United States
Department of
Agriculture

Forest Service

Northeastern Forest Experiment Station

General Technical
Report NE-96

Prescribing Silvicultural Treatments in Hardwood Stands of the Alleghenies (Revised)

David A. Marquis
Richard L. Ernst
Susan L. Stout

Abstract

This publication brings together the results of 20 years of research and experience in the silviculture of hardwood forests of the Allegheny region. Part I provides a brief synopsis of silvicultural knowledge and recommended practices. Part II provides guidelines, decision tables, and step-by-step instructions for determining silvicultural prescriptions in individual stands.

The Authors

David A. Marquis received his bachelor of science degree in forestry from the Pennsylvania State University in 1955, and his master's and doctoral degrees in forest ecology and silviculture from Yale University in 1963 and 1973, respectively. He joined the Northeastern Forest Experiment Station's silviculture research unit in New Hampshire in 1957, where he studied problems of regeneration and thinning in northern hardwoods. Between 1965 and 1970 he served on the timber and watershed management research staff at the Station's headquarters in Upper Darby, Pennsylvania. Between 1970 and 1990, Dr. Marquis was project leader of the silviculture research unit at Warren, Pennsylvania, where he headed a program of research on problems related to the regeneration and culture of high-value hardwoods on the northern Allegheny Plateau. Currently, Dr. Marquis is Coordinator for the Northeastern Forest Experiment Station's Stand Culture Working Group, which is developing a silvicultural decision model for multi-resource management of all major forest types in the Northeastern United States. In addition, he is an Adjunct Professor of Forestry at the College of Environmental Science and Forestry, State University of New York at Syracuse, and is Forestry Director of Plessey Pension Investments, Inc.

Richard L. Ernst received his bachelor of science in forestry and master of science in forest management/operations research from the Pennsylvania State University in 1974 and 1979, respectively. He joined the Northeastern Forest Experiment Station's silviculture research unit at Warren, Pennsylvania, in 1976. Since that time, his research has concentrated on the effects of thinning on the growth and yield of Allegheny hardwoods and on the development of cultural guidelines for the valuable hardwood species found in this type.

Susan Laurane Stout received an A.B. degree in applied mathematics from Radcliffe College in 1972. In 1983 she completed an M.S. degree in silviculture at the State University of New York, College of Environmental Science and Forestry. Since 1981 she has been employed by the Northeastern Forest Experiment Station in the Forestry Sciences Laboratory at Warren, Pennsylvania. In 1991, she became project leader of the silviculture research unit at Warren, Pennsylvania. This unit conducts research to develop multi-resource management guidelines for forests of the northeast, especially those of the Allegheny Plateau region. Her special research interests include the development of mixed-species stands and quantifying multiple resource effects of forest management practices.

Manuscript received for publication 1 June 1990

Northeastern Forest Experiment Station
5 Radnor Corporate Center, Suite 200
100 Matsonford Road
Radnor, PA 19087-4585

January 1992

CONTENTS

TABLES, FIGURES AND APPENDICES

INTRODUCTION

This publication brings together the results of 20 years of research and experience in the silviculture of hardwood forests of the Allegheny region. It is designed primarily as a guidebook for practicing foresters whose goal is timber production, but includes options and modifications for coordination of wildlife, aesthetics, recreation, and other forest uses where appropriate. Although intended as a guide to short-term silvicultural prescriptions in individual stands, it also contains information needed for long-term management planning.

The prescription process outlined here is built around a series of decision charts that indicate appropriate treatments for particular stand conditions. To use these charts, it is necessary to make a stand examination, and then to analyze the data collected to determine present stand condition and the potential for future growth or regeneration. This information is then used with the decision charts to arrive at a course of action--a prescription outlining the work to be done in that stand to achieve specific forest management objectives.

