellow-poplar stems, reflecting the shifting canopy dominance patterns in the cutting units. Red oak removals, too, had increased by the fourth decade following establishment and comprised about 15 percent of the removals during the last two decades. By the end of this 50-year period, cull material in this stand was virtually nonexistent.

Shift in Stand-Level Species Composition

Species composition and stand structure in the single-tree selection area has changed throughout the course of the first 50 years of observation. Initially, yellow-poplar, beech, sugar maple, and red oak were the only species accounting for more than 10 percent of the total standing volume with yellow-poplar exceeding all others

Table 1.—*Fifty-year volume production of two Farm Woodlands Study demonstration stands on the Fernow Experimental Forest in eastern West Virginia. Volume units denote average per acre board foot volume (International 1/4-inch rule) for all stems greater than 11 inches diameter at breast height. The study was initiated in 1949.*

	Years since establishment					
Volume component	**0**	**10**	**20**	**30**	**40**	**50**
-	-------------------------*Single-tree selection system*---					
Growing stock	(bf/ac)	(bf/ac)	(bf/ac)	(bf/ac)	(bf/ac)	(bf/ac)
Merchantable	9,240	10,051	12,045	14,209	14,033	15,024
Cull	1,204	169	44	48	0	43
Dead	0	77	19	36	77	107
Removals						
Merchantable		3,491	1,335	1,611	3,961	2,427
Cull		1,249	99	36	5	0
Cumulative yield [1]	9,240	13,542	16,871	20,646	24,431	27,849
	-------------------------- *4% diameter limit cutting*--					
Growing stock						
Merchantable	5,366	6,108	9,097	10,443	11,251	12,204
Cull	697	105	75	47	54	19
Dead	0	33	43	42	151	102
Removals						
Merchantable		2,204	496	3,377	3,931	2,829
Cull		822	40	33	76	22
Cumulative yield	5,366	8,312	11,797	16,520	21,259	25,041

[1]Cumulative yield for a given period includes initial merchantable volume, the change in merchantable volume, and the volume of merchantable removals.

(18 percent). After 50 years, yellow-poplar accounted for 36 percent of the volume followed by red oak with 26 percent. No other species accounted for more than 8 percent.

The change in composition has not stopped. Despite the fact that yellow-poplar and red oak have grown to dominate stand composition, the increasingly larger proportion of these species in the harvest volume, combined with their lack of ingrowth into smaller size classes indicates a future depletion of these species from this unit (fig. 2). Moreover, shade tolerant species like American beech, red maple, and sugar maple have increasingly dominated ingrowth into the smaller size classes (fig. 3) and will likely begin to dominate merchantable harvest volumes in the next half-century.

4 Percent Diameter Limit Cutting

Initial Composition

In Compartment 21, initial volume was lower than in Compartment 13 because past logging and logging-era fire left fewer residual trees. Still, just over two-thirds of the stems measured were poletimber-sized and stand structure was similarly well characterized by a negative exponential diameter distribution. Absolute initial stem density was 200 stems ac^{-1} and comprised mostly of red oak (18 percent), birch (16 percent), yellow-poplar (13 percent), and beech (10 percent). Initial board foot volume was largely beech (28 percent), yellow-poplar (13 percent), red oak (15 percent), and sugar maple (10 percent).

Volume Production

Initial standing merchantable volume (5,366 bf ac^{-1}) in this compartment was only 58 percent of that in Compartment 13 (table 1). Yet, periodic harvesting of the two compartments during half a century generated almost identical volumes.

