Some Options for Managing Forest Land in the Central Appalachians

by George R. Trimble, Jr.
James H. Patric
John D. Gill
George H. Moeller
James N. Kochenderfer

USDA FOREST SERVICE GENERAL TECHNICAL REPORT NE-12
1974

NORTHEASTERN FOREST EXPERIMENT STATION
FOREST SERVICE, U. S. DEPARTMENT OF AGRICULTURE
6816 MARKET STREET, UPPER DARBY, PA. 19082
WARREN T. DOOLITTLE, DIRECTOR

FOREWORD

This paper reports the joint efforts of a multifunctional research team to assess the interactions of different management activities on four resources of the Appalachian forests.

The team was established and is conducting research so that management decisions on the forest lands may reflect various alternative management objectives, and so that better multiresource management may be practiced.

The field of multiresource management is controversial. One reason for this is that products such as visual appeal, water quality, and wildlife do not have tangible market values. Value determinations for them are rudimentary and imprecise so it is difficult to compare the consequences of various management decisions in a meaningful manner. Also, there is much less knowledge as to the effects of different management actions on wildlife and visual appeal than there is about timber and water responses to management.

Of necessity, this report is a tentative step in the direction of multiresource management and evaluation. In the future, we hope that many of the subjective evaluations presented in this report can be made much more precise. And finally, we are grateful for the many review comments and suggestions given us by our friends in universities, state agencies, and industries and by our colleagues in the Forest Service.

W. T. Doolittle
Director

The Authors

GEORGE R. TRIMBLE, JR., now retired, was principal silviculturist at the Timber and Watershed Laboratory at Parsons, West Virginia.

JAMES H. PATRIC is a forest hydrologist at the Timber and Watershed Laboratory at Parsons, West Virginia.

JOHN D. GILL is a wildlife biologist at the Forestry Sciences Laboratory at Morgantown, West Virginia.

GEORGE H. MOELLER is a research forester in recreation located on the campus of the State University College of Environmental Science and Forestry at Syracuse, New York.

JAMES N. KOCHENDERFER is a research forester at the Timber and Watershed Laboratory at Parsons, West Virginia.

All are members of the Northeastern Forest Experiment Station.

MANUSCRIPT RECEIVED FOR PUBLICATION 5 SEPTEMBER 1973

Some Options for Managing Forest Land in the Central Appalachians

ABSTRACT

For years foresters have recognized the principle of multiple use, and progress has been made toward managing forest resources to satisfy more than a single human need. But much more progress is needed if our forest land is to satisfy the many needs of a growing population with more free time and more money.

This publication is intended to broaden the forester's perspective in evaluating the suitability of tracts for a variety of uses and use mixes.

We made an attempt to evaluate for the area of the central Appalachians (which includes most of West Virginia and portions of the five adjacent states) the general effects of different forest practices on the following resources: timber, water, visual appeal, and wildlife. What is presented is a series of options from which choices can be made to meet particular owner objectives. With this information in hand, the manager should be in a better position, not only to fulfill his objectives, but to favor conditions beneficial to other uses with different objectives.

The management options presented apply to the forest ecosystems that predominate in the central Appalachian region. These are the basic forest land units we chose to use in comparing and evaluating the effects of the various practices on the four forest resources. The seven forest ecosystems, which are described in detail, are: (1) the oaks, (2) Appalachian mixed hardwoods, (3) northern hardwoods, (4) white pine, (5) Virginia pine, (6) red spruce, and (7) flood-plain hardwoods. Each of these ecosystems, and quality of forest sites likely to occur within it, was rated as to its inherent capacity to supply each of the four resources.

Management for any forest product ordinarily involves tree cutting, so profitable tree harvest offers the most practical vehicle of management. Three broad management methods were considered for each ecosystem: even-aged management, uneven-aged management, and no commercial harvesting. The first two of these methods were subdivided into conventional cutting practices, and all were rated as to desirability to produce timber, water, visual appeal, and wildlife. The desirability ratings have no quantitative significance; they express a specialist's judgment of how each forest product is likely to be influenced by the specified practice.

Thus, the user of this paper is presented with a series of forest management options, from which he may choose those cutting practices best suited to his peculiar combination of forest resources and of land ownership objectives. Examples at the end of the paper show how options might be selected in actual forest management.

CONTENTS

Introduction

FOR YEARS FORESTERS have recognized the principle of multiple use, and progress has been made toward managing forest resources to satisfy more than a single human need. But much more progress is needed if our forest land is to satisfy the many needs of a growing population with more money and more free time.

The type of forest ownership and size of property affect the degree to which multiple use can and will be practiced. On large public holdings, where great pressure exists for the fulfillment of a wide diversity of demands, there is no doubt that a real attempt will be made to meet the needs. And on any large forest area that is in one ownership, the practice of multiple use is more feasible than on small woodlots. However, 90 percent of the forest land in the Appalachian area is owned by private individuals and much of it is in small holdings. Studies have shown that even among these private owners few have single objectives in land ownership. Ordinarily they voice two or three objectives; often these objectives are not clearly defined.

This publication is intended to broaden the forester's perspective in evaluating the suitability of tracts for a variety of uses and use mixes. It should help the landowner crystalize reasonable expectations about the potential of his tract to satisfy some of his objectives. Also, it should be a valuable communication aid between the forester and the landowner.

The management options presented apply to the forest ecosystems that predominate in the central Appalachian region. These are the basic forest land units we chose to use in comparing and evaluating the effects of the various practices on the four forest resources. The seven forest ecosystems, which are described in detail later on, are: (1) oaks, (2) Appalachian mixed hardwoods, (3) northern hardwoods, (4) white pine, (5) Virginia pine, (6) red spruce, and (7) floodplain hardwoods. The ecosystem format is a compromise that caused the authors to speculate to some degree because available research information, particularly for wildlife and visual appeal, was not accumulated in the context of these particular ecosystems.

For brevity, only the common names of plants and animals are given. The names of most of the trees and some shrubs are those preferred in the *Check List of Native and Naturalized Trees (Little 1953)*. However, in some cases we used the locally accepted common names of trees. For other plants our authority was *Flora of West Virginia (Strasbaugh and Core 1952-64)* whose nomenclature is based on *Gray's Manual of Botany (Fernald 1950)*.

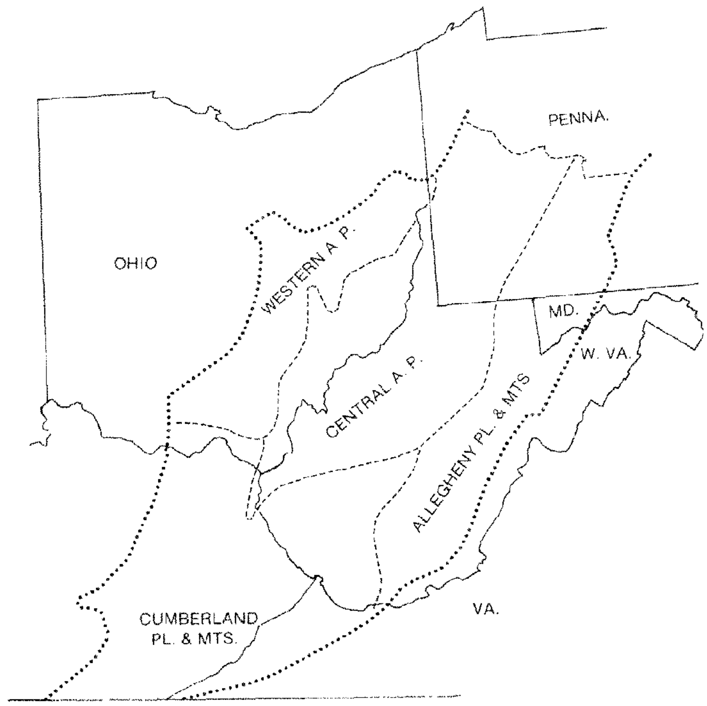
Description of the Area

The central Appalachian region includes most of West Virginia and parts of the five adjacent states (fig. 1). Unifying features of the region are that it was once a nearly level plateau underlain by sedimentary deposits (including coal, gas sands, limestone, salt, and other minerals); it has not been glaciated; but it has been severely dissected by streams. The long eastern and western boundaries are distinct with respect to topography and land uses, but the northern and southern limits were chosen somewhat arbitrarily.

The region encompasses about 80 percent of four Appalachian land resource areas described by Austin (*1965:55-57*) (fig. 2): eastern Allegheny Plateau and Mountains, central Allegheny Plateau, western Allegheny Plateau, and Cumberland Plateau and Mountains.

The broad social and economic situation in central Appalachia has been discussed by many authors and will not be repeated. Instead the status of four forest resources is summarized in the "Rationale" section, and

Figure 1.—Land Resource areas in the central Appalachians.



here we summarize forest survey data which have not been previously published for central Appalachia as a unit (see Appendix for details).

Two-thirds of the 35-million-acre central Appalachian area is forested. Forestation is greatest in West Virginia, Virginia and Kentucky (75 to 80 percent), and least in Pennsylvania and Ohio (about 52 percent). Nearly all the forested area is classed as commercial forest land (land that is producing, or physically capable of producing, crops of industrial wood, and that is economically available now or prospectively). Less than 200,000 acres of woodlands have either been officially withdrawn from timber utilization or are incapable of yielding industrial wood products (Appendix, table 10), but many more are not available for commercial timber production because the owners are not interested in selling timber.

Nearly half of the commercial forest land is occupied by sawtimber stands—those at least 10 percent stocked with suitable growing-stock trees, with half or more of the stocking in sawtimber or poletimber trees, and with sawtimber stocking at least equal to poletimber stocking. Sawtimber is least abundant in Ohio (where it is about 30 percent of the commercial forest area) but constitutes 42 to 52 percent of the forest area in the other five states. The remainder of the commercial forest area is divided between poletimber (23 percent) and seedling or sapling stands (29 percent). About half a million acres is classed as nonstocked; that is, in stands less than 10 percent stocked with growing-stock trees (Appendix, table 12).

The pattern of forest ownership is a mosaic of small holdings (Appendix, table 11). Almost 90 percent of the land belongs either to farmers (35 percent) or "miscellaneous private owners" (54 percent). Forest industries hold only about 820,000 acres (4 percent) of the total. the remaining 7 percent is either in National Forest (1,008,000 acres), or other public ownership (620,000 acres).

Ownership objectives have not been measured for central Appalachia as a separate unit, but the results of a West Virginia survey (*Christensen and Grafton 1966*) show that among all classes of private woodland owners, including industrial ownerships, objectives of ownership were ranked as follows: (1) wildlife, (2) timber for own use, (3) soil protection, (4) pasturage, (5) recreation, (6) watershed, (7) timber for sale, (8) secondary products for own use.

Forest-type acreages reported in timber resource bulletins were difficult to adapt to the forest ecosystems defined here. Many local forest types (such as white oak, northern red oak, yellow-poplar oak, sweetgum yellow-poplar, and various combinations) made up the oak-hickory major forest type and accounted for nearly two-thirds of the total commerial forest area. These types are the ones in which oaks or hickories, singly or in combination, make up a plurality of the stocking. Next in rank is the general type maple-beech-birch (mostly the local cherry-maple type) which occupies about 14 percent of the commercial forest land. The only other type that occupies more than 5 percent of the area is ash-elm-red maple. It occurs mostly on floodplains and in cold wet upland depressions. The oak-pine and pitch-shortleaf-Virginia pine forest types each occur on 4 to 5 percent of the area. The remaining acreage (4 percent) is split among aspen-birch, white pine, oak-gum, and spruce forest types (Appendix, table 13).

Rationale for Multiple-use Considerations

To compare and discuss multiple-use options within a framework meaningful for the four resources we had to be concerned with a wide range of systems for managing forest lands. Thus we recognized that the optimum system for any one multiple-use may diverge greatly from the optimum for another use. Because forest manipulation for any use depends largely on cutting trees, operations which return a profit from timber harvesting usually offer the most practical vehicle for manipulating forest stands. In all, three generalized systems were rated:

(1) Even-aged management, involving growing and harvesting trees of the same age.

(2) Uneven-aged management, involving periodic harvesting in the same stand of selected trees of different ages.

(3) No commercial forest cutting, leaving the stand intact or at most involving removal of certain designated stems.

Within these three management options, we felt that we could consider most types of operations aimed at enhancing the four resources: timber, water, visual appeal, and wildlife.

We did not feel that it was desirable within the scope of this paper to discuss in detail or to present guidelines for all the elements inherent in the various proposed systems. For example, good road management—which is pertinent to management for all the resources—was not discussed simply because the technical principles are known and available. Likewise control of wildfire, extremely important to the practice of forestry for any purpose, was not discussed since methods of applying proper fire control are available. In the same way, procedures for elimination of roadside debris and thinning forest stands are examples of the types of practices for which information would ordinarily be available to practitioners or could be worked out for the local situation based on established principles. Thus failure to prescribe methodology in these areas was not due to lack of recognition of their importance but to the belief that it was unnecessary.

In the following, we discuss our rationale as developed separately for each resource.

TIMBER

Timber is an important crop in the central Appalachians. A large number of commercial species are found in several widely diverse ecosystems. Many of these species are valuable hardwoods, badly needed in the wood economy of the Nation. The complexity of species mixtures and the variability in site quality combine to give us some of the most productive stands in the Nation and some of the poorest.

Overall, however, productivity is good; and prospects for profitable timber management are encouraging.

It is not practical to describe in detail in this paper all the potential ramifications of forestry operations that exist under the wide range of physical and economic conditions. For simplicity, the forestry operations are grouped under two main management systems—even-aged and uneven-aged. Within these two systems, forest practices will vary from crude to highly intensive and will be adjusted to meet the variations in sites, stand conditions, markets, and owner objectives (both private and public). Within these constraints, and within the limitations imposed by the other-than-timber demands on the forest resource, our recommendations assume the practice of the best silviculture possible.

Because this is a discussion of options, we had to develop a framework for timber operations that rated stumpage returns relative to different broad kinds of practices. In the framework we chose, all considerations are relative *within* an ecosystem and a site class, and we could ignore to a certain extent the differences in stumpage returns among ecosystems and sites. The following generalized relationships formed the bases for rating stumpage returns:

1. Even-aged systems are more profitable than uneven-aged systems.
2. Within even-aged systems, large clearcuts are more profitable than small ones.
3. Again within even-aged systems, for the rotations cited, the shorter rotations yield higher rates of return than the longer rotations.
4. Where uneven-aged management is practiced (and for the range of tree sizes cited), a low rate of return is correlated with the larger-sized harvestable trees and a high rate of return is correlated with the smaller harvestable trees.

The rotation ages given for comparative purposes were based on rate of return (financial maturity) studies (*Trimble and Mendel 1969; Mendel and Trimble 1969; Grisez and Mendel 1972; Mendel, Grisez and Trimble 1973*). Because changing costs and returns can alter specific rates, it is best to think of these rotations as characterized by high rates of return, medium rates of return, and low rates of return. Actually the shortest rotation is predicated on harvesting the trees when they no longer return 6 percent for sawtimber; the medium-length rotation is predicated on a return rate of 4 percent; and the long rotation is based on a 2 percent return. The rates of return refer to the earning power of individual sawtimber-sized trees based on their current value and their increase in value annually for the next 10 years.

The rotation length associated with the 6 percent rate of return would be the first choice where only timber is important to the landowner. But, the longer rotations (lower rates of return) merit consideration where other resources are also important—say where the landowner wants more mast production for wildlife. In such cases, one might even want to know the tree diameters associated with the zero rate of financial return from timber. However, for technical reasons, the tree diameters calculated for return rates approaching zero tend to be unrealistic. The zero rate occurs when the rate of value deterioration equals the rate of value growth. A tree may reach its maximum physiological age or size before this happens, and calculated diameters for low return rates such as 0.5 percent may be 40 to 50 inches—clearly larger than the maximum size generally reached by many species.

This is not a serious barrier to using information about the low rates of return on timber. The 2 percent rate, in particular, is appropriate for planning multiple-use management where nonmonetary benefits may compensate for reductions in financial return.