This system of stand inventory, analysis, and prescription relies heavily on numerical guidelines. What we have tried to do is assign mathematical quantities to things we have had to guess in the past. This system reduces the amount of subjectivity traditionally used in making silvicultural decisions, providing instead an objective, measurable, and remeasurable basis for judgment. These guidelines have been applied successfully on both public and private lands over the past 10 years, and have produced results that seem to be silviculturally sound. They provide prescriptions that are consistent among stands of similar characteristics, and among prescription writers.

Nevertheless, these guides must not be applied uncritically. They represent only our best judgment at the present time; they will undoubtedly be improved and modified as research results and experience accumulate. Furthermore, no guide can ever be complete and perfect for all of the many possible circumstances likely to be encountered. So, these guides must be used as an aid to professional judgment, not as a substitute for it.

Part I provides a brief synopsis of silvicultural knowledge and recommended practices in hardwood forests of the Alleghenies. This background material is essential to the understanding and proper use of the guidelines in Part II. More complete details on this scientific background are contained in the articles cited in Part I, and we urge anyone using this guidebook to examine the articles. When specific research results were not available, the guidelines had to be based upon judgment and experience. In other situations, research from other geographic areas was adapted to fit conditions in the Alleghenies. We have indicated the source of all guidelines so that the user can evaluate the reliability and applicability to his or her particular situation.

Part II of this publication contains the step-by-step procedures, decision charts, and guidelines used to arrive at silvicultural prescriptions.

The data analysis and prescription writing portions of the system can be automated, and a computer program called SILVAH is available (Ernst 1982, Stout 1983, Marquis 1986b)[1] on request. For information, please write: U.S. Department of Agriculture, Forestry Sciences Laboratory, P.O. Box 928, Warren, PA 16365.

Research leading to the development of these guidelines was conducted between 1971 and 1989 by scientists at the U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, at the Forestry Sciences

---

[1] Marquis, David A.; Ernst, Richard L. User's Guide to SILVAH: A stand analysis, prescription, and management simulator program for hardwood stands of the Alleghenies. In preparation.

Laboratory, Warren, Pennsylvania. In addition to the authors, research contributing to these guidelines was done by Luther R. Auchmoody, John C. Bjorkbom, David deCalesta, Kurt W. Gottschalk, Ted J. Grisez, Stephen B. Horsley, Benjamin A. Roach, James Redding, Nancy G. Tilghman, and Russell S. Walters. The assistance of many agencies in the area contributed substantially to the research and the testing of results. These include: Hammermill Paper Company; International Paper Company; Texasgulf, Inc.; Kane Hardwood Division of Collins Pine; Glatfelter Paper Company; The Allegheny National Forest; The Pennsylvania Bureau of Forestry; The Pennsylvania Game Commission; and the New York Department of Environmental Conservation.

LIMITS OF APPLICABILITY

The guidelines presented here are intended for use in the cherry-maple, beech-birch-maple, and oak-hickory forests of the Allegheny Plateau and Allegheny Mountain sections of Pennsylvania, New York, Maryland, and West Virginia.

Most of the guidelines for the cherry-maple type are based on research from a 6- or 7-county area in northwestern Pennsylvania. Most of those for the beech-birch-maple type come either from the same area in northwestern Pennsylvania, or from selected literature from northern New Hampshire, northern New York, or north central West Virginia. Most of the information on the oak-hickory type comes from the central states or West Virginia with a small amount of supplementary data from central Pennsylvania and southern New York. Although the guidelines have been used rather extensively throughout the Allegheny region since about 1980, they have been most thoroughly tested in northwestern Pennsylvania. Caution is therefore needed in the application of these guides outside of the tested area.

We believe the guides to intermediate even-age culture to be rather widely applicable, even outside of the Allegheny region, and would not hesitate to use them on a trial basis anywhere in hardwood stands of the Northeast. The guides to regeneration are much more restricted in applicability because of local differences in such factors as deer browsing, site characteristics, climate, and insect pests. Caution