Using the 4 percent diameter limit selection system, this compartment exhibited positive increases in standing merchantable volume in each of the five decades of this study. By the end of the first decade, merchantable volume had increased 742 bf ac^{-1} (14 percent) to 6,108 bf ac^{-1} from its initial volume. Standing volume

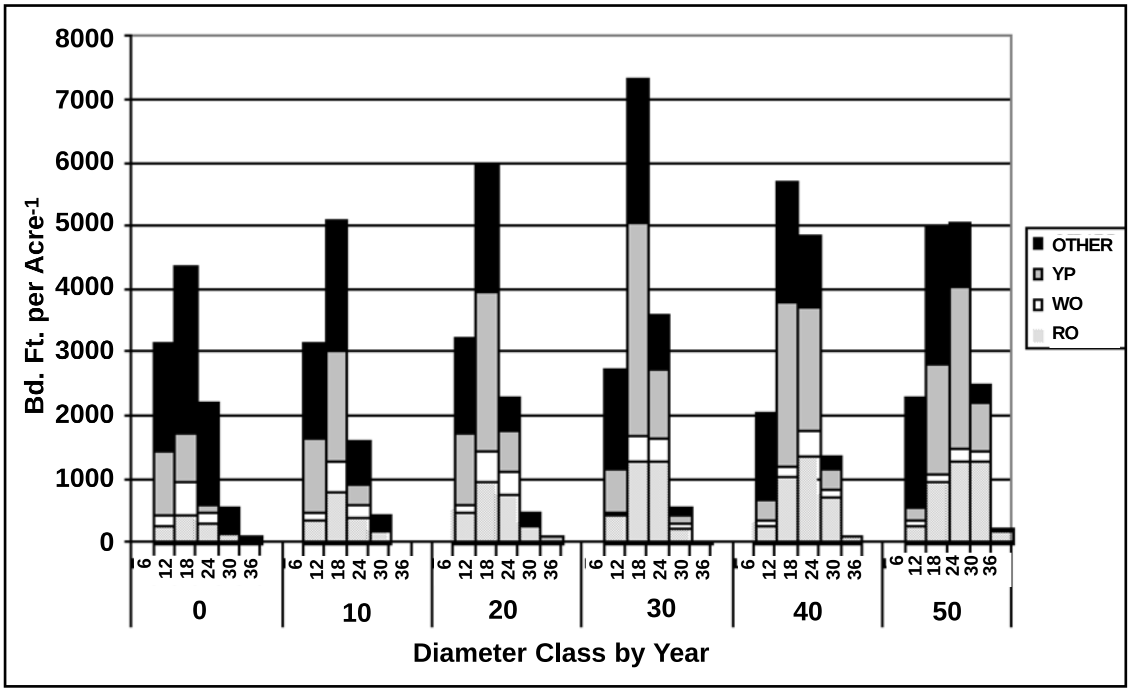

Figure 2.—*Volume distribution (International 1/4-inch rule) in single-tree selection area, highlighting red oak, white oak, and yellow-poplar by years following establishment of the Farm Woodlots Demonstration at the Fernow Experimental Forest near Parsons, West Virginia. Legend codes are: YP = yellow-poplar, WO = white oaks, RO = red oaks, and Other = composite of species as described in Methods.*