Reducing the size of the area harvested in a single clearcut below some practical minimum reduces the net stumpage and the percentage return because of increased forest management and harvesting costs. An additional disadvantage of small clearcuts in hardwood stands is increased border-tree degrade from epicormic branching—the smaller the size of clearcuts made to harvest a given acreage, the greater the length of border and the larger the number of border trees exposed to epicormic branching.

Uneven-age management with selection cut-ng is generally considered to involve higher anagement and harvesting costs than even-ged systems. As with even-aged management, iides were set based on financial maturity. rowing the trees to the greatest age and size dicated is based on a low rate of return, and owing them to the smallest size shown is ased on a high return. The ages and dbh's iven in the tables are for the average size of e sawtimber trees harvested. The assump-on is made that in marking these stands lvicultural considerations will be stressed.

For some ecosystems, financial maturity in-rmation was not available as a basis for rec-mmendations for either even-aged or uneven-ged systems, and for some it was not ap-ropriate. In these cases, other considerations ere used and these are described in the eparate ecosystem discussions.

WATER

Most of this region receives at least 40 nches of well-distributed precipitation annu-lly, the basis of a water resource ample for nost local needs. Many perennial streams rise n forested hills and mountains of the central Appalachian region. Water in these smaller streams is abundant and clean. It contributes substantially to domestic and public supplies. But downstream from residential and manu-facturing areas, most larger streams are pol-luted by acid drainage from coal mines and mine wastes, or by industrial and domestic wastes. Ground water often is accessible through deep wells but may be polluted by high mineralization. The technical know-how is available to decontaminate all of these water supplies, although many of the processes are expensive and seldom used when alternative supplies are available. These summary state-ments illustrate the major water problem of the central Appalachians; there is plenty of water but too often it is unusable without costly treatment.

Research has, however, tested several meth-ods of forest management that improve, or at least maintain, the upstream water resource. Flow in headwater streams is increased by tree cutting (*Douglass and Swank 1972*). At least 20 percent of the basal area on a given water-shed must be cut to cause a measurable flow increase and at least half of it must be cut to achieve an increase of useful size. Forest re-growth is so rapid in the central Appalachians that increases following partial cutting rarely persist for more than 2 years thereafter. Maxi-mum increases, on the order of 10 or more inches during the first year after treatment, are possible after cutting all of the vegetation on a given watershed. But again, so rapid is forest regrowth that, even after clearcutting, flow increases taper off quickly and usually are inconsequential 6 years later. There is some evidence (*Hibbert 1967*) that north-facing slopes are more responsive to treatment than those facing south, an effect likely to be restricted to the steepest of mountain land.

Several useful generalizations are known concerning timing of streamflow increases from cutover forest land. All of them are predicated on maintaining a fairly continuous litter cover over the soil, and on maintaining the high infiltration rates characteristic of forest land. There is little question that most flow in-creases occur during the growing season, re-flecting the fact of reduced transpiration and rainfall interception losses that greatly aug-ment the soil moisture (*Patric 1973*) from which most headwater streamflow is derived. With augmented soil moisture, stormflow is higher from cutover forest land—but only during the growing season. Dormant season stormflow usually is little influenced by forest cutting because, in the humid climate of the central Appalachians, soil moisture in the dormant season is at near-maximum levels everywhere, regardless of forest cover. There has been considerable speculation that snow-melt might be desynchronized by judicious forest cutting, thereby lessening snow-melt floods, but it is now felt (*Federer et al. 1972*) that this form of flood regulation is imprac-tical in the eastern United States.

Timber harvest often has detrimental though preventable effects on quality of streamflow. Water temperature increase ac-companying heavy cutting near streams is pre-vented by retaining an uncut or lightly cut strip of trees to shade channels. There is evi-dence of increased chemical content in New

Hampshire streams after heavy cutting (*Pierce et al. 1972*), although a review of research (*U.S. Forest Service 1971*), showed no similar effects elsewhere in the country. Fire is currently regarded as of negligible importance to water quality in this region. Increased turbidity caused by eroded soil and organic matter has been and remains the paramount threat to water quality in forest streams. Tree cutting per se, even clearcutting, does not cause soil erosion but careless logging can and does, regardless of the silvicultural systems applied. Again, the critical need is to maintain the high infiltration rates characteristic of litter-covered forest land. Road building and log skidding push aside the protective litter, exposing the underlying mineral soil to erosion. Methods both to prevent and to control such erosion and associated damage to water quality are known (*Kochenderfer 1970*) but all too often are regarded as too costly and are not applied. The key is intelligently regulated road and logging practices which, if followed, will assure streamflow of continued high quality. Otherwise, impairment of forest water quality is certain.

The preceding paragraphs summarize years of research concerning timber harvest effects on quantity, timing, and quality of forest water resources. These results have been achieved repeatedly in dozens of carefully controlled experiments. But it is commonly found that many experimental results, particularly the effects of forest cutting on amount and timing of streamflow, seldom are demonstrated on nonresearch watersheds. The reason, often not appreciated by the nonscientist, is that lack of experimental control in routine forest operations minimizes most opportunity to duplicate research results. It is not realized that a multitude of interacting influences, in addition to whatever forest management measure is applied, actually control streamflow from any forested watershed.

Given carefully applied watershed treatments, the universal condition of diversity virtually assures a minimum of water response to management in central Appalachian streams of greater than first-order magnitude. Diversity among tree species, sizes, and ages is characteristic of the regional forest, each combination affording a different opportunity for management practices. Diverse topography and soil properties will cause a wide range of hydrologic response to the selected management practice.

Markets for forest products vary from place to place and from year to year, some affording opportunities for profitable timber harvest. Superimposed on all of these variables is the predominant pattern of land ownership, a mosaic of small holdings having little or no relation to hydrologic boundaries, with management applied to each holding likely to reflect different objectives of forest land ownership. Given such diversity, practices having one effect on water resources tend to be nullified by other practices having unrelated or even opposite effects. For a simple example, streamflow increases caused by cutting seem to be balanced by decreases accompanying tree regrowth elsewhere on large watersheds. The probability is slight that any practice, or even group of practices, will be applied within the requisite limits of time and space to cause significant response on any but the smallest of watersheds.

The public is likely to look askance at most efforts to augment forest water supplies by cutting, an unshakeable tenet of their faith holding that the uncut forest optimizes water resources. In this light, most tree-cutting will be seen as hydrologically undesirable, regardless of research results to the contrary. Since public acceptance of a controversial practice usually is necessary before it is widely applied, intensive forest management for more water remains well in the future. Moreover, water is so relatively abundant in the humid central Appalachians that any sacrifice for it of timber, wildlife, or recreational values also will be reckoned as undesirable on economic grounds. Given these value judgments, intensive forest management to produce more water is not likely, but managers must be prepared to deal constructively with increasing public concern for protecting water quality.

In subsequent sections, a number of forest practices are assigned desirability ratings as to their influence on forest water resources. Ordinarily, those practices are considered desirable that:

1. Increase water productivity. Here, cutting practices are ranked most desirable as they decrease evaporative losses and correspondingly increase streamflow. Streamflow is maximized by eliminating all cover or by converting a forest ecosystem to some permanent low cover such as grass, but this conversion is costly and unwarranted in view of water abundance in the central Appalachians.
2. Protect water quality. Those practices causing least frequent and extensive exposure of mineral soil are rated most desirable. Water quality ordinarily is maximized on forest land by maintaining an unbroken tree and litter cover but this practice too is prohibitively costly in terms of other resource values necessarily foregone in its application.
3. It is further assumed that all forest practices will embody silviculturally acceptable techniques and that the accompanying logging and road practices will be regulated carefully and intelligently.

It will be noted that those practices tending to increase water productivity tend decreasingly to protect its quality. However, we know that use of silviculturally acceptable techniques to harvest forest products harms water quality so little that it remains fit for most human uses without additional purification. Thus, implementation of existing knowledge permits forest products harvest with some possibility of increased streamflow but without serious impairment of water quality. At this stage in the evolution of forest management in the central Appalachians, there is sufficient water to meet human needs; quality protection of existing resources is the most important hydrologic task facing forest managers.

VISUAL APPEAL

The visual appeal of a forest environment is influenced by existing resource configurations and by man-made changes. Whatever a particular ownership objective may be, a single common thread in managing for social uses of forest resources is to provide a visually appealing forest environment. The truly creative part of forest management, while meeting demand for all products, is to promote perception of intangible values—such as visual appeal (*Titus 1967*).

Timber harvests influence visual appeal of both the forest landscape and the forest "on site". The forest landscape, as used here, refers to the forest as viewed from a distance, and the forest on-site refers to the forest as seen from within.

Sharp breaks in the characteristic central Appalachian forest landscape are relatively rare. When man-made changes are introduced into the landscape, such as forest harvest patterns or logging access roads, visual landscape harmony may be damaged. In central Appalachia, as elsewhere, large clearcuts have had a negative impact on landscape appeal. Forest harvesting practices that promote either excessive homogeneity or heterogeneity in the characteristic forest landscape should be avoided (*Shafer 1967*).

Any forest practice that involves timber removal has an influence on landscape appeal. Skid trails are needed to collect felled timber and access roads must be constructed. But a considerable range exists in the overall effect of any one forest practice on landscape appeal. Carefully planned timber harvests, if conducted in harmony with the characteristic forest landscape, may have little influence on landscape visual appeal (*U.S. Forest Service 1973*). For example, by limiting the size of clearcuts, creating irregularly shaped units, and feathering the edge of clearcut units into the surrounding forest, the influence of clearcutting on landscape appeal may be eliminated or clearcutting even may improve visual appeal by creating needed diversity in monotonous forest landscapes. Single tree and group selection cuts, too, can be conducted to minimize the effect of timber removal on landscape values.

Both landscape and on-site visual appeal may be enhanced by growing large trees. Thus, forest management systems with long rotations promote a more appealing forest landscape than those with short rotations, because larger trees occupy the landscape for longer periods and the forest will be disturbed only at long intervals.

The on-site visual impact of various harvesting methods depends on the harvest system used, the reproductive capacity of the site, and post-logging practices conducted to minimize site damage. Varying degrees of on-site disruption are inherent in each harvesting method. However, proper skid trail management, spreading of slash and other logging debris, and the felling of damaged and dead trees are all practices that can help minimize the visual impact of logging. The duration of visual site damage or disruption depends largely on the reproductive potential of the site and on the post-logging practices used to encourage rapid site recovery.

There is much disagreement about the visual impact of forest practices on the forest landscape and forest site. Any system designed to evaluate the visual effects of timber harvesting on visual appeal must be highly subjective and open to meaningful criticism. Research has not yet developed "aesthetic recovery charts" to relate the effects of forest harvesting over time to visual appeal. Table 1 describes the general visual effects of forest cutting practices that were used to make the visual impact evaluations contained in this guide. Specific criteria used to evaluate harvest practices subjectively within forest ecosystems were as follows:

A forest practice was judged to maximize visual appeal (or have the least negative visual impact) if:

1. A relatively small forest area is affected.
2. Cutting patterns complement the shape and form of characteristic forest openings.
3. The practice favors rapid vegetative regeneration and growth.
4. The practice allows larger trees to occupy the site for long periods.
5. The practice allows for maximum time between cuttings so that forest cover will occupy the site as long as possible.
6. Physical site damage is minimized.
7. The practice occurs on relatively fertile sites.

WILDLIFE

Hunting and fishing have received substantially more attention than non-consumptive enjoyment of wildlife, but both kinds of use have been increasing. Hunters in the region include about 400,000 resident licensees, an unknown number of unlicensed people (prob-

Table 1.—*Effects of forest harvesting practices on visual appeal*[a]

Forest practice	Effect on visual appeal	
	Forest landscape	On-site impact
Uneven-aged management with selection cutting	Maintains characteristic visual landscape character and unity. Has least visual impact compared to other commercial harvesting practices.	Relatively short-term effects. If properly done, can improve on-site visual appeal.
Even-aged management with clearcutting—"Naturalistic" clearcuts.[b] ½—1 Acre	If natural openings occur, can emulate characteristic landscape patterns and satisfy landscape expectations. May enhance landscapes with little variety.	Difficult to eliminate visual effects of logging. Residual slash may be visible for 3 to 5 years.
Clearcuts of 25 acres or more	May enhance landscapes with little variety, but more typically results in visual disharmony.	Limited opportunities to minimize visual impact of logging. Residual slash may be visible for 3 to 5 years.
No commercial harvest	Maintains characteristic landscape.	No effect; or by judicious cutting on-site appeal may be improved through reduction in forest density or removal of unsightly snags.

[a]Material adapted from Forest Landscape Management, Vol. 1, 1972. USDA Forest Service, Northern Region.
[b]Clearcuts made with attention to preserving natural landscape character. Attempt made to shape clearcuts and cut patterns to promote landscape harmony.

ably about 80,000) who hunt only on their own lands, and a relatively small proportion of non-resident licensees. Perhaps 700,000 people engage in non-consumptive recreation activities that largely concern wildlife and woodlands. We have no local estimates of these activities but nationally the participation ratios *per 100 hunters* were 146 nature walkers, 36 birdwatchers, and 23 wildlife photographers (*Fish and Wildlife Service 1970*). Numbers of people derived from such estimates should not be added, however, because many individuals fit into more than one category.

Among all ownership objectives of forest landowners in West Virginia, wildlife was important to 62 percent of the owners—more than any other objective (*Christensen and Grafton 1966*). Concern among biologists and the public about forest habitat management centers on gray squirrels and wild turkeys in all states. There is less concern about habitat of deer and the other game animals (except bear in West Virginia), and little concern about non-game, forest-dwelling animals. The popularity ranking by hunters for forest game animals (in West Virginia) is squirrels, deer, ruffed grouse, wild turkey, raccoon, bear, woodcock and snowshoe hare.[1] Hatchery-reared rainbow trout are the most popular forest-related fish; few streams support the native brook trout or naturalized rainbow trout.

Most authorities agree that wildlife habitat can be most efficiently maintained or improved by coordinating timber and habitat management so that timber returns pay part or all of the habitat management cost. Accordingly, the wildlife habitat evaluations herein relate mostly to commercially feasible timber management options plus some that may be nearly marginal, at least. Direct management practices such as seeding log roads and putting up nest boxes are not discussed nor is regulation of animal numbers, control of access, local problems concerning certain animals, and such. These omissions do not mean that we consider such practices or problems unimportant.

The framework chosen for relating timber and wildlife evaluations was the "ecosystem", as indicated by forest overstory type and timber site characteristics. Although this framework was considered the best one for timber and wildlife purposes combined, it has deficiencies for evaluating wildlife habitat relationships. The most serious flaws stem from the mobility and adaptability of wildlife and the fact that few kinds of animals are restricted to any one ecosystem throughout the year. How then do we deal with mobility factors and other variables peculiar to wildlife but not to timber? Complete discussion within a tree-oriented framework is impractical.

Instead, the discussion is limited to general statements about the sets of variables considered to be most common. The risk in this approach is obvious—some of the evaluations given will be inaccurate for some individual forest properties and sets of land-owner objectives. The evaluations should not be taken as challenges to local judgments concerning specific woodlands or to habitat problems that are outside the scope of this paper.

Another simplification was necessary. To reduce the complexity and variability in habitat requirements among some 250 wildlife species, they were separated into two groups called "edge" and "interior" species. Edge species are those associated more with forest edges, openings, shrub cover, and understory plants than with maturing and old forest stands. The animals considered typical were deer, grouse, rabbits, and many non-game bird species—about two-thirds of which nest within 20 feet of the ground. The typical "interior" species are gray squirrels, turkeys, and canopy-nesting birds such as the broad-winged hawk, Baltimore oriole, and others. But consideration was not limited to the named, typical species, and need not be. Although any one species can be a useful model in planning or evaluating habitat management, each species has habitat requirements sufficiently like those of several other species that they can be considered collectively.

Readers may question many of the evaluations; few are technically documented, and

[1]Riffe, Jan E. 1971. *Hunting survey*. W. Va. Dep. Nat. Resour. Wildlife. Res. Div. Unpublished report FW-4R-2, III-I.

practically none has been rigorously proven on the ground. Lacking proofs, the evaluations are simply judgments based on relating knowledge of animal needs and preferences against knowledge of habitat conditions. Preliminary judgments were compared with the information in a recent handbook: USDA Forest Service. 1971. WILDLIFE MANAGEMENT HANDBOOK — SOUTHERN REGION. FSH 2609. 23R., Atlanta, Ga. These initial judgments were revised following consultation with several biologists.