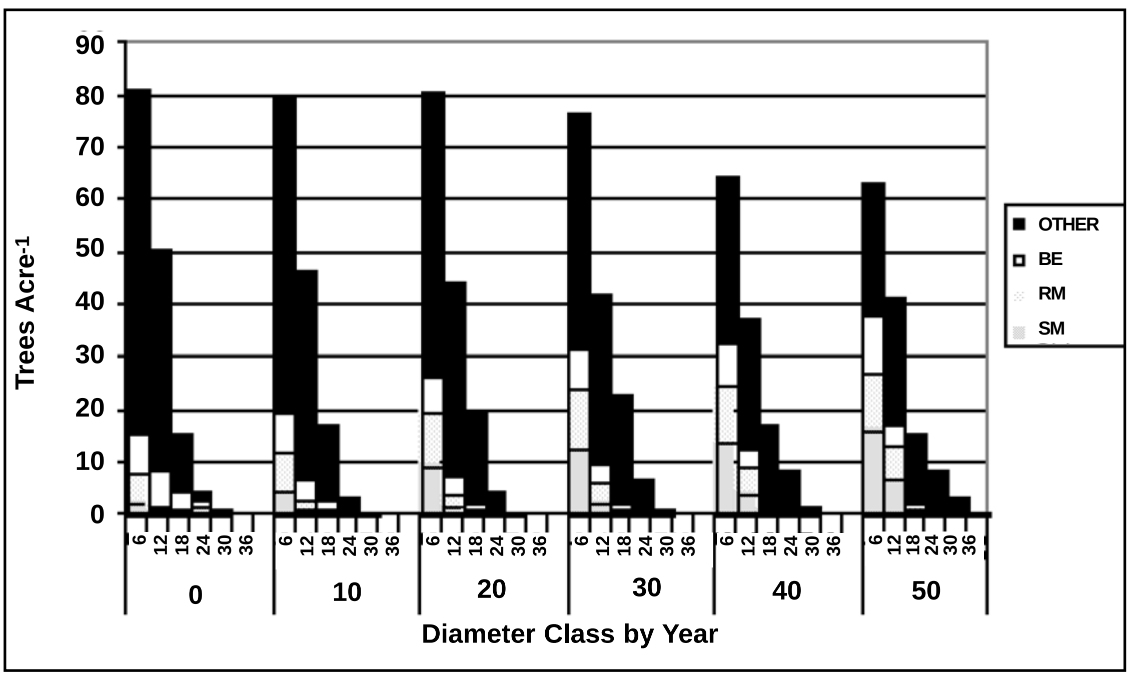

Figure 3.—*Frequency distribution (trees per acre) in single-tree selection area, highlighting shade tolerant species, by years following establishment of the Farm Woodlots Demonstration at the Fernow Experimental Forest near Parsons, West Virginia. Legend codes are: SM = sugar maple, RM = red maple, BE = American beech, and Other = composite of species as described in Methods.*

increased to 9,097 bf ac^{-1}—a change of 49 percent—during the second decade when a pulse of poletimber grew into small sawtimber-sized trees. Over the next three decades standing merchantable volume increased 15 percent, 8 percent, and 8 percent, respectively, resulting in 12,204 bf ac^{-1} at the end of the fifth decade.

Cull and Merchantable Removals
Of the initial 6,063 bf ac^{-1} measured in this compartment, 697 bf ac^{-1} (11 percent) were cull. During the first decade, 822 bf ac^{-1} of cull material were removed. Fifty-five percent of this volume was beech between 12 and 24 inches dbh and 22 percnt was red maple mostly greater than 16 inches dbh. This compartment was rapidly cleared of its unmerchantable and undesirable growing stock. Table 1 attests to this fact and shows very little cull volume following the first decade.

Species composition of removals changed through time in this stand. Initially, the majority of the volume removed was beech, but composition of removals became mostly red oak and yellow-poplar in the later cutting cycles (fig. 4). Proportions of these two species relative to the total volume removed in five decades from the beginning of the study to the end of year 50 were: 7 percent, 13 percent, 59 percent, 69 percent, and 66 percent.

Shift in stand-level species composition
Continuing change in species composition in this compartment is evident, given the diminution of shade intolerant species ingrowth into smaller diameter classes (fig. 5). Further evidence of this compositional shift is found in the increasing number and dominance of shade tolerant species in these smaller size classes (fig. 6).

DISCUSSION
At a minimum, these two compartments of the Farm Woodlands study have provided a long-term view of the behavior of forest communities as forest management guides them into selection systems.

In both systems, the common and consistent practice of first removing all undesirable (or unacceptable) growing stock and applying the protocols of each system, led to a period during