Method of Presentation

We have rated the seven forest ecosystems that make up most of the forest land in the central Appalachians with respect to their potential importance as producers of timber, water, visual appeal, and wildlife (table 2). These ratings are intended only to provide landowners with some relevant options. To some extent, different factors determined the ratings for each resource. For example, for timber we considered such factors as unit productivity (quantitative and qualitative), aereal extent, existing stand conditions, and estimated future importance. We emphasize that landowners, with their own special point of view, may logically take exception to many of the ratings that we have assigned.

For each of the ecosystems, we rated forest practices as to their effect on timber, visual appeal, water, and wildlife (tables 3 to 9). The ratings in each table permit the manager to compare — within the ecosystem — the

Table 2.—*Importance of the Ecosystems for timber, water, visual appeal, and wildlife*

Ecosystems	Resources				
	Timber	Water	Visual appeal	Wildlife: Edge species	Wildlife: Interior species
1. Oaks:					
Fair site[a]	M[b]	M	M	H	H
Poor site	L	L	L	H	H
2. Mixed Appalachian hardwoods:					
Excellent site	H	H	H	H	M
Good site	H	M	M	H	M-H[c]
3. Northern hardwoods:					
Excellent site	H	H	H	H	M
Good site	M	M	M	H	M
Fair site	L	M	M	H	M
4. White pine:					
Good site	M	H	H	M	L
Fair site	M	M	H	M	L
Poor site	L	L	M	M	L
5. Virginia pine:					
Fair site	L	L	M	M	M
Poor site	L	L	L	M	L
6. Red spruce:					
Good site	L	H	H	L	L
Fair site	L	M	H	L	L
Poor site	O	M	M	L	L
7. Floodplain hardwoods:	L	H	H	M	L

[a]Site quality refers to the timber-growing potential of the area. Sites are oak site indexes based on Schnur (1937) and related to land features (Trimble and Weitzman 1956). With the use of the interspecies relationships developed by Doolittle (1958), and a little extrapolation, they were adapted to all ecosystems except floodplain hardwoods. The scale of oak site indexes corresponding to the descriptive terms used is as follows: excellent site = 75 ft. +; good site = 65-74 ft.; fair site = 55-64 ft.; and poor site = 45-54 feet.

[b]H (high), M (medium), L (low), and O (none or insignificant).

[c]Rating higher where oaks predominate; this ecosystem intergrades with the oak type.

Table 3.—*Effects of oak management on forest resources—a desirability rating*

[For rating explanation, see page 16]

Forest practice	Size of cleared areas	Rotation length or average age and dbh of crop trees: Fair site, Age	Fair site, Dbh	Poor site, Age	Poor site, Dbh	Timber: maximizing stumpage returns	Water: Productivity	Water: Quality	Visual appeal: landscape and on-site quality	Wildlife: Edge species	Wildlife: Interior species
	Acres	*Years*	*Inches*	*Years*	*Inches*						
OBJECTIVE: SAWLOGS											
Even-aged management with clearcutting	½-1[a]	115	22	—	—	+	0	+++	++++[b]	++	+++
		95	18	—	—	+	0	+++	+++	+++	++
		85	17	—	—	++	++	++	+++	+++	++
	5	115	22	—	—	+	0	+++	++	++	(++++)
		95	18	—	—	++	++	+++	+	++++	++
		85	17	—	—	+++	++	++	+	+++	++
	25	115	22	—	—	++	++	+++	—	++	++
		95	18	—	—	+++	++	+++	+	++	+
		85	17	—	—	++++	+++	++	+	++	+
Uneven-aged management with selection	—	135	22	—	—	+	0	++	++++	+	(+++)
	—	115	18	—	—	+	0	++	+++	++	++
	—	105	17	—	—	++	0	++	++	++	++
OBJECTIVE: PULPWOOD											
Even-aged management with clearcutting	½-1	—	—	60	8	?	0	++	+	++	+
		—	—	50	7	?	0	++	+	++	+
	5	—	—	60	8	?	0	++	+	++	+
		—	—	50	7	?	++	++	+	++	+
	25	—	—	60	8	?	++	++	+	++	+
		—	—	50	7	?	+++	++	+	++	+
No commercial harvest	—	—	—	—	—	0	0	++++	++++	+	(++++)[c]

[a]Clearcutting in small areas such as these can be regulated as patch cutting with area control or group selection with volume control.
[b]Clearcuts to blend with natural landscape patterns as feasible.
[c]Assuming about 5 percent of area in openings with herbaceous or brushy covers.

Table 4.—*Effects of Appalachian mixed hardwood management on forest resources—a desirability rating*

[For rating explanation, see page 16]

Forest practice	Size of cleared areas	Rotation length or average age and dbh of crop trees: Excellent site, Age	Excellent site, Dbh	Good site, Age	Good site, Dbh	Timber: maximizing stumpage returns	Water: Productivity	Water: Quality	Visual appeal: landscape and on-site quality	Wildlife: Edge species	Wildlife: Interior species
	Acres	*Years*	*Inches*	*Years*	*Inches*						
Even-aged management with clearcutting	½-1[a]	90	26	105	25	+	0	+++	+++[b]	++	++++
		75	21	85	20	+	0	+++	++	+++	+++
		65	18	70	17	++	++	++	++	+++	++
	5	90	26	105	25	+	0	+++	++	+++	+++
		75	21	85	20	++	++	+++	+	++++	++
		65	18	70	17	+++	+++	++	+	+++	+
	25	90	26	105	25	++	++	+++	+	++	+
		75	21	85	20	+++	+++	+++	+	++	+
		65	18	70	17	++++	+++	++	+	+	+
Uneven-aged management with selection cutting	—	125	26	135	25	+	0	++	+++	+	++
	—	105	21	110	20	+	0	++	+++	+	++
	—	95	18	100	17	++	0	++	++	++	+
No commercial harvest	—	—	—	—	—	0	0	++++	++++	+	(++)[c]

[a]Clearcutting in small areas such as these can be regulated as patch cutting with area control or group selection with volume control.
[b]Clearcuts to blend with natural landscape patterns as feasible.
[c]Assuming at least 5 percent of area in openings with herbaceous or brushy covers.

Table 5.—*Effects of northern hardwood management on forest resources—a desirability rating*

[For rating explanation, see page 16]

Forest practice	Size of cleared areas	Rotation length or average age and dbh of crop trees: Excellent site Age	Excellent site Dbh	Good site Age	Good site Dbh	Fair site Age	Fair site Dbh	Timber: maximizing stumpage returns	Water: Productivity	Water: Quality	Visual appeal: landscape and on-site quality	Wildlife[c]: Edge species	Wildlife[c]: Interior species
	Acres	*Yrs.*	*In.*	*Yrs.*	*In.*	*Yrs.*	*In.*						
Even-aged management with clearcutting	½-1[a]	100	28	110	27	135	26	+	0	+++	++++[b]	+	++++
		70	20	80	19	95	18	+	0	+++	+++	+++	++
		60	17	70	17	85	17	++	++	++	++	+++	+
	5	100	28	110	27	135	26	+	0	+++	++	+++	+++
		70	20	80	19	95	18	++	++	+++	+	++++	++
		60	17	70	17	85	17	+++	+++	++	+	++++	+
	25	100	28	110	27	135	26	++	++	+++	++	+	++
		70	20	80	19	95	18	+++	+++	+++	+	++	+
		60	17	70	17	85	17	++++	+++	++	+	++	+
Uneven-aged management with selection cutting	—	135	28	145	27	155	26	+	0	++	++++	+	++
	—	100	20	110	19	115	18	+	0	++	+++	++	+
	—	90	17	100	17	105	17	++	0	++	+++	++	+
No commercial harvest	—	—	—	—	—	—	—	0	0	++++	++++	+	+

[a]Clearcutting in small areas such as these can be regulated as patch cutting with area control or group selection with volume control.
[b]Clearcuts to blend with natural landscape patterns as feasible.
[c]All ratings concern stands where cherry is to be favored; see text for different practices to favor beech and other species.

Table 6.—Effects of white pine management on forest resources—a desirability rating

[For rating explanation, see page 16]

Forest practice	Size of cleared areas	Rotation length or average age and dbh of crop trees by white pine site index[a]						Timber: maxi-mizing stumpage returns	Water		Visual appeal: landscape and on-site quality	Wildlife	
		SI 75		SI 65		SI 55			Produc-tivity	Quality		Edge species	Interior species
		Age	Dbh	Age	Dbh	Age	Dbh						
	Acres	*Yrs.*	*In.*	*Yrs.*	*In.*	*Yrs.*	*In.*						
Even-aged management with clearcutting	½-1[b]	80	24	80	22	80	16	++	0	+++	+++[c]	+++	++++
	5	80	24	80	22	80	16	+++	++	+++	++	++++	+++
	25	80	24	80	22	80	16	++++	+++	+++	+	++	+
No commercial cutting	—	—	—	—	—	—	—	0	0	++++	++++	+	(+++)

[a]Site index for oak corresponding to site indexes for pine of 55, 65, and 75 are respectively 45, 55, and 65 (Doolittle 1958).
[b]Clearcutting in small areas such as these can be regulated as patch cutting with area control or group selection with volume control.
[c]Clearcuts to blend with natural landscape patterns as feasible.

Table 7.—Effects of management for Virginia pine (and two other hard pines) on forest resources—a desirability rating

[For rating explanation, see page 16]

Forest practice	Size of cleared areas	Rotation length or average age and dbh of crop trees by Virginia pine site index[a]				Timber: maxi-mizing stumpage returns	Water		Visual appeal: landscape and on-site quality	Wildlife	
		SI 60		SI 50			Produc-tivity	Quality		Edge species	Interior species
		Age	Dbh	Age	Dbh						
	Acres	*Years*	*Inches*	*Years*	*Inches*						
Even-aged management with clearcutting and hardwood control	½-1[b]	45	9	45	7	+	0	+	+++[c]	(+)	+
	5	45	9	45	7	+++	0	+	++	(+)	+
	25	45	9	45	7	++++	++	+	++	+	+
No commercial cutting	—	—	—	—	—	0	0	++++	++++	(+++)	(++++)[d]

[a]Site indexes for oak corresponding to site indexes 50 and 60 for Virginia pine are 45 and 55 (Doolittle 1958).
[b]Clearcutting in small areas such as these can be regulated as patch cutting with area control or group selection with volume control.
[c]Clearcuts to blend with natural landscape patterns as feasible.
[d]Assuming about 5 percent of area in natural openings, with herbaceous or brushy cover.

Table 8.—*Effects of red spruce management on forest resources—a desirability rating*

[For rating explanation, see page 16]

Forest practice	Size of cleared areas	Rotation length or average age and dbh of crop trees: Good site, Age	Good site, Dbh	Fair site[b], Age	Fair site[b], Dbh	Timber: maximizing stumpage returns	Water: Productivity	Water: Quality	Visual appeal: landscape and on-site quality	Wildlife: Edge species	Wildlife: Interior species
	Acres	*Years*	*Inches*	*Years*	*Inches*						
Even-aged management with clearcutting	½-1[a]	120-150	22	120-150	16	++	0	+++	+++[c]	+++	++++
	5	120-150	22	120-150	16	+++	0	+++	++	++++	++
	25	120-150	22	120-150	16	++++	++	+++	+	++	+
Partial cutting	—	150-200	22	150-200	16	+++	0	++	++++	++	++
No commercial cutting	—	—	—	—	—	0	0	++++	++++	+	(+++)

[a]Clearcutting in small areas such as these can be regulated as patch cutting with area control or group selection with volume control.
[b]On poor sites the only forest practice feasible is "No commercial cut".
[c]Clearcuts to blend with natural landscape patterns as feasible.

Table 9.—*Effects of floodplain hardwood management on forest resources—a desirability rating*

[For rating explanation, see page 16]

Forest practice	Size of cleared areas	Timber: maximizing stumpage returns	Water: Productivity	Water: Quality	Visual appeal: landscape and on-site quality	Wildlife: Edge species	Wildlife: Interior species
	Acres						
Even-aged management with clearcutting	½-1	+	++	++	+++	+++	++
	1-5	++	+++	++	++	++++	+
	5+	++++	+++	++	+	++	+
Selection cutting	—	+	++	++	+++	(++)	+++
No commercial cutting	—	0	0	++++	++++	(++)	(++++)

general effects of various practices on the resources of interest. The comparisons should aid the owner in choosing his management options. The ratings and their symbols are:

Excellent	++++
Good	+++
Fair	++
Poor	+
Either no impact or no return	0
Unknown	?
Limited application	()

A forest practice that is rated "excellent" in its effect on a resource is, from the standpoint of that resource, a most desirable practice. Conversely, a practice that is rated "poor" in its impact on a resource is a relatively undesirable practice as it pertains to that resource. Brackets used with the above ratings indicate particular situations which are discussed and qualified in the text.

Because of the detail involved, it was not feasible to display in a table all the modifications and alternatives possible within a management option. Accordingly, and as an aid in interpreting the tables, we included for each ecosystem a discussion of the effects of the forest practices on each resource. Used in conjunction with the tables, the discussions help the reader make a balanced appraisal of the effects of the practice.

We must emphasize that the ratings are comparable within but not among ecosystems. Failure to appreciate this noncomparability can mislead users of these tables because the relative importance of the resource varies greatly among ecosystems (table 2). For example, timber stands are scattered and small in the floodplain hardwoods in the central Appalachians, and stumpage return is relatively unimportant. But this ecosystem is important for visual appeal and edge wildlife species.

Multiple-use Evaluations of Forest Practices by Ecosystems

1. THE OAKS

Description of the Ecosystem

Oak-dominated stands on good to excellent sites are classed with Appalachian mixed hardwoods and discussed in the following section of this paper. Here, we restrict our definition of the oak ecosystem to stands on areas of the oak-hickory complex with site indexes below 65 feet for oak *(Schnur 1937)*. And for discussion purposes, we split these sites into two classes; fair—55 to 64 feet, and poor—45 to 54 feet. Although some oak stands are found also on the good sites (65+ site index) and some oak stands are found on sites below 45, most oak stands occur on areas between site index 45 and 65 and at elevations below 3,000 feet *(Core 1966)*.

The five widely-distributed upland oaks in this type are white, northern red, black, scarlet, and chestnut. Although less abundant, the hickories are consistent stand components. Other commonly found associates are blackgum, beech, red maple, sourwood, sassafras, black locust, and sweet birch.

Most of the species found in this ecosystem are in the middle range in shade tolerance as exemplified by the oaks and hickories. However, considerable difference exists among species. For example, scarlet oak is relatively intolerant compared to white oak and red maple. At the extremes, beech is very tolerant and black locust is very intolerant.

Red oak is the most demanding oak in terms of site quality and is more abundant on the higher quality sites. Scarlet and chestnut oak are more commonly found at the lower end of the site range *(Weitzman and Trimble 1957)*.

Throughout the lower half of their site range (45 to 54 feet site index), oaks are often found associated with pines; white pine in scattered locations throughout the region, and the hard pines in warmer locations mostly in the western and southern parts of the central Appalachians.

Compared to Appalachian mixed hardwoods, oaks commonly have less herbaceous vegetation in the understory but the shrub/vine layer may be as dense or denser. Sassafras is a key shrub or small tree, and some others are flowering dogwood, serviceberry, sumacs, hawthorns, redbud, and eastern hophornbeam.

Among the vines and small shrubs, mountain laurel and other ericaceous species usually predominate on the drier sites. Across all kinds of sites the most common low, woody plants in West Virginia oak types are: greenbriers, blueberries and huckleberries, grapes, blackberries and raspberries, mountain laurel, azaleas, roses, and teaberry. And more than 20 other small woody plants were found.[2]

Evaluation and Discussion

Timber.—Oak stands make up the most extensive forest ecosystem in the central Appalachians. On the fair sites, the product objective should be sawlogs, with small products coming from thinnings, tops, and limbs. However, in stands growing in the lower part of the site range, pulpwood may be the product objective in some situations. The poor sites, oak site index 45 to 54, should be managed for small products. Following Roach and Gingrich *(1968)*, these sites should probably be managed for pulpwood on rotations of 40 to 60 years, unless conversion to pine is envisioned.