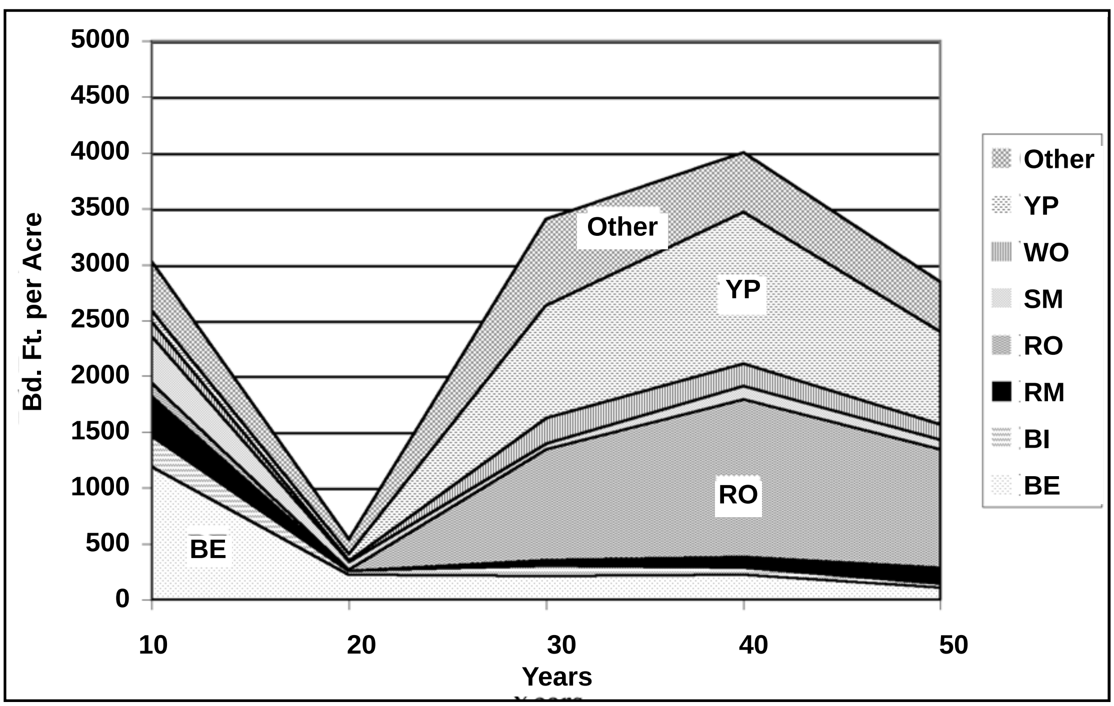

Figure 4.—*Total board foot per acre removals from 4 percent diameter limit cutting by species group and years following establishment of the Farm Woodlands Study areas at the Fernow Experimental Forest. "Years" represents the decade that the removals were made, e.g., 10 is the first 10 years of the study, 20 is the second 10 years, and so on. Legend codes are: YP=yellow-poplar, WO = white oaks, SM = sugar maple, RO = red oaks, RM = red maple, BI = birch, BE = American beech, and Other = composite of species as described in Methods.*

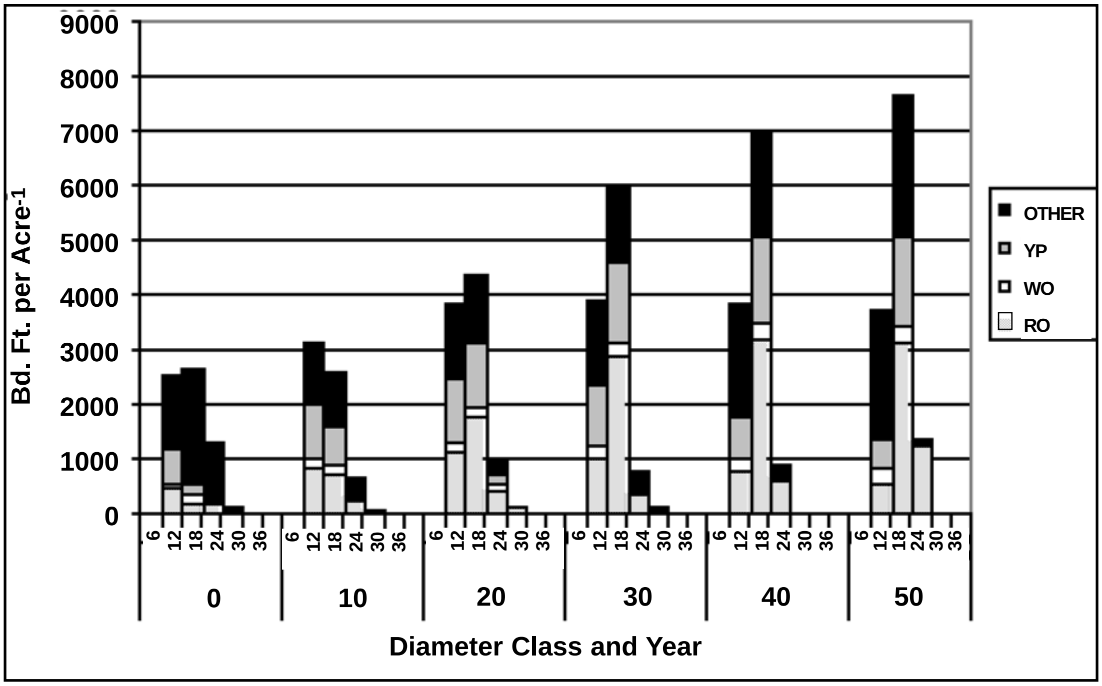

Figure 5.—*Volume distribution (International 1/4-inch rule) in 4 percent diameter limit cutting, highlighting red oak, white oak, and yellow-poplar by years following establishment of the Farm Woodlots Demonstration at the Fernow Experimental Forest near Parsons, West Virginia. Legend codes are: YP = yellow-poplar, WO = white oaks, RO = red oaks, and Other = composite of species as described in Methods.*

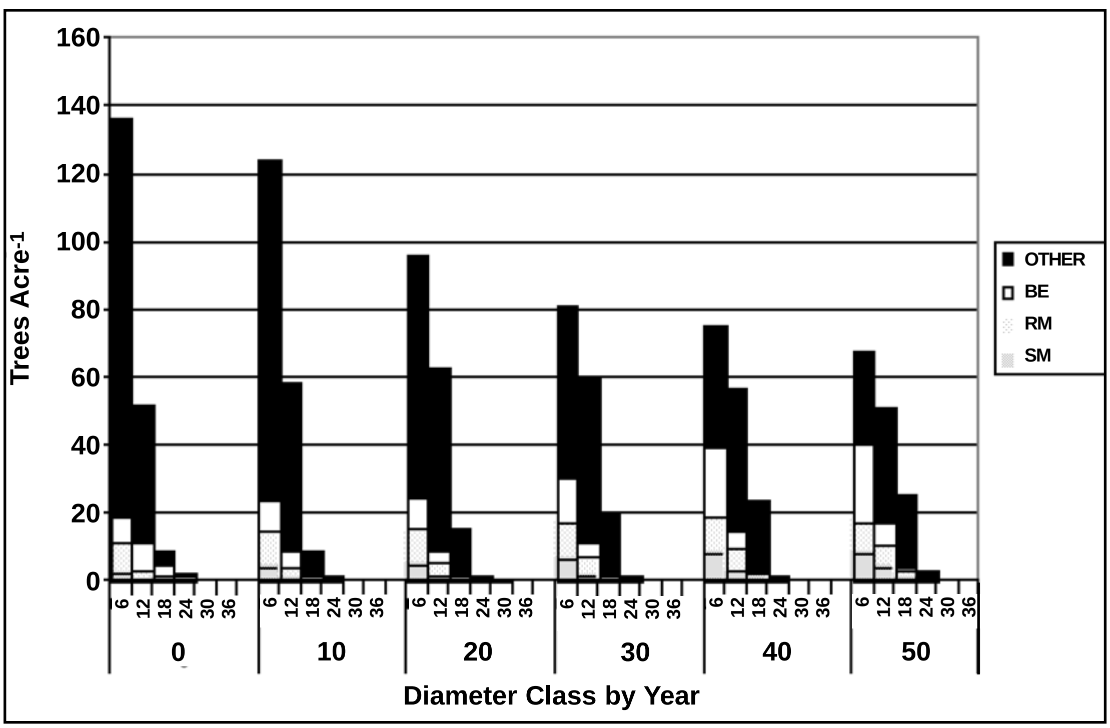

Figure 6.—*Frequency distribution (trees per acre) in 4 percent diameter limit cutting, highlighting shade tolerant species, by years following establishment of the Farm Woodlots Demonstration at the Fernow Experimental Forest near Parsons, West Virginia. Legend codes are: SM = sugar maple, RM = red maple, BE = American beech, and Other = composite of species as described in Methods.*