On fair sites and where markets are available, a thinning program is practicable and will increase total yields *(Gingrich 1971)*. Probably neither thinning nor other cultural operations are feasible on poor sites.

Again on fair sites, clearcutting offers the best opportunity for reproducing the moderately tolerant oaks — if advanced oak reproduction is on the ground at the time of cutting. Otherwise, a shelterwood cutting seems most promising, but research results are not available to define the timing or intensity of shelterwood cutting needed.

Individual tree selection cutting on fair sites will not reproduce a new stand in which there are many oaks. More tolerant species, especially red maple and beech, will make up a high proportion of the stand reproduced in this manner.

Group-selection cutting is an excellent reproduction method for oak stands which have large advance oak reproduction on the ground. But controlling the amount of area regenerated (small openings cut deliberately to favor the moderately tolerant oak) and regulating the rate of cutting for sustained yield are difficult and expensive; and the many small stands of different age classes make cultural and harvesting operations complicated and costly.

In determining the sizes of trees to be cut on the fair sites — for both even- and uneven-aged management systems — rate of return data were used (table 3). Such information was not available to apply to clearcutting pulpwood on the poor sites.

For sawtimber objectives, higher stumpage earning rates are favored by even-aged systems, by clearcutting larger areas, and by removing the trees at the smaller sizes.

For the pulpwood objective — suggested only for the poor sites — we had no economic data on which to base an appraisal of stumpage returns. However, hardwood pulp in the central Appalachians brings a low stumpage return and growth rates are very low on poor sites. This suggests that ratings for stumpage returns should be low in comparison with rating for the other resources — if these other resources are important. However, if these areas are managed for wood, returns will be increased by increasing the size of individual clearcuts.

Water.—The oaks predominate on exposed ridges above the mixed hardwoods and on warm, dry slopes. Evaporation is high on such sites, and with soils rockier and shallower than in mixed hardwoods there is less opportunity for rainfall storage, so streams originate far less frequently on oak sites. Cutting here has little potential to increase

[2]Wilson, H. L., C. M. Smithson, R. Kletzly, T. R. Samsell, K. Kruse, and G. Hubbard. 1951. *Cover mapping and habitat analysis.* Conser. Comm. of W. Va. Unpublished final report, Federal Aid in Wildl. Restoration Proj. 31-12, viii + 221 p. + 116 p. supplement.

streamflow, but from the standpoint of water quality the oak sites provide some of the best locations for logging roads (table 3). There is usually enough soil to shape an adequate road surface, enough stone to maintain a firm surface, and enough sun to dry it quickly. Roads on these sites have fewest drainage problems and do not erode easily, yet they are not so arid and infertile that revegetation is long delayed after logging.

Visual Appeal. — Oak stands, normally found on middle to upper slopes, are often quite visible. The oak forest is usually continuous with few natural or man-made openings. Because the ecosystem occupies a greater acreage in central Appalachia than any other type, it is basic to the overall landscape character of the region.

Forest practices that use longer rotations will result in larger trees and higher visual appeal. Large clearcuts are less visually appealing because of the disharmony they introduce in the characteristic landscape (table 3). But small to medium-sized clearcuts can often be used to enrich landscape diversity.

Clearcutting also allows for the control of stand succession and thereby maintains the characteristic forest type. Stand succession is more difficult to control with uneven-aged forest management. Application of uneven-aged management will result in a subtle change in the characteristic visual landscape. Selection cuttings, however, can overcome the disadvantage of large clearcuts by maintaining harmony in characteristic landscape patterns.

Even-aged management with a pulpwood objective has the same negative visual impact as clearcutting with a timber objective. The practice has the added disadvantage of producing smaller trees because of shorter harvest rotations.

The "no commercial harvest" practice could have either no effect or a desirable effect on visual appeal. No cutting at all would maintain the characteristic landscape. Judicious partial cutting, when made in appropriate situations to improve stand appearance, or to open up scenic views, would have an immediate positive impact on visual appeal.

Wildlife. — Although Appalachian mixed hardwoods and floodplain hardwoods are potentially more productive wildlife habitats, the oaks are by far the most common ecosystem in central Appalachia and for this reason the most important one for wildlife. Oak stands tend to be larger in area than those of other ecosystems, except northern hardwoods in the mountains. Since oak stands are common almost everywhere below 3,000 feet elevation, they may border any of the other ecosystems except spruce.

More species of upland wildlife are adapted to the oak ecosystem than to any other. The animals which interest people the most are squirrels and turkeys. Squirrels are periodically abundant in oak stands, but their numbers often fluctuate in a pattern lagging one year behind that of mast production. Turkeys are well adapted to the oak stands and the intergrading "good-site" mixed hardwoods. These are the best areas for turkeys where sufficiently extensive and undisturbed. Oak associations have a high potential for supporting increasing turkey populations on unoccupied and recently reestablished range in the hill country.

Many species of small birds and mammals thrive in oak stands. This is partly due to availability of hard mast; but perhaps more important is the quality of understory vegetation, as the oaks rank near the top among all ecosystems in density and variety of shrubs and vines.

In selecting tree species to favor, it's hard to go very wrong in an oak ecosystem. Generally, the pines and hemlock have less value for wildlife than hardwoods, but some portion of the stand, say 10 to 15 percent, may merit retention in softwood cover for variety and whatever shelter it provides. Among the hardwoods, mixtures of hickories and oaks with lesser numbers of the associated hardwoods are desirable. The red oaks generally fruit more consistently than the white oak species, and most stands should be managed to include both kinds in a ratio of two red to one white *(Nixon 1968)*. Exceptions are old stands of white oak that have an overriding aesthetic appeal, and chestnut oaks in some locations where they are better mast producers than red oaks (*K. L. Carvell*, personal communication).

Within species of oaks, and hickories to a lesser extent, individual trees vary extremely in capacity for mast production. Those dominant and codominant trees that produce few nuts in good mast years are candidates for culling.

Stand size-class distributions that favor wildlife are essentially the same for oak and mixed hardwoods forests. Keeping about half of the stands in sawtimber-size trees is a reasonable compromise in meeting the conflicting habitat needs of species such as grouse and gray squirrels (*Shaw 1967*). This sawtimber target and others each imply managing to attain a balanced mix of smaller trees. For example, on a fair site with even-aged management and a 125 year rotation, sustaining the sawtimber production requires approximately these percentages of the area in younger stands: seedlings—7, saplings—15, and poles—25. But these percentages would be higher on poorer sites, under shorter rotations, and in uneven-aged silviculture.

Because the oaks and good-site Appalachian mixed hardwoods are best for turkeys, squirrels and associated species—and these are premium animals in central Appalachia—sawtimber proportions exceeding 60 percent are often preferable. These larger sawtimber proportions imply low proportions of the brushy or herbaceous cover required by turkeys, for example. Special measures may be needed to maintain say 10 percent of the area in openings such as 0- to 5-year old clearcuts, small fields, and log roads and landings.

Silviculture should be keyed to maintaining mast production by oaks, hickories and the associated shade-intolerant or moderately tolerant species. Where there is risk that these species will eventually lose out to trees such as maples, beech, and hemlock, clearcutting followed by thinning is more effective in retaining them than is selection cutting or no commercial harvest. Clearcut patches can usually be larger than in Appalachian mixed hardwoods, simply because oak stands usually cover a larger area. But, as with other ecosystems, the width of clearcuts is more important than their area. Strips about 100 to 500 feet wide should be favored, allowing stand and operating conditions to determine the area of the individual strip and allowing the risk of browsing damage to regeneration to determine the total area cut in any one or two years. Clearcutting and weeding should be arranged to retain much of the understory, particularly the soft-mast producers (flowering dogwood, sassafras, grape, and others), except where aggressive competitors may seriously limit regeneration of oaks, hickories, and blackgum. Thinning at stand age 30 to 40 years or older can be designed to favor the better individual mast producers; and to do this, marking should be done during September or October in a good mast year.

Choice of rotation length depends on the wildlife objectives. Rotations of 150 to 200 years, or no cutting in some cases, are better for squirrels, turkeys and canopy-nesting songbirds, whereas shorter rotations—down to about 70 years—are better for forest edge species, including the majority of non-game birds. Pulpwood rotations, 50 to 60 years, would usually be inferior to schedules which allow a longer period of hard-mast production. The shortest rotations would favor some species of small birds, about two-thirds of which nest within 15 to 20 feet above the ground, but would not favor a diverse mix of wildlife species. For example, lack of large, old trees is detrimental to about 40 percent of non-game bird species (*Ray Evans, unpublished management guide*).

2. APPALACHIAN MIXED HARDWOODS

Description of the Ecosystem

Appalachian mixed hardwoods is a forest complex found in moist locations and is characterized by great diversity in species composition. This ecosystem falls within the mixed-mesophytic complex described by Braun (*1950*). Appalachian mixed hardwoods are found in topographic coves, on lower slopes, on northern and eastern aspects, and on gentle terrain.

Typical soils are moderately deep, medium-textured, and well-drained. Abundant, well-distributed rainfall (*Yawney and Trimble 1968*) and limestone parent material (*Yawney 1964*) favor the occurrence of this type.

The stands may be composed almost entirely of red oak or yellow-poplar but a species mixture is typical; 20 or more commercial species may grow in the same stand. Among the more important trees are: yellow-poplar, sugar maple, northern red oak, hickories, black cherry, white oak, basswood, cucumbertree, white ash, red maple, sweet birch, beech, elm, and black locust. The mixtures vary with site quality, past treatment, elevation, and latitude. A few hemlocks and white pines are found within some stands.

Site quality ranges from good to excellent. In terms of the oak site index scale (*Schnur 1937*), the good sites are considered to cover the range from 65 to 74 feet while the excellent sites extend upward from 74 feet.

On excellent sites (above site index 74 for oak) yellow-poplar is the predominating species following heavy cutting, and in many areas yellow-poplar expresses a site index of well over 100 feet (*Doolittle 1958*). A number of other hardwoods valuable for timber are found in mixture.

The good site (between 65 and 74 site index for oak) is a transition zone between the mesophytic excellent site and the drier, oak-dominated fair site (site index 55 to 64 for oak). The species mixture is often greater than on either of the bracketing sites, with yellow-poplar often predominating at the upper end of the site range, and the oaks, particularly northern red oak, more numerous at the lower end of the range. Sites of this quality, which occupy somewhat less favorable topographic and soil positions than the excellent sites, probably cover a greater area in the central Appalachians than do the excellent sites.

Appalachian mixed hardwoods usually have a rich, varied understory and are noted for abundance of spring wildflowers. Spicebush is a key indicator shrub, and the typical large shrubs or small trees include flowering dogwood, sassafras, hawthorns, eastern hophornbeam, American hornbeam, striped maple, serviceberry, sumacs, and redbud. Among the lower-growing woody plants, vines often predominate over erect shrubs. In an unpublished West Virginia study the most common small woody plants in this and the red oak types were, in decreasing order: greenbriers, grapes, blackberries and raspberries, Virginia creeper, poison-ivy, blueberries, witch hazel, hydrangias, spicebush, azaleas, elderberries, teaberry and mountain laurel. About 30 other shrubs and vines also were recorded.[2]

Evaluation and Discussion

Timber.—Appalachian mixed hardwoods grow on the best forest sites in the central Appalachians; this is our most profitable timber-producing ecosystem. Product objectives should be high-quality sawlogs and veneer logs; small products will come from thinnings, tops, and limbs. Intensive management with intermediate operations is profitable where a market for small products exists.

Because even-aged management favors the fast-growing high-value intolerants such as yellow-poplar and black cherry, and because both management costs and harvesting costs are lower with this system than with an uneven-aged system, even-aged management is preferable where wood production is the main objective. Within the even-aged system, rotations of three lengths and clearcut areas of three sizes are used for comparison purposes (table 4). Stand ages and average tree diameters were estimated from available growth information.

Because of high growth rates and valuable species, this ecosystem lends itself better than any other to intensive timber management. Where markets support thinnings, rotations for sawtimber may be as low as 60 to 70 years. However, with a thinning schedule heavy enough to appreciably shorten rotations, control of the tolerant understory will probably be necessary at harvest time to reduce such tolerants as sugar maple and beech to an acceptable proportion in the new stand.

Uneven-aged management with selection cutting is a less desirable system because it involves higher management and harvesting costs. Moreover, this system encourages a stand of less valuable and slower-growing tolerant species such as maple and beech. Compared to even-aged systems, a longer period will be required for trees to reach harvestable size (table 4); and with the species favored, a higher proportion of the wood produced will be low value top and limb wood.

Group selection or patch cutting of small areas—½ to 1 acre—would permit the development of desirable yellow-poplar and black cherry, but the high management costs involved would almost certainly preclude the practice of intensive forestry for timber production.

Water.—Mixed hardwoods grow on cooler aspects, on relatively deep soils kept moist by drainage from soils upslope. These include the "coves", some of the most water-productive of upland sites, source areas of most springs and first-order streams in the region. Here, even-aged management can visibly increase growing season flow for 2 to 5 years after clearcutting—if all growth is cut in an entire cove. In general, flow is most increased by even-aged management and by clearcutting large blocks frequently.

Considerable erosion hazard must be expected on logging roads in moist cove soils. Many coves in the central Appalachians are underlain with limestone, and roads on fine-textured, relatively stone-free soils derived from it are easily eroded. The high timber productivity of coves also contributes to the erosion hazard by tempting loggers to return periodically for fast-growing, high-value timber, thus reopening roads to recurring possibilities of erosion. Seeps are common in coves, and logging roads across them must be drained and sometimes gravelled to prevent muddy and rutted surfaces. Damage to water quality is best avoided in coves by locating roads around identifiable trouble spots.

Visual appeal.—Where Appalachian hardwoods are found in topographic coves, the ecosystem is usually low in visibility and visual effects of cutting are not as severe as in more visible forest types. Because of the inherently high site productivity, the impacts of timber harvesting on visual appeal are likely to be of shorter duration than for ecosystems that normally occupy less productive sites.

Forest openings, such as those created through even-aged management, are likely to promote disharmony in the characteristic landscape pattern, because such openings are not normally found in the ecosystem. Because of the limited area normally covered by the ecosystem, the larger the opening created the more negative the visual impact (table 4). Even-aged systems with long rotations have less impact on visual appeal than even-aged systems with short rotations because the longer rotations produce larger trees that occupy the site for longer periods.

Selection cutting practiced with concern for natural landscape harmony can be used to improve visual appeal by eliminating unsightly stems or clearing to open up scenic vistas. The high regeneration capacity of the sites will further reduce the visual impact of selection cutting on the ecosystem. Selection cutting, although it does not result in as much immediate site disturbance as does clearcutting, will require disruption of the site at relatively short intervals. As in the case of clearcutting, growing trees for greater size will improve visual appeal.

The practice "no commercial harvest" could have either a positive effect or no effect on visual appeal. Cutting dead and dying trees, removal of vegetation to provide scenic vistas, and removal of vegetation to facilitate access, could increase visual appeal. Obviously, "no cutting" would have no impact on existing visual appeal.

Wildlife.—Potentially, Appalachian mixed hardwoods are better and more adaptable as wildlife habitat than any of the other systems described here. The primary advantages are: (1) soil fertility and moisture conditions capable of supporting a more lush and varied understory than any other system except floodplain hardwoods and (2) a large number of tree species. Secondarily, Appalachian mixed hardwoods increase the variety of total habitat where they intersperse with other systems—usually with the oaks.

Practically all species of forest wildlife frequent Appalachian mixed hardwoods, at least occasionally. But the degree and importance of wildlife usage vary, depending on conditions around and within the type.

Because most individual stands are not large enough to furnish the complete seasonal or annual habitat requirements of the wider-ranging animals, the value of an individual stand depends on how well it supplements habitat conditions nearby. Conversely, the narrower-ranging wildlife species, notably most kinds of small birds during the nesting season, may find excellent, complete habitat within an Appalachian mixed hardwood stand.

The tree, shrub and vine species present within a stand also determine its value for wildlife. Paradoxically, the species typical of "good" sites provide better habitat than those typical of sites rated "excellent" for timber. The good sites are somewhat drier and less fertile and are likely to have more oaks and less yellow-poplar than the excellent sites.

Yellow-poplar, the key species in excellent-site Appalachian mixed hardwoods, has only moderate value for wildlife (recorded as food of 14 species). Other mast producers such as the oaks (particularly the red oaks), hickories, black cherry, beech, flowering dogwood, and even the maples are all superior to yellow-poplar for wildlife purposes and should be favored. But there are exceptions—small stands of yellow-poplar near extensive oak-hickory stands might supplement adjacent habitat. Small stands of white pine or hemlock within the Appalachian mixed hardwoods may similarly merit retention where they diversify the habitat.

Aside from such exceptional cases, stand conditions to favor as habitat for most wildlife species are those which maintain the greatest diversity of desirable mast producers. However, choices can be made in relation to differing preferences among wildlife species for various mixes of tree sizes (stand ages). For example, the habitat needs of gray squirrels versus grouse, or whippoorwills versus catbirds are so different that both kinds of species (interior and edge) cannot be ideally accommodated in the same stand. Perhaps the best compromise among these conflicting habitat needs would be the groups of stands that are produced through group-selection cutting. Thus stands of all size classes would be interspersed over short distances.

The wildlife habitat management choices range up to the maximum proportion of sawtimber attainable (probably 80 to 90 percent) for favoring gray squirrels, turkeys, etc., and down to a minimum desirable sawtimber proportion of 30 to 40 percent, to favor deer, grouse, the majority of non-game birds, etc. Within these choices of sawtimber proportions and emphasis on mast producers, shelter needs of the target wildlife species would usually be accommodated without any special measures. But in some Appalachian mixed hardwood stands, tree dens for squirrels and raccoons may be lacking due to causes such as high proportions of yellow-poplar. Replacement of some but not all of the poplar by better mast producers and by species that more frequently become den trees, such as oaks, beech, and maples, is a long-term remedy. For the short run, a few large den trees per acre, preferably of the better mast species, should be retained. Needs for "evergreen" cover will usually be adequately met by growth of hemlock and rhododendron, but these kinds of cover are of debatable value and beyond some minimum, covering say 10 to 15 percent of the area, should not be favored over either mast producers or thicket-forming vines and shrubs.

Choices among silvicultural practices to use in improving wildlife habitat are complicated by the variability among Appalachian mixed hardwood stands. The suggestions given in table 4 apply to stands including a mix of yellow-poplar, oaks, hickories, black cherry, and other trees, but no strong dominance by either yellow-poplar or sugar maple and beech.

In such stands, clearcutting in small patches and group selection cutting are good choices for maintaining a variety of species in the stand. Small patches in either system are preferable. For a given acreage cut in one year, several small patches (say 2 to 5 chains wide) give a better distribution of attractive habitat and put more of it close to adjacent cover than fewer large patches. Risk of damage to regeneration by browsing may be greater in the narrower patches, however. This risk has been low in most of central Appalachia, but must be judged locally. To guard against damages to regeneration, patch width can be increased (*McGinnes 1969*).

For "edge" species of wildlife, shorter rotations are preferred although they involve sacrificing mast production and tree den sites in favor of understory food and cover. Conversely, longer rotations are preferred for habitat of squirrels, turkeys, canopy nesting birds, etc. For these species, in some stands, no cutting at all may be best for some period. But cutting or the equivalent will be required at some later stage to prevent replacement of the more valuable mix of intolerant and moderately tolerant tree species by sugar maple, beech, and hemlock.

Those early successional stage stands that are dominated by yellow-poplar can be changed through individual tree cutting to successionally more advanced stages. Clearcutting in successionally more advanced stands would tend to increase the proportion of the yellow-poplar. Stand composition more favorable to wildlife conceivably can be attained by such extreme measures as planting oaks, hickories, etc. and suppressing yellow-poplar, but this would rarely be practical. Perhaps the best practice for squirrels, turkeys, etc. would be to clearcut in small patches utilizing a very long rotation.

3. NORTHERN HARDWOODS

Description of the Ecosystem

This widely divergent ecosystem is designated "northern hardwoods" for lack of a more appropriate title. This term is synonymous with the Forest Survey designation "sugar maple-beech-yellow birch." Actually, the following types of the northern forest region are included (*Soc. Am. Foresters 1967*): (1) hemlock-yellow birch, (2) sugar maple-beech-yellow birch, (3) sugar maple-basswood, (4) sugar maple, (5) black cherry-sugar maple, and (6) black cherry. The beech-sugar maple type of the central forest region is also represented.

Northern hardwoods are generally found at higher elevations in the central Appalachians. At its highest limits, the type may merge with red spruce or may occupy areas where red spruce was formerly abundant but has been depleted by cutting and fire. When found at lower elevations on the good and excellent sites, the type often merges with Appalachian mixed hardwoods; and, depending on cutting practices, may replace the typical Appalachian mixed hardwood mixture or be replaced by it.

Perhaps the most typical "northern hardwood" aggregation is the cherry-maple or Allegheny hardwood type—a second-growth forest type that owes its origin to lumbering and fire (*Braun 1950*). The type is composed primarily of black cherry, red maple, and sugar maple; with white ash, yellow and sweet birch, beech, and eastern hemlock as common associates (*Hough and Forbes 1943; Illick and Frontz 1928*).

The shade tolerance of a species largely determines its reaction to different silvicultural systems. The tolerance ratings of the most common northern hardwoods are (*U.S. Forest Service 1965*): *Tolerant*—sugar maple, beech, hemlock, spruce; *Moderately tolerant*—red maple, sweet birch, yellow birch; *Intolerant*—black cherry. Basswood is tolerant to moderately tolerant, and white ash lies between moderately tolerant and intolerant.

The northern hardwood ecosystem is found on excellent sites (site index 75 and better for oak), good sites (site index 65 to 74 for oak), and fair sites (site index 55 to 64 for oak). It may also occur to a limited extent on poor sites.

The understory of northern hardwoods typically includes about as many woody plant species as the Appalachian mixed hardwoods and oak ecosystems, but usually is less dense. Among the tall shrubs or small trees, mountain maple and serviceberry are key species and the other common ones are striped maple, chokeberry, sassafras, eastern hophornbeam, flowering dogwood, fire cherry, and sumacs.

Rhododendron and hobblebush virburnum are key plants among the lower-growing shrubs and vines. They and others, in approximate decreasing order of abundance are: blackberries and raspberries, greenbriers, witch-hazel, viburnums, hydrangeas, spicebush, grapes, rhododendron, Virginia creeper, elderberry, mountain laurel, poison ivy, and the small dogwoods.[2]

Evaluation and Discussion

Timber.—This ecosystem occurs perhaps most commonly on good sites, but it also occurs on excellent and fair sites. For most situations, sawlogs and veneer logs should be the objectives of management, but for some fair-site stands small products may be the objective. The better the site, other factors being equal, the higher the level of management that is economically feasible.

Clearcutting offers the best opportunity to reproduce the highly desirable black cherry and white ash. However, because of the prevalence of sugar maple in this type, selection cutting is feasible when there is little opportunity to reproduce cherry and ash.

The birches, both sweet and yellow, present real problems in some areas where sufficient seed sources are not available to reproduce other more desirable species. The birches seed in and germinate prolifically, and sweet birch particularly grows very fast as a seedling. In spite of the high intrinsic value of birch logs, the birches are generally undesirable because in this area both species are heavily attacked by *Nectria* canker (*Hepting 1971*), and after they reach large sapling size their growth rates are very slow.

In determining sizes and ages of trees to grow to harvest time, rate of return information was used, as with the previously-described ecosystems, and the same considerations apply.

Overall, stumpage earning rates are favored by even-aged systems, by clearcutting larger areas, and by removing the trees at sizes which cease to return 6 percent (table 5).

Water.—Site conditions under northern hardwoods are variable in the central Appalachians and water behavior is hard to characterize. In general, soils are deeper and rainfall is least at lower elevations; soils are rockier and shallower and rainfall heavier at higher elevations. Perhaps northern hardwood sites are more water-productive and erosion-prone than in the oak ecosystem, less so than mixed hardwoods.

Visual Appeal.—Where the ecosystem occupies upper slopes, most northern hardwoods are highly visible. Northern hardwood forest cover is normally continuous over large areas. In some places, however, the northern hardwood type has been cleared primarily for grazing. In such areas, small clearcuts in adjacent forest stands may not have as severe an impact on visual appeal as in landscapes that have not been permanently or historically altered by man. As in other ecosystems, clearcutting in smaller patches with long rotations has less negative impact on visual appeal than clearcutting in larger patches with short rotations (table 5).

Uneven-aged management provides little opportunity to create visual landscape diversity. But the practice allows the characteristic landscape to be maintained. Where the characteristic landscape has not been altered through past land-use practices, selection cutting should be favored over clearcutting in order to preserve the visual landscape.

The practice "no commercial harvest" would not have an impact on existing visual quality unless cutting is done specifically to improve visual appeal.

Wildlife.—Northern hardwoods are generally less productive of wildlife than the other three hardwood ecosystems but are better than any of the three softwood ecosystems. This judgment applies to central Appalachia where black cherry and wild turkeys are particularly important but not to the beech-birch-maple associations farther north.

Black cherry-sugar maple is the most common subtype and is the focus of discussion here. Stands at higher elevations tend to be larger than those of other ecosystems except the oaks, at any elevation, and are good habitat for the wider-ranging wildlife species—notably deer, turkey, bear, and red fox. Cherry-maple can sustain good grouse populations, many non-game bird species, and, along with the spruce ecosystem, is suited locally to snowshoe hare. The type is not suited to the needs of gray squirrels; but fox squirrels may do well in northern hardwoods where mature stands with open understories border on favorable habitat such as cornfields and oak-hickory woods.

Where northern hardwoods occur at lower elevations, they usually are in small stands and their importance to wildlife depends largely on their interspersion with non-forested land and other forest types.

In ranking the tree species to be favored for wildlife, black cherry is the strong front runner. Beech is a distant second but usually is preferable to the maples, birches, ash, basswood and magnolias, and to hemlock, white pine, and red spruce where they exceed 10 to 20 percent of the stand or are replacing cherry or beech.

Stand conditions to be favored for wildlife are those which increase or maintain black cherry and maintain beech. This is an impractical goal within individual small stands since cherry and beech have conflicting attributes, particularly in shade tolerance. Therefore, in most individual small stands, management should favor one species or the other. Preference should be given to cherry on more fertile sites such as coves surrounding spring seeps, and to beech on upper slopes and ridges. But favoring either one of these species does not imply attempting to totally exclude the other one or other mast producers such as ash and magnolia. Spruce, hemlock, and white pine generally should not be favored on ridges or slopes, but are most useful to wildlife around the mouths of intermittent streams and along permanent streams. There, the softwoods and associated rhododendron best serve as shelter for deer, grouse, snowshoe hare, bear, and other species.

Rotation lengths and proportions of stands in sawtimber-size trees, as with the other hardwood types, should be based on the wildlife preference objective—shorter rotations for deer and other edge species and longer rotations for turkeys and other interior species. But in either case, rotations of stands to favor cherry should be considerably shorter than rotations to favor beech.

Where black cherry or ash is featured, even-aged management is more effective than selection cutting and the aggregate acreage clearcut in any one or two years should be sufficient to disperse browsing by deer, rabbits and hares. Clearcuts as small as one-half acre are large enough for regenerating cherry. Proper sizes and distribution of clearcuts should be determined locally, and mostly in relation to expected browsing by deer. Thinning at age 30 or older should be designed to improve crown development of dominant and codominant black cherries primarily, but should retain small groups of aspen, a scattering of vigorous beech, and any dominant or codominant oaks present.

Where beech and other shade-tolerant species are to be favored, selection cutting is more appropriate than clearcutting. Marking should be done in the late summer or fall of a good beech mast year, should favor development of vigorous, full-crowned, mast-producing beeches, and should particularly discriminate against competing red and sugar maples, spruce, and hemlock. In some stands, group selection cutting can be arranged to favor beech plus some cherry in small patches which have been dominated by sugar maple or other shade tolerants except beech.

Where spruce or hemlock are to be favored—along runs and streams—no commercial cutting is usually the best alternative.

Spring seeps in northern hardwoods are of special and well-known value to turkeys and deer in winter and may require special attention. The conservative habitat management approach has been to exclude any cutting in and around spring seeps. Certainly, logging roads, skid trails, and slash should be kept out of the seeps. But their value to turkeys and deer is partly that they function as seed traps, catching mast which falls or rolls into them. This suggests that stands above and upslope from spring seeps should be managed for increased mast production. And this objective may indicate cutting to favor cherry—either clearcutting or thinning depending on the stand composition and age. Softwoods which shade spring seeps probably should be removed in nearly all cases where they retard snow-melt in the seeps (*William M. Healy, personal communication*).

4. WHITE PINE

Description of the Ecosystem

White pine, a moderately-tolerant, long-lived, subclimax species, occurs throughout the Appalachians in pure stands and as a dominant species in association with hardwoods, hemlock, and hard pines. It grows under a wide variety of site conditions. Best development is in moist stream bottoms, lower slopes, and protected coves. However, white pine is able to compete on upper slopes and ridge tops, and holds its own on the dry southerly exposure (*Ball 1949*). It is probably most typically associated with chestnut oak (*Soc. Am. Foresters 1967*). Doolittle (*1958*) found that white pine had a higher site index than nine of its most common associates on all lands except the very best, where yellow-poplar was superior.

White pine regeneration frequently follows major disturbance such as destructive logging, windfall, and fire, and is often the pioneer species on abandoned agricultural lands (*Cope 1932*). Although it has been classified as intermediate in tolerance, in the seedling stage it can survive and grow, if slowly, with as little as 20 percent of full sunlight (*U. S. Forest Service 1965*). However, in order to develop past the seedling-sapling stage, it must eventually be released from overtopping trees. Once it is established, it grows best in full sunlight (*U. S. Forest Service 1965*). Unless there is a major disturbance it is eventually displaced by more tolerant species.

Beneath pure or nearly pure stands of white pine, the shrub/vine layer is usually sparse and consists mostly of ericads—blueberries, huckleberries, azaleas, teaberry, and mountain laurel—plus scattered blackberries and greenbriers. Where there are more hardwoods, the understory associations are those typical of hardwood stands, but their growth is usually sparse due to shading by the pines.

Evaluation and Discussion

Timber.—Because white pine requires ever-increasing exposure to sunlight as it gets older, it can best be managed by an even-aged system. However, young white pine trees are fairly tolerant and they can be started under canopy (*Wendel 1971*). This means that this species can be regenerated not only by clearcutting but also by shelterwood and small patch cutting. The seed tree method, while feasible, has little to recommend it (*Frothingham 1914*). The initial requirements are that the white pine reproduction be well started before the overstory is removed and that the overstory be harvested before the young white pine suffers seriously from shading. For the clearcutting method, if the final thinning in a stand is made about 10 years before the harvest cut, coincides with a good seed year, and is fairly heavy (somewhat similar to a first cut of a two-cut shelterwood); then a catch of pine reproduction can usually be expected. At that time, or shortly thereafter, the hardwood understory should be treated to favor the pine. At some later date, additional release work may be necessary to bring the young pine through to the time of the first commercial thinning.

Indications are that white pine competes successfully with hardwoods on sites of low quality for hardwood and, if favored by cultural measures, can be successfully managed as the predominant species. On such sites, much greater volumes of sawlogs can be produced by white pine than by hardwoods. As site quality improves, the difficulty and cost of favoring white pine over hardwoods increases and the growth advantage of white pine decreases. Based on present knowledge, it seems that conversion—or a heavy introduction of white pine into hardwood stands—may be profitable on areas of oak site index 45 to about 60 or a little lower. Where pine already exists, it should be favored on areas of oak site index up to about 65.

The product objective for white pine management should be sawlogs; small products may be obtained from thinnings and from tops and limbs. White pine is not an esteemed pulpwood species because of its low specific gravity. No rate of return information similar to that used in appraising hardwood stands is available for the pine. For a site of given quality, however, we can expect a higher stumpage interest rate to be earned as the size of clearcut openings is increased, at least between the sizes of openings used for comparison (table 6).

Most of the information on rotation ages and dbhs (shown in table 6) is based on unpublished data used by the Monongahela National Forest in managing white pine in pure stands and in stands mixed with hardwoods.

Water.—The discussions under floodplain hardwoods and mixed hardwoods apply to white pine on the best sites, while that under oaks is pertinent to white pine on poorer sites. Because most white pine likely will be grown on dry sites, the latter discussion seems applicable most often.

Rainfall interception and transpiration losses are higher in pure white pine than in hardwood stands. However, these differences are small in terms of precipitation in the central Appalachians, perhaps on the order of 2 to 4 inches per year. Nevertheless, it seems advisable to hold down the proportion of white pine (or any conifer) where water production is an important goal of forest management. Presumably, white pine (or any conifer) is as effective as hardwood for protecting the quality of headwater streams.

Visual appeal.—The white pine ecosystem provides visual enrichment to the central Appalachian landscape by presenting islands of diversity in the region's "sea of hardwoods".

The major criterion used to evaluate the visual impact of even-aged management was the size of the clearcut unit (table 6). As in other ecosystems, the visual appeal is reduced as clearcut size increases. Where white pine occurs mixed with hardwoods, clearcutting accompanied by hardwood control would be a desirable way to encourage white pine reproduction, and promote enrichment of the characteristic landscape. The negative visual impact of clearcutting is likely to be greater where white pine occurs in pure stands.

The effect of no commercial cutting would be much the same as in other ecosystems.

Wildlife.—Because this type occupies less than one percent of the forest acreage in central Appalachia, it is not important regionally for wildlife. Locally, however, white pine may occupy sites with high potential value as wildlife habitat. Mature stands that are large, uniform, and not interspersed with hardwoods have low value for wildlife. But stands at the other extreme—narrow, young or of various-sized trees, well interspersed with hardwoods—have at least moderate value through increasing the diversity of wildlife habitat.

Few kinds of wildlife are specifically associated with white pine. The wildlife species to be favored usually are those associated with adjacent forest types, typically the oak associations.

The tree species to favor are white pine in some stands as noted above, and the better mast-producing hardwoods. Some young pine and hemlock are desirable; they provide good cover for small birds during the nesting season and for grouse, rabbits, and sometimes quail. But as pine and hemlock mature they become less useful to wildlife than most hardwoods. White pine is notably unlikely to provide denning trees for squirrels, raccoons, owls, etc.

The stand conditions most favorable to wildlife are found where white pine stands are intermixed with hardwoods. Where pine—or hemlock—is to be retained, patches of nearly pure softwoods are preferable to scattered, isolated trees, or clusters of a few trees.

Silvicultural practices that favor the conversion of pine to shade-intolerant and moderately tolerant hardwoods are appropriate for wildlife purposes where pine stands are so large or so uniform that they appreciably reduce the diversity of the habitat. This conversion, under any silvicultural system, would require using cultural practices to favor the hardwoods and discriminate against the pine. However, converting all of a pine stand to hardwoods would rarely be good wildlife habitat management.

5. VIRGINIA PINE

Description of the Ecosystem

In the central Appalachians the yellow pines are Virginia, pitch, and shortleaf. The discussion in this report is keyed to the short-lived, intolerant Virginia pine which is strictly a pioneer species. The principal associates of this species are: shortleaf pine, pitch pine, white pine, white oak, chestnut oak, scarlet oak, black oak, red oak, red maple, sourwood, and blackgum.

When farmlands are abandoned, or forest openings are created by windthrow or other major disturbance, pines often seed in on the open lands. After 20 to 30 years, the pine stands are invaded by hardwoods which compete so strongly with the pine reproduction for light and moisture that few pine seedlings are able to survive (*Chapman 1948; Koslowski 1949; Kramer, Oosting, and Korstian 1952*). Thus mature stands of pine commonly contain a dense understory of young hardwoods. Harvesting of large pines and losses of pine trees by windthrow, insects, diseases, and fire create openings in the pine forest which are quickly occupied by the oaks and other hardwoods already present in the understory. In this way, the stands of pine gradually are transformed into oak-pine forests. As this process continues, the pine forest is ultimately replaced by oak-hickory forest. The change from forests predominately pine to an oak-pine mixture or to oak-hickory is hastened by heavier cutting of mature pine than of mature hardwood (*Wahlenberg 1949*), unless appropriate cultural methods are used to promote pine reproduction, survival and growth.

On the lowest quality sites where Virginia pine is found, forest succession from pure pine goes through a rotation of pine-hardwood before reverting to pure hardwood. The natural conversion process is shorter on the better sites, with pure hardwood often following nearly pure pine. (*Professor Kenneth L. Carvell, personal communication*).

The understory vegetation in Virginia pine stands may include grasses and sedges, but is commonly poor in herbaceous plants. The woody species vegetation is often moderately dense, more so than in spruce or most white pine associations. As in the oak types on drier sites, sassafras and flowering dogwood are key species among the large shrubs. Sumacs, serviceberry, redbud, eastern hophornbeam, and hawthorns are also common. The typical vines and small shrubs in approximate decreasing order are: brambles (blackberry, raspberry, dewberry), blueberries and huckleberries, greenbriers, grapes, mountain laurel, roses, deerberry, Virginia creeper, teaberry, poison ivy, St. John's wort, witch-hazel, and several others.[2]

Evaluation and Discussion

Timber.—The objective of management for Virginia pine will be to grow pulpwood in as pure stands as possible; only even-aged systems will be considered because it is not feasible to grow this species in uneven-aged stands (*Slocum and Miller 1953*).

Mean annual growth culminates between 40 and 50 years of age, and stands older than 50 tend to become excessively open, thus permitting the development of a vigorous understory (*Slocum and Miller 1953*). For these reasons, clearcutting is recommended when the stands are 40 to 50 years old. This provides ample time for the production of pulpwood. Clearcutting should remove all merchantable stems of both pine and hardwoods.

To perpetuate Virginia pine, hardwood control will be necessary. Because Virginia pine is so intolerant, it is desirable to treat the hardwoods at or near the time of the regeneration cut. It is also desirable to use a chemical treatment to reduce sprout competition.

Thinning of commercial-sized Virginia pine is not recommended because of poor growth response (*Slocum and Miller 1953*) and the probable encouragement of hardwoods in the understory.

Virginia pine site indexes 50 and 60 correspond to oak site indexes 45 and 55 (*Doolittle 1958*). This fairly well covers the range of sites where we are likely to be growing Virginia pine in the central Appalachians.

The ratings in table 7 indicate that if the decision is made to grow Virginia pine on these sites, then returns on investment will be greater on the larger clearcut areas. They do not mean that Virginia pine stumpage will necessarily return a net profit under any of the situations listed. It may be that a grower dependent on net stumpage cannot afford to fight the hardwoods to the extent necessary to maintain Virginia pine, but an industrial owner supplying a mill with pulpwood may find it profitable to grow this species.

Water.—Virginia Pine occurs naturally on some of the driest sites in the central Appalachians, sites having virtually no potential for increased water production and with considerable erosion hazard. Virginia Pine also seeds in or is planted on abandoned farmland. Here, soils may be deep, fine textured, and not stony but severely eroded in the recent past and likely to cause water quality problems. Traction may be poor for trucks, so unregulated use of logging roads in wet weather may rut them deeply and renew soil erosion. Extra care in road and logging practice is important to protect water quality. Two alternatives should be considered for watershed management:

(1) If the litter cover is adequate to protect the soil from erosion, let trees continue to grow to insure high quality of whatever water is produced naturally.

(2) If the litter cover and vegetation are sparse to the extent that soil is eroding, encourage establishment of cover to prevent further soil erosion.

This ecosystem ordinarily has little value if water production is an important goal of land management. On this or other dry and damaged sites, the manager will do well to look elsewhere for other than minimum water values.

Visual Appeal.—Although overall visual appeal of this ecosystem is low, Virginia pine stands do provide landscape diversity. But the ecosystem is often found on poor sites and trees seldom grow to large size in pure stands. Forest practices that encourage replacement of Virginia pine with hardwoods may have the most desirable long-run impact on visual appeal.

Because the ecosystem is not extensive and trees are usually small, clearcutting may not have the adverse visual impact it has in other forest types (table 7). Clearcutting with control of hardwood reproduction will retard visually desirable stand succession to hardwoods.

The visual appeal of Virginia pine stands may be improved through noncommercial cutting, but under most circumstances little can be done to enhance its visual quality.

Wildlife.—The Virginia pine ecosystem is substantially less important as wildlife habitat in central Appalachia than in the ridge and valley area to the east. The yellow pine and oak-pine forest types, of which the Virginia pine ecosystem is a part, occupy about 9 percent of central Appalachia forest land. Most of the stands are small and are growing on reverting farmland in Ohio, Kentucky, and western West Virginia. The pine forest types are generally less productive of wildlife than any of the moister site types except spruce, but they become more productive as oaks, hickories and other hardwoods replace the pines.

Rabbits, quail, many nongame birds, and a few other species find good habitat in very young stands of pine. But as the pines mature, self-prune, and shade out understory plants, they rapidly decline in value for nearly all wildlife species.

Accordingly, favoring hard pine will seldom provide good wildlife habitat. Exceptions occur where young pines are needed to furnish thickets of low cover, and comparable cover could not as easily be provided in thickets of greenbriers, grapes, brambles, hawthorns, or other species. Otherwise, oaks, hickories, and nearly all other hardwoods are preferable to pines. This is particularly true where the landowner's objectives favor the forest game species such as gray squirrels and turkeys over species such as rabbits and quail.

The stand conditions to favor for forest wildlife usually are those which accelerate replacing some of the pines with oaks, hickories, and associated hardwoods. As this change occurs, the stands will first improve for edge species (deer and grouse for example), will pass through an awkward pole stage, of marginal quality for either edge or interior species, and then will succeed to the mast production stage more favorable to turkeys and squirrels but still fair as deer and grouse range. This conversion process will take about 40 years. During that time, a choice can be made on proportions of the stands to be in the various stand-size classes and then the stands can be planned for management under the options suggested for the oak types.

Because clearcutting accompanied by control of hardwood regeneration favors pines, it would seldom improve wildlife habitat, except for a few years and for a few species of wildlife. No commercial cutting—except for removal of pines—would usually be a better choice. But where advanced regeneration of hardwoods is abundant and thrifty, clearcutting most of the pines would accelerate conversion from pine to hardwoods.

6. RED SPRUCE

Description of the Ecosystem

Red spruce attained its maximum development in the Appalachians (*Korstian 1937*). Almost all the red spruce in the central Appalachians is in West Virginia. Core (*1966*) estimated that the red spruce type originally occupied 469,000 acres in the mountains of northern and eastern West Virginia at elevations above 3,200 feet. The acreage of this type was drastically reduced by the intense fires that followed the original clearcuttings around the turn of the century.

In the spruce areas, the climate is cool and humid with annual rainfall in the neighborhood of 60 inches.

Red spruce grows in association with hemlock, red and sugar maple, yellow birch, pin cherry, beech, and black cherry, but it may grow in almost pure stands. Part of the national forest land formerly occupied by red spruce has been planted to Norway spruce in pure planations.

Because the wildfires that reduced the acreage of spruce also reduced the depth of the largely-organic soil in which most of the spruce formerly grew, site quality, too, was reduced. The relatively small acreage of spruce in pure or nearly pure stands generally occupies areas of shallow rocky soils where site quality is fair to poor. Most of the spruce found on better sites occurs as scattered groups or as individual trees in the northern hardwood ecosystem. By definition, the red spruce type includes stands composed 50 percent or more of red spruce, but because in most situations the type includes stands composed of up to 50 percent hardwood stems, the type can logically be considered a spruce-hardwood complex.

The understory beneath closed stands of spruce is usually dominated by mosses, lichens, and club-mosses with ocassional wood sorrel, trillium, and teabury plants. In openings and along edges or beneath open mature stands, rhododendron, mountain ash, and wild raisin are key shrubs. They may be associated with high-bush cranberry, mountain holly, mountain laurel, speckled alder, pin cherry, serviceberry, brambles, blueberries, and huckleberries. Where the type intergrades with northern hardwoods, the understory is usually better developed and becomes more like that of the cherry-maple type.

Evaluation and Discussion

Timber.—Because the spruce ecosystem occurs in the "high country" where recreation is increasingly important, and because it offers pleasing scenic contrasts in this predominately hardwood region, in most locations it is probably of greater value for esthetics than for wood. Although this type covers only a very small area, its inclusion in this paper is justified by its strategic location and uniqueness from a scenic standpoint.

Because red spruce is shade tolerant, it is amenable to all the silvicultural systems except seed-tree harvesting (*Hart 1963; Westveld 1953*); the species is so shallow-rooted that seed trees tend to blow down.

Clearcutting is the best harvesting system for even-aged stands that are mature or overmature and on sites where windthrow is a problem (*Frank 1968; Hart 1963; Westveld 1953*). It yields the heaviest cut and costs the least per unit of volume removed. Intermediate operations may be practicable in some stands growing on better sites.

Selection cutting secures regeneration and is particularly applicable where site protection, esthetic values and recreational use are dependent on a healthy, continuous forest cover. However, care should be taken on exposed areas not to open up the stand heavily enough to risk windthrow.

The shelterwood system in which the overstory is removed in two or more cuttings is applicable to most stands except those that are on shallow soils on very exposed sites.

Because no silvicultural research has been done on red spruce in the Appalachians, the ratings in table 8 are based on generalized practices. First, we recommend that no commercial cuttings be applied on poor sites. Then, we recommend that on the fair and good sites the objective be to grow large sawtimber trees—the dbhs shown are relative rather than absolute. The ratings simply reflect the fact that we can expect greater returns from our timber investment on large clearcuts than on small clearcuts, and we can expect a higher stumpage return from clearcutting and even-aged management than we can for selection cutting and uneven-aged management.

Water.—The spruce zone is the only part of central Appalachia where snow management principles developed in the west could be applied to increase water yields. However, there is little reason to do so because the spruce forest is too limited in extent and too remote from water-short large cities to render such management useful.

Today, wildfire rarely burns the spruce type but severe water quality problems may result if it does. With organic matter burned away, infiltration of water into the rocky subsoil may be so reduced that subsequent overland flow will wash away sparse soil and tree nutrients. Thus, burning in red spruce poses the dual hydrologic problem of reduced capacity to store rain and snowmelt in addition to considerable stream pollution by ash and mud.

Visual Appeal—The spruce hardwood ecosystem, although limited in extent, provides variety in the central Appalachian landscape. Because red spruce is shade-tolerant and occurs in pure and mixed, even- and uneven-aged stands, it is difficult to generalize about the visual impact of timber harvesting methods. Selection cutting in uneven-aged stands would have little impact on visual appeal (table 8).

Where stands are even-aged, clearcutting would maintain the familiar landscape in the long-run, but would have a negative immediate effect. Large clearcuts would have a negative impact on visual appeal, but small and medium sized clearcuts may improve visual appeal in even-aged stands — particularly when man-made openings predominate in the characteristic landscape or where opening scenic vistas will enhance panoramic views. Selection or other partial cutting practices will not significantly influence visual appeal.

"No commercial cutting" can be used to improve visual appeal either by maintaining pristine conditions or by removal of unsightly trees in appropriate situations.

Wildlife.—The spruce ecosystem might rank with the least productive ecosystems for wildlife because it accommodates few species, and as the least important because the type accounts for only one one-thousandth of the forested acreage. But this type has a special appeal because it is scarce—less than 10 percent of the original acreage remains. And natural spruce systems include wildlife that either are not regularly found elsewhere in central Appalachia or are scarce elsewhere during spring and summer. These "northern" species include snowshoe hare, but are mostly wood warblers and other songbirds, rodents, salamanders and the like—not game animals.

Several game species such as bear, grouse, and deer are adapted to using at least the edges of mature spruce stands but are not necessarily attracted by them. Generally, game habitat is improved when aspen, northern hardwoods, or shrub cover replaces some of the mature spruce. Accordingly, large stands of red spruce should seldom be favored over hardwood-spruce mixtures where the objective is to improve habitat for game animals except snowshoe hare. Black cherry, beech, viburnums, and most other deciduous plants are preferable to spruce.