the second decade where removals were at a minimum (figs. 1 and 4). This period of decreased removals was less pronounced in the single-tree selection system where higher initial volumes provided the opportunity to remove merchantable material without sacrificing stand structure goals.

Both silvicultural systems have produced remarkably similar volumes through the second half of the 20th century. As mentioned earlier, total removals were virtually identical and averaged only 2 bf ac^{-1} $decade^{-1}$ difference between the two units (2,567 bf ac^{-1} $decade^{-1}$ removed in Compartment 13 and 2,565 bf ac^{-1} $decade^{-1}$ removed from Compartment 21). Average gross and net productivity also have similarly close values (table 2). Interestingly, while the 4 percent diameter limit cutting started with just over 3,800 bf ac^{-1} less standing merchantable volume than that initially in the single-tree selection system, by the end of 50 years—and with nearly equal removals over the period—the gap between standing merchantable volumes had narrowed to a difference of about 2,800 bf ac^{-1}. Indeed, over this period the net periodic annual increment (PAI) in the 4 percent diameter limit averaged 394 bf ac^{-1} yr^{-1}, nearly a 6 percent higher PAI than that of the single-tree selection system.

When considering the similarities in productivity and species composition that both systems have produced, the greater complexities of stand management using single-tree selection guidelines hardly seem justified. Miller and Smith (1993) provide additional suggestions for using the flexible diameter-limit approach and recommend it as a practical alternative to single-tree selection based on other long-term studies. Moreover, small private woodland owners are unlikely to have the skills to apply a single-tree selection system, but may be able to employ many of the ideas of the flexible diameter limit system.

What might these systems have produced if left unmanaged? A rough comparison can be made to a nearby compartment that serves as an unmanaged reference stand for the Fernow Experimental Forest. Watershed 4B (WS4B) (13 acres) has been measured five times in the last 48 years using four, 100-percent cruises and one fixed radius plot sample. These data provide a mirror against which we can cautiously compare managed stands. Table 3 shows the yields achieved on the 13-acre reference area beginning in 1959 at approximately the same time as the year 10 inventories were made on the Farm Woodlands study. At the initial measurement in 1959, WS4 contained 9,325 bf ac^{-1} of merchantable sawtimber. At the comparable

Table 2.—*Growth and yield values from two selection systems of the Farm Woodlot Study Compartments located on the Fernow Experimental Forest near Parsons, West Virginia. Both gross and net increments express compartment growth including ingrowth. Gross increment treats cull volumes cut during harvesting operations as mortality.*

Growth Parameter	Years 0	10	20	30	40	50	Mean
			Single-tree selection system				
Yield	9,240	13,542	16,871	20,646	24,431	27,849	
Gross Increment		5,551	3,428	3,811	3,790	3,418	
Gross PAI		555	343	381	379	342	*400*
Δ GPAI			-38%	11%	-1%	-10%	
Net Increment		4,302	3,329	3,775	3,785	3,418	
Net PAI		430	333	378	379	342	*372*
Δ NPAI			-23%	13%	0%	-10%	
			4 percent diameter limit cutting				
Yield	5,366	8,312	11,797	16,520	21,259	25,041	
Gross Increment		3,768	3,525	4,756	4,815	3,804	
Gross PAI		377	353	476	482	380	*413*
Δ GPAI			-6%	35%	1%	-21%	
Net Increment		2,946	3,485	4,723	4,739	3,782	
Net PAI		295	349	472	474	378	*394*
Δ NPAI			18%	36%	0%	-20%	

measurement, the single-tree selection system had 10,051 bf ac^{-1} and the 4 percent diameter limit had 6,108 bf ac^{-1}, or 726 bf ac^{-1} more and 3,217 bf ac^{-1} less than WS4B, respectively.