Where deer, grouse, and the like are considered less important than the nongame species that are more or less uniquely associated with the type, red spruce should be more favored over shrubs and hardwood trees. In general, nongame species and snowshoe hare would benefit from more spruce, either in a mosaic of small even-aged stands of several age classes or in old-growth stands that include scattered openings and patches of mixed spruce-hardwood growth.

The conditions to favor for game animals except hares are those suggested for spruce and hemlock in the northern hardwood discussion, namely, retention of the softwoods along streams where spruce usually has a well developed understory. Elsewhere spruce can be retained in small patches but scattered single trees or small, isolated clumps of a few spruce might better be replaced by hardwoods or shrubs. Wind-exposed sites are particularly suitable for replacement of closed-canopy spruce stands by shrubs mixed with shrubby spruce and hardwood trees and herbaceous cover.

Where spruce is managed for improvement of deer and grouse habitat, even-aged management based on clearcutting narrow patches of moderate size, say about 5 acres, may be the best of the timber management options. Spruce regeneration can be controlled, if need be, during the harvest cut or subsequent weedings. Smaller and more numerous clearcuts would be better for hares and the non-game animals, nearly all of which have smaller home ranges than the game animals. Patch cutting in ½ to 1 acre patches can be used to furnish interspersion, and may be preferable in spruce stands that are somewhat uneven-aged at the start.

7. FLOODPLAIN HARDWOODS

Description of the Ecosystem

This is a composite of pioneer to subclimax forest types which can be described more readily in landscape terms than by plant species composition. The ecosystem occurs mostly in narrow bands or "oxbows" along low-gradient streams, particularly the Ohio River and the lower reaches of its tributaries. Landforms within the bands or oxbows have been categorized as water margin, backwater pocket, bar, cutbank, floodplain proper, and floodplain depression *(Lindsey et al. 1961)*.

Soils supporting floodplain hardwoods generally are finer textured, wetter, more fertile, higher in organic content, and more variable within small areas than upland forest soils. The better-drained soils have mostly been cleared for agricultural and other uses. Floodplain hardwoods grow mostly on poorly drained soils such as the Atkins, Lindside, Melvin, and Senecaville series *(Ellyson, Fonner, and Kunkle 1970; Keith O. Schmude, personal communication)*.

Plant succession may be more variable in bottomland types than in most upland types, due to flooding and other disturbances. But the normal progression of stages is: annual grass-forb, perennial grass-sedge, perennial forb-sapling, sapling-woodland forb, to subclimax forests; i.e. river birch-sycamore, silver maple-elm, or equivalent *(Lindsey et al. 1961)*.

The floodplain hardwoods group includes three types defined by the Society of American Foresters *(1967)*: river birch-sycamore (61); silver maple-American elm (62); and cottonwood (63). In forest survey reports by the US Forest Service, such types are combined within the major forest type elm-ash-maple.

Tree species as given by Core *(1966)* are: *Widespread*: black willow, sycamore, American elm, sweet gum, silver maple, river birch, red maple, boxelder, green ash, cottonwood, shell-bark hickory; *Local*: Kentucky coffee-tree, honey-locust, hackberry, paulonia, catalpa, pin oak and several "white" oak species, and others. On the higher, better drained bottoms the highly-valuable black walnut is often found.

Core *(1966)* lists the following shrubs and woody vines as commonly found in the understory of this ecosystem: sandbar willow, silky willow, grapes, trumpet vine, Virginia creeper, poison ivy, alder, ninebark, meadowsweet, winterberry, bladdernut, wahoo, kinnikinnick, buttonbush, black elderberry, greenbriers, blackberries, swamp rose, bittersweet, moonseed, virgin's bower, and others.

Evaluation and Discussion

Timber.—Floodplain hardwoods are substantially less important for commercial timber production than the other hardwood types in central Appalachia. However, locally they are a source of both pulpwood and sawlogs. Timber growth is rapid and some of the species—among which are cottonwood, sycamore and silver maple—are quite valuable.

In many situations, the ecosystem—in most instances forming only a ribbon along the streams—is not large enough to be managed as a unit but is best handled as part of the contiguous forest ecosystem lying above it.

However, in the larger river valleys, stands are often large enough to justify applying a separate management system.

The key species in this type—cottonwood and sycamore—are highly intolerant and can be reproduced only by clearcutting. However, the vegetative response on cut-over sites is heavy to Johnson grass, other weeds, brush, and box elder. In the absence of early intermediate treatments, the lush growth of undesirable plants often prevents the establishment of a good stand of timber. So while clearcutting is called for, so is early precommercial work if intensive forestry is to be practiced. In general, the feeling is that the larger the clearcut, the more the profits from the operation.

In areas where forestry will be practiced in the future, it is probable that the experience and research developed in the floodplains to the south has real pertinence, and some foresters strongly recommend clearcutting, site preparation, planting cottonwood, and some cultivation, as is practiced in southern bottomlands. A little planting has been done, mostly silver maple, cottonwood, and sycamore, but this is not a prevalent practice.

It is a consensus among foresters in the area that selection cutting is impractical. However, perhaps in woodlots the system could be justified—with very light cutting to prevent the establishment of a brushy understory.

Insufficient information on growth rates and other characteristics of these stands prevents the definition of even-aged relationships in terms of tree size and stand age (table 9). For the same reason, it was not possible to present tree-size data for alternate choices in the selection system.

Growing black walnut with intensive culture is a possibility for the higher, better drained bottoms.

Many, if not most, floodplain hardwood stands are used for livestock grazing—a practice that conflicts with some other uses.

Much of this land is so valuable for farming, particularly growing corn, that land clearing is a continuous threat to the growing of wood crops.

Water.—This ecosystem is the most water-productive in the region, the only one where ground water is both common and easily accessible. Water tables are close to the land surface along streams, at the mouths of coves, and at the base of slopes. Floodplains are high-value sites for recreation and wildlife, so plans to manage these areas intensively for water must be conditioned by other resource needs. But if water need is paramount, then forest cutting should provide high yields, although studies on which this claim is based were done in the American west. In addition, proximity to cities and farms assures transport at minimum cost of water so produced.

There are, however, serious hazards to quality in managing this ecosystem for water. It is a floodplain formation on which periodic overflow is commonplace. Roads inevitably will alter the natural drainage and expose some soils to erosion. Muddy ditch water also is inevitable and has no place to drain except into streams. High recreation use contributes all sorts of pollutants, also with no place to drain except into streams. In addition, eroded soil and other pollutants of upstream origin are carried into the floodplain. Sensible regulation of all uses (e.g., zoning, policing, and control of access) probably provides the best water resource protection.

Visual Appeal.—Floodplain hardwoods, by their association with stream bottoms, have the highest potential for socially-oriented forest uses of any of the central Appalachian ecosystems.

The ecosystem is usually associated with farming activities, urbanization, and transportation routes. The characteristic landscape, therefore, has been strongly influenced by man's activity. Because of this landscape variability, the negative visual impact of clearcutting is not as great as in more steep terrain, or where continuous forest cover forms the major landscape character.

Selection cutting would have little impact on visual appeal in most situations. As with other ecosystems, "no commercial cutting" either has no effect or can be used to enhance visual appeal through judicious selective cutting.

Wildlife.—This ecosystem and the adjacent woodlands were once the most productive of all wildlife habitats. Now, the remnants of floodplain hardwoods are regionally unimportant in wildlife production, but locally their value is high and is subject to changing appraisals as public concern for environmental quality grows.

Floodplain hardwood sites are suited for more wildlife species than any other type. Floodplains accommodate most upland species plus wetlands-associated animals such as wading and shore birds, ducks, several furbearers, and frogs. But the shape, size, and ownership pattern among floodplain hardwood stands imply that many are as well or better suited to management for trapping and non-consumptive uses of wildlife as for hunting.

Choices among tree species to be favored for wildlife are usually narrow, due to microsite conditions. Generally, the oaks, hickories, hackberry and other hard-mast producers should be favored on better drained sites. Most of the other species have moderate value for wildlife but cottonwood and sycamore may be the least useful.

The stand conditions most favorable to variety among wildlife species include mixtures of many different tree species, scattered openings in the overstory, and a well-developed midstory and understory. Openings made near streams or trails may be appropriate for nesting habitat of songbirds, berry production, and so on.

Stands should include trees suitable for tree denning or nesting species such as squirrels, raccoons, owls, wood ducks, and hooded mergansers. Livestock foraging generally should not be permitted, except where the understory is too dense for some desirable habitat condition such as the openness preferred by woodcock.

Most stands are too small or narrow for conventional timber management practices. Where there is a need to open up the canopy to favor the understory or to release the more desirable species of trees, such as oaks or hickories, girdling or selective removal of individual stems can be used.

In larger stands, clearcutting of small patches may be used to diversify wildlife habitat, particularly where sycamore or cottonwood predominate.

Application Examples

The following examples illustrate how the information in this report can be used as an aid to evaluating forest management alternatives for specific situations. Theoretical situations were set up within specified ecosystems with indicated priorities among the four resources: timber, water, visual appeal, and wildlife.

It should be emphasized that the material contained in this report is intended to serve only as a guide. Actual decisions can only be made by owners or managers who specify their own sets of objectives.

Case I. Appalachian Mixed Hardwoods. Excellent site.—This is a large back-country hollow, not readily visible to the travelling public. The owner's first objective is timber production, but he has considerable side interest in improving deer habitat. The only watershed consideration is protection of water quality. The importance of visual appeal is minimal; sight-seers don't get into the area, and recreation is not an important management concern.

From the standpoint of the two management objectives—timber and deer habitat—even-aged management with clearcutting produces better effects than any other forest practice (table 4). While the optimum size clearcut unit for deer habitat is 5 acres, the optimum sized clearcut unit for timber production is 25 acres or more. The manager has narrowed his alternatives and must identify the tradeoff values between his two objectives —timber and deer habitat.

Based on the above considerations, the decision is made to practice even-aged management with clearcut units ranging between 5 and 25 acres. Rotation ages will be short (about 65 years) to favor both timber returns and deer habitat.

Where markets permit, periodic thinnings from below will be made. On occasion it may be necessary to reduce the tolerant understory before clearcutting to provide opportunity for post-harvest development of the desirable intolerants.

Design, construction, and after-logging care of the logging road system will follow established guidelines to minimize damage to water quality.

Case II. Oak ecosystem. Fair site.—This area covers a long south slope, and a large part of it is visible from a heavily-travelled highway. Both game management—largely for squirrels and turkeys—and visual appeal are important owner objectives. Timber production also is important, but to a lesser extent. No need exists for increased water yield, but it is important to protect water quality.

To maintain the mast-producing oak, even-aged management is necessary, but to provide the best habitat conditions for squirrels and turkeys (interior species), clearcut openings should be kept small (table 3). Another reason for keeping clearcut openings small is to guard against adverse visual impact on the highway users. But the efficient production of timber is penalized when opening size is limited to less than 5 acres. The length of rotation also affects the desirability of the practice: longer rotations with larger trees will enhance visual appeal and produce better conditions (more mast) for squirrels and turkey, but they lower rates of return from timber.

Balancing the diverse pressures, the owner decides to practice even-aged management with 5-acre clearcuts on a rotation of 115 years. This plan favors conditions for squirrels and turkey, is fair from the standpoint of visual impact and gives a low return from stumpage (table 3).

Within the framework of this plan, other practices can be implemented to enhance or protect desired resource values. If markets permit periodic thinning, mast production and possibly stumpage returns can be increased. Den trees can be left for squirrels. Road patterns and clearcut units can be laid out to minimize their impact on visual appeal. And the use of erosion control measures on the logging road system will protect water quality.

Case III. Red Spruce. Fair site.—The forest property is in the high country and is made up of middle-aged, mixed spruce and scrubby hardwoods. It is readily accessible and heavily used for hiking and camping. Moreover, the area is a favorite place for bird watchers who find here many species of warblers. Streams provide fishing for stocked trout.

The owner's major management objectives are to enhance visual appeal and wildlife values. Timber production is not important.

Based on his use priorities, the manager decides to apply the forest practice "no commercial cutting" (table 8). Although small clearcut units would be of some value in producing wildlife habitat, the owner feels that these gains in wildlife production would be more than offset by resulting deterioration of visual appeal. The practice adopted does not preclude all cutting. Trees will be removed for trails, scenic vistas, and improved access, as well as to reduce hazards and release particularly attractive vegetation specimens. Erosion-reducing measures will be carried out in access trails and roads to maintain water quality.

As the stand matures (120+ years old) under the "no commercial cutting" management practice, it may be necessary to conduct limited timber harvesting—accompanied by cultural measures to favor spruce—to perpetuate the spruce ecosystem.

Literature Cited

Austin, Morris E.
1965. LAND RESOURCES REGIONS AND MAJOR LAND RESOURCE AREAS OF THE UNITED STATES. USDA Agric. Handb. 296. 82 p.

Ball, J. Curtis.
1949. ASSOCIATION OF WHITE PINE WITH OTHER FOREST TREE SPECIES AND RIBES IN THE SOUTHERN APPALACHIANS. J. For. 47: 285-291.

Braun, E. Lucy.
1950. DECIDUOUS FORESTS OF EASTERN NORTH AMERICA. 596 p. Hafner Pub. Co., New York.

Chapman, H. H.
1948. HOW TO GROW LOBLOLLY PINE INSTEAD OF INFERIOR HARDWOODS. Soc. Ac. Foresters Proc. 1947: 347-353.

Christensen, Wallace A., and Edwin A. Grafton.
1966. CHARACTERISTICS, OBJECTIVES, AND MOTIVATION OF WOODLAND OWNERS IN WEST VIRGINIA. W. Va. Univ. Agric. Exp. Sta. Bull. 538. 28 p.

Cope, J. A.
1932. NORTHERN WHITE PINE IN THE SOUTHERN APPALACHIANS. J. For. 30: 821-828.

Core, Earl L.
1966. VEGETATION OF WEST VIRGINIA. 217 p., illus. McClain Printing Co., Parsons, W. Va.

Doolittle, Warren T.
1958. SITE INDEX COMPARISONS FOR SEVERAL FOREST SPECIES IN THE SOUTHERN APPALACHIANS. Soil Sci. Soc. Am. Proc. 22: 445-458, illus.

Douglass, James E., and Wayne T. Swank.
1972. STREAMFLOW MODIFICATION THROUGH MANAGEMENT OF EASTERN FORESTS. USDA Forest Serv. Res. Pap. SE-94, 15 p., illus.

Ellyson, W. V., R. F. Fonner, and W. M. Kunkle. 1970. SOIL SURVEY OF WOOD AND WIRT COUNTIES, WEST VIRGINIA. USDA Soil Conserv. Serv., W. Va. Agric. Exp. Sta. 79 p., illus.

Federer, Anthony C., Robert S. Pierce, and James W. Hornbeck
1972. SNOW MANAGEMENT SEEMS UNLIKELY IN THE NORTHEAST. Watersheds in Transition. p. 212-219. American Water Resources Ass. and Colorado State Univ., Urbana, Ill.

Fernald, M. L.
1950. GRAY'S MANUAL OF BOTANY. 742 p. Am. Book Co., New York.

Frank, Robert M.
1968. CLEARCUTTING IN SPRUCE-FIR TODAY AND TOMORROW. New England Sect. Soc. Am. Foresters. 48th Ann. Meet. Proc. 28-35.

Frothingham, E. H.
1914. WHITE PINE UNDER FOREST MANAGEMENT. U.S. Dep. Agric. Bull. 13. 70 p.

Gingrich, Samuel F.
1971. MANAGEMENT OF YOUNG AND INTERMEDIATE STANDS OF UPLAND HARDWOODS. USDA Forest Serv. Res. Pap. NE-195. 26 p., illus.

Grisez, Ted J. and Joseph J. Mendel.
1972. THE RATE OF VALUE INCREASE FOR BLACK CHERRY, RED MAPLE, AND WHITE ASH. USDA Forest Serv. Res. Pap. NE-231, 26 p.

Hart, Arthur C.
1963. SPRUCE-FIR SILVICULTURE IN NORTHERN NEW ENGLAND. Soc. Am. Foresters Proc. 1963: 107-110.

Hepting, George H.
1971. DISEASES OF FOREST AND SHADE TREES OF THE UNITED STATES. USDA Agric. Handb. 386, 658 p.

Hibbert, Alden R.
1967. FOREST TREATMENT EFFECTS ON WATER YIELDS. *In* International Symposium on Forest Hydrology. p. 527-543. Pergamon Press, New York.

Hough, A. F., and R. D. Forbes.
1943. THE ECOLOGY AND SILVICS OF FORESTS IN THE HIGH PLATEAU OF PENNSYLVANIA. Ecol. Monogr. 13: 299-320.

Illick, Joseph A., and Leroy Frontz.
1928. THE BEECH-BIRCH-MAPLE FOREST TYPE IN PENNSYLVANIA. Penna. Dep. of Forests and Waters Bull. 46, 40 p.

Kochenderfer, James N.
1970. EROSION CONTROL ON LOGGING ROADS IN THE APPALACHIANS. USDA Forest Serv. Res. Pap. NE-158, 28 p., illus.

Korstian, Clarence F.
1937. PERPETUATION OF SPRUCE ON CUTOVER AND BURNED LANDS IN THE HIGHER SOUTHERN APPALACHIAN MOUNTAINS. Ecol. Monogr. 7: 125-167.

Koslowski, T. T.
1949. LIGHT AND WATER IN RELATION TO GROWTH AND COMPETITION OF PIEDMONT FOREST TREE SPECIES. Ecol. Monogr. 19: 207-231.

Kramer, P. J., H. J. Oosting, and C. F. Korstian.
1952. SURVIVAL OF PINE AND HARDWOOD SEEDLINGS IN FOREST AND OPEN. Ecology 33: 427-493.

Lindsey, A. A., R. O. Patty, D. K. Sterling, and W. Van Asdall.
1961. VEGETATION AND ENVIRONMENT ALONG THE WABASH AND TIPPECANOE RIVERS. Ecol. Monogr. 31 (2): 105-156.

Little, E. L., Jr.
1953. CHECK LIST OF NATIVE AND NATURALIZED TREES OF THE UNITED STATES. USDA Handb. 41, 472 p.

McGinnes, Burd S.
1969. HOW SIZE AND DISTRIBUTION OF CUTTING UNITS AFFECT FOOD AND COVER OF DEER. White-tailed Deer in the Southern Forest Habitat Symp. Proc.: 66-70. USDA Forest Serv. S. Forest Exp. Sta.

Mendel, Joseph J., and George R. Trimble, Jr.
1969. THE RATE OF VALUE INCREASE FOR YELLOW-POPLAR AND BEECH. USDA Forest Serv. Res. Pap. NE-140, 27 p.

Mendel, Joseph J., Ted J. Grisez, and George R. Trimble, Jr.
1973. THE RATE OF VALUE INCREASE FOR SUGAR MAPLE. USDA Forest Serv. Res. Pap. NE-250. 19 p. illus.

Nixon, Charles M.
1968. SQUIRREL MANAGEMENT GUIDELINES FOR WILDLIFE AREAS. Ohio Dep. Nat. Resour., Div. Wildl., Inservice Doc. 55, 8 p.

Patric, James H.
1973. DEFORESTATION EFFECTS ON SOIL MOISTURE STREAMFLOW, AND WATER BALANCE IN THE CENTRAL APPALACHIANS. USDA Forest Serv. Res. Pap. NE-259. 12 p. illus.

Pierce, Robert S., Wayne Martin, Calvin C. Reeves, Gene E. Likens, and F. Herbert Bormann.
1972. NUTRIENT LOSS FROM CLEARCUTTING IN NEW HAMPSHIRE. Watersheds in Transition. pp. 285-295. American Water Resources Ass. and Colorado State Univ., Urbana, Ill.

Roach, Benjamin A., and Samuel F. Gingrich.
1968. EVEN-AGED SILVICULTURE FOR UPLAND CENTRAL HARDWOODS. USDA Agric. Handb. 355, 39 p., illus.

Schnur, G. Luther.
1937. YIELD, STAND, AND VOLUME TABLES FOR EVEN-AGED UPLAND OAKS. USDA Tech. Bull. 560, 87 p., illus.

Shafer, Elwood L.
1967. FOREST AESTHETICS—A FOCAL POINT IN MULTIPLE-USE MANAGEMENT AND RESEARCH. 14th IUFRO Congress, Pap. 7, Sect. 26, Munich, Germany, Sept. 4-9, p. 47-71, illus.

Shaw, Samuel P.
1967. WOODLOTS, WILDLIFE, AND TIMBER MANAGEMENT. North American Wildl. and Nat. Resour. Conf., Trans. 32: 238-246.

Slocum, G. K., and W. D. Miller
1953. VIRGINIA PINE. N. C. Agric. Exp. Sta. Tech. Bull. 100, 52 p., illus.

Society of American Foresters.
1967. FOREST COVER TYPES OF NORTH AMERICA (EXCLUSIVE OF MEXICO). 66 p. Report of the Committee on Forest Types, Society of Am. Foresters, Washington.

Strasbaugh, P. D., and Earl L. Core
1952-64. FLORA OF WEST VIRGINIA. Parts I-IV. W. Va. Univ. Bull. 1075 p.

Titus, Vance C.
1967. BEAUTY AND THE FORESTER. Forest Conserv. 1967 Ed., p. 12. Washington State College Forestry Club, Washington State Univ., Pullman, Washington.

Trimble, George R., Jr. and Joseph J. Mendel.
1969. THE RATE OF VALUE INCREASE FOR NORTHERN RED OAK, WHITE OAK, AND CHESTNUT OAK. USDA Forest Serv. Res. Pap. NE-129, 29 p.

Trimble, G. R., Jr. and Sidney Weitzman.
1956. SITE INDEX STUDIES OF UPLAND OAKS IN THE

NORTHERN APPALACHIANS. Forest Sci. 2: 162-173, illus.

U. S. Fish and Wildlife Service.
1970. NATIONAL SURVEY OF FISHING AND HUNTING—1970. USDI Bur. Sportfish and Wildl. Resource Publ. 95: 95.

U. S. Forest Service.
1971. EFFECT OF FOREST-MANAGEMENT PRACTICES ON NUTRIENT LOSSES. *In* "Clear-Cutting" Practices on National Timberlands. U. S. Senate: Ninety-Second Congress, Part 3. p. 1057-1067.

U. S. Forest Service.
1965. SILVICS OF FOREST TREES OF THE UNITED STATES. USDA Agric. Handb. 271, 762 p.

U. S. Forest Service.
1973. NATIONAL FOREST LANDSCAPE MANAGEMENT. VOLUME I. USDA Agric. Handb. 434, 77 p.

Wahlenberg, W. G.
1949. FOREST SUCCESSION IN THE SOUTHERN PIEDMONT REGION. J. For. 47: 713-715.

Weitzman, Sidney and G. R. Trimble, Jr.
1957. SOME NATURAL FACTORS THAT GOVERN THE MANAGEMENT OF OAKS. USDA Forest Serv., NE Forest Exp. Sta. Pap. 88, 40 p.

Wendel, G. W.
1971. CONVERTING HARDWOODS ON POOR SITES TO WHITE PINE BY PLANTING AND DIRECT SEEDING. USDA Forest Serv. Res. Pap. NE-188, 19 p., illus.

Westveld, Marinus.
1953. ECOLOGY AND SILVICULTURE OF THE SPRUCE-FIR FORESTS OF EASTERN NORTH AMERICA. J. For. 51: 422-430.

Yawney, H. W.
1964. OAK SITE INDEX IN BELMONT LIMESTONE SOILS IN THE ALLEGHENY MOUNTAINS OF WEST VIRGINIA. USDA Forest Serv. Res. Pap. NE-30, 16 p.

Yawney, H. W., and G. R. Trimble, Jr.
1968. OAK SOIL-SITE RELATIONSHIPS IN THE RIDGE and VALLEY REGION OF WEST VIRGINIA AND MARYLAND. USDA Forest Serv. Res. Pap. NE-96, 19 p.

Appendix

TIMBER-RELATED RESOURCES OF CENTRAL APPALACHIA

From data in forest survey files of the Northeastern Forest Experiment Station and in USDA Forest Service Resource Bulletins NE-9, Kentucky (1968); NE-7, Maryland (1967); NE-14, Ohio Hill Country (1969); NE-8, Pennsylvania (1968); SE-8, Virginia (1966); and NE-2, West Virginia (1964).

Table 10.—*Area in Central Appalachia, by land classes and states*

[Thousands of acres]

State and survey unit	Total land area	Nonforest land area	Forest land area: Total	Forest land area: Non-commercial	Forest land area: Commercial
KENTUCKY					
No. Cumberland	2,494.1	624.7	1,869.4	11.6	1,857.8
Eastern	2,135.7	317.2	1,818.5	23.0	1,795.5
So. Cumberland	2,774.4	553.8	2,220.6	19.9	2,200.7
State total	7,404.2	1,495.7	5,908.5	54.5	5,854.0
MARYLAND					
Garrett Co.	423.7	131.5	292.2	2.3	289.9
OHIO					
East-central	3,417.7	1,830.0	1,587.7	20.8	1,566.9
Southeastern	2,074.2	792.7	1,281.5	8.8	1,272.7
Southcentral, part	2,349.1	1,053.8	1,295.3	2.6	1,292.7
State total	7,841.0	3,676.5	4,164.5	32.2	4,132.3
PENNSYLVANIA					
Western, part	4,013.3	2,138.5	1,874.8	27.1	1,847.7
Southwestern, part	1,647.0	602.5	1,044.5	12.3	1,032.2
State total	5,660.3	2,741.0	2,919.3	39.4	2,879.9
VIRGINIA					
S. Mountain, part	1,394.5	385.9	1,008.6	19.0	989.6
WEST VIRGINIA					
Northwestern	4,454.0	1,364.0	3,090.0	6.0	3,084.0
Southern, part	4,723.9	739.2	3,984.7	11.3	3,973.4
Northeastern, part	3,096.3	937.0	2,159.3	29.3	2,130.0
State total	12,274.2	3,040.2	9,234.0	46.6	9,187.4
Regional total	34,997.9	11,470.8	23,527.1	194.0	23,333.1

Table 11.—*Area of commercial forest land in central Appalachia, by ownership classes and states*

[Thousands of acres]

State and survey unit	Public		Private			Total
	National forest	Other	Forest industry	Farmer	Miscellaneous	
KENTUCKY						
No. Cumberland	109.2	0.8	5.2	1,246.3	496.3	1,857.8
Eastern	1.0	39.5	85.8	613.8	1,055.4	1,795.5
So. Cumberland	306.0	19.4	61.4	1,454.8	359.1	2,200.7
State total	416.2	59.7	152.4	3,314.9	1,910.8	5,854.0
MARYLAND						
Garrett Co.	—	76.0	([a])	74.6	139.3	289.9
OHIO						
East-central	4.3	32.2	12.1	587.6	930.7	1,566.9
Southeastern	59.0	45.5	44.9	514.9	608.4	1,272.7
Southcentral, part	49.0	112.2	58.2	457.2	616.1	1,292.7
State total	112.3	189.9	115.2	1,559.7	2,155.2	4,132.3
PENNSYLVANIA						
Western, part	—	48.2	2.9	541.2	1,255.4	1,847.7
Southwestern, part	—	122.8	18.7	296.4	594.3	1,032.2
State total	—	171.0	21.6	837.6	1,849.7	2,879.9
VIRGINIA						
S. Mountain, part	44.8	13.7	136.5	229.1	565.5	989.6
WEST VIRGINIA						
Northwestern	—	45.0	77.0	1,124.0	1,838.0	3,084.0
Southern, part	119.5	43.0	168.7	547.9	3,094.3	3,973.4
Northeastern, part	314.7	21.1	149.8	609.5	1,034.9	2,130.0
State total	434.2	109.1	395.5	2,281.4	5,967.2	9,187.4
Regional total	1,007.5	619.4	821.2	8,297.3	12,587.7	23,333.1

[a]Combined with miscellaneous private to avoid disclosing individual industry ownership.

Table 12.—*Area of commercial forest land in central Appalachia, by stand-size classes and states*

[Thousands of acres]

State and survey unit	Sawtimber stands	Poletimber stands	Seedling-sapling stands	Nonstocked areas	Total
KENTUCKY					
No. Cumberland	847.5	503.9	505.5	0.9	1,857.8
Eastern	1,074.8	256.8	459.3	4.6	1,795.5
So. Cumberland	1,141.6	508.7	534.4	16.0	2,200.7
State total	3,063.9	1,269.4	1,499.2	21.5	5,854.0
MARYLAND					
Garrett Co.	121.7	115.6	46.1	6.5	289.9
OHIO					
East-central	367.3	179.5	966.8	53.3	1,566.9
Southeastern, part	397.2	153.6	680.7	41.2	1,272.7
Southcentral, part	420.1	191.7	661.4	19.5	1,292.7
State total	1,184.6	524.8	2,308.9	114.0	4,132.3
PENNSYLVANIA					
Western, part	926.7	322.0	484.0	115.0	1,847.7
Southwestern, part	524.6	287.9	190.9	28.8	1,032.2
State total	1,451.3	609.9	674.9	143.8	2,879.9
VIRGINIA					
S. Mountain, part[a]	323.6	368.9	291.1	6.0	989.6
WEST VIRGINIA					
Northwestern	1,439.0	713.0	750.0	182.0	3,084.0
Southern, part	2,023.7	1,096.5	853.2	—	3,973.4
Northeastern, part	1,027.6	626.4	445.5	30.5	2,130.0
State total	4,490.3	2,435.9	2,048.7	212.5	9,187.4
Regional total	10,635.4	5,324.5	6,868.9	504.3	23,333.1

[a]Estimates are based on the statewide percentages since county and unit data were not available.

Table 13.—*Area of commercial forest land in central Appalachia, by forest types and states*

[Thousands of acres]

State and survey unit	White pine	Spruce	Pitch-shortleaf-Virginia pine	Oak-pine	Oak-hickory	Oak-gum	Elm-Ash-Cottonwood	Maple-beech-birch	Aspen	Total, all types
KENTUCKY										
No. Cumberland	—	—	99.5	151.2	1,541.5	—	22.1	43.5	—	1,857.8
Eastern	—	—	30.4	43.1	1,610.4	—	7.3	104.3	—	1,795.5
So. Cumberland	—	—	132.8	287.9	1,676.1	—	54.7	49.2	—	2,200.7
State total	—	—	262.7	482.2	4,828.0	—	84.1	197.0	—	5.854.0
MARYLAND										
Garrett Co.	23.3	—	—	14.5	227.2	—	4.9	20.0	—	289.9
OHIO										
East-central	37.5	—	11.7	112.9	600.2	4.3	457.7	303.3	39.3	1,566.9
Southeastern	6.1	—	57.0	74.7	768.2	13.2	149.4	197.2	6.9	1,272.7
Southcentral, part	7.5	—	99.5	91.1	768.1	6.6	165.7	148.5	5.7	1,292.7
State total	51.1	—	168.2	278.7	2,136.5	24.1	772.8	649.0	51.9	4,132.3
PENNSYLVANIA										
Western, part	86.5	—	13.3	—	522.0	37.9	428.8	350.3	408.9	1,847.7
Southwestern, part	23.3	—	14.9	7.1	558.6	48.9	92.7	231.2	55.5	1,032.2
State total	109.8	—	28.2	7.1	1,080.6	86.8	521.5	581.5	464.4	2,879.9
VIRGINIA										
S. Mountain, part	11.7	—	46.6	212.1	689.1	—	1.6	28.5	—	989.6
WEST VIRGINIA										
Northwestern	15.0	—	299.0	42.0	1,916.0	14.0	299.0	499.0	—	3,084.0
Southern, part	41.2	3.8	77.5	27.1	2,763.6	54.2	236.8	769.2	—	3,973.4
Northeastern, part	6.8	16.9	106.2	25.2	1,328.8	43.6	89.0	513.5	—	2,130.0
State total	63.0	20.7	482.7	94.3	6,008.4	111.8	624.8	1,781.7	—	9,187.4
Regional total	258.9[a]	20.7	988.4	1,088.9	14,969.8	222.7	2,009.7	3,257.7	516.3	23,333.1

[a]Includes a small acreage in spruce plantations.