At its final measurement, which occurred in 2001, WS4 contained 20,677 bf ac^{-1} in merchantable volume and 2,789 bf ac^{-1} in dead sawtimber volume. Even if the assumption that the dead material was still recoverable, its yield at that time would be 23,466 bf ac^{-1}. In both of the managed systems in this study, yield exceeded that of WS4B by 4,383 bf ac^{-1} in the single-tree selection system and by 1,575 bf ac^{-1} in the 4 percent diameter limit.

CONCLUSIONS

Given the initial structure, composition, and silvicultural regimes applied to these compartments, species composition shifts have occurred over the study period. Yellow-poplar and red oak, once existing among larger maples and beech, now dominate the site in the larger size classes. The compositional shift will continue as the larger yellow-poplar and oaks are harvested and replaced by more shade tolerant maples and beech that are now dominating the pole-timber-size classes. This shift will likely occur more quickly in the 4 percent diameter limit system because the oaks and yellow-poplar can be cultured throughout the size distribution in the single-tree selection system to a maximum of 32 inches dbh.

The silvicultural activities that aimed to bring these compartments under management aggressively eliminated cull trees from the stands. This consequently served to maximize merchantable volume production on the crop trees, evidenced by very little or no cull volumes in the later remeasurements and harvest data. Under these management scenarios, stand transition from states of unspecified management to uneven-aged silvicultural systems, the volume of removals in both compartments was relatively high in the first decade and had the lowest levels in the second decade. This is related to ridding the stand of undesirable trees during the first decade of management and then allowing the stands to accumulate growing stock during the second decade of management. This general pattern can be expected when applying these partial cutting practices to previously unmanaged and exploited forest stands.

The flexible diameter system is a practical alternative to the complexities of single-tree selection. When applied appropriately, similar outcomes in productivity and species composition can be expected.

Both systems evaluated here lead to dominance of shade tolerant species. In our case, sugar maple provides a valuable shade tolerant commercial species. However, relative values of red maple and beech are much less and landowners should be aware of the potential of ultimately changing periodic revenues even while periodic productivity may not be drastically altered. Moreover, American beech is suffering the effects of beech bark disease and is likely to be limited to predominantly understory status in many areas.

ACKNOWLEDGMENT

During the past 50 years many individuals have played important roles in this case study. We especially want to acknowledge the pioneering

Table 3.—*Sawtimber volumes from unmanaged (control) Watershed 4 at the Fernow Experimental Forest near Parsons, West Virginia. Dates of remeasurement roughly correspond to 10, 20, 30, 40, and 50 year remeasurements of the Farm Woodlands Study established in nearby compartments. Volumes are expressed as board feet (International 1/4-inch rule) per acre. Yield assumes dead material is merchantable.*

	Year of measurement				
	1959	**1972**	**1984**	**1994‡**	**2001**
Years in interval		14	11	10	7
Volumes					
Merchantable	9,325	13,149	16,942	21,351	20,677
Dead	-	369	1,202	2,629	2,789
Cull	490	698	325	-	-
Yield	9,325	13,518	18,144	23,980	23,466
Percent Dead and cull	5%	8%	8%	11%	12%

efforts of C.J. Holcomb and Sidney Weitzman in establishing this study; G.R. Trimble, Jr. for his continuation of their initial concepts; H.C. Smith for establishing the more explicit silvicultural guidelines used to achieve the initial management objectives; G.M. Miller for carefully documenting and applying prescriptions; R. Rosier and R. Hovatter for much of the cruising and marking over the past several decades; and F. Wood and L. Plaugher for database management. We also want to thank the Fernow logging crew, which has done all of the logging for this study for the past half-century. Current member of this crew include R. Poling, M. Owens, and S. Hockman.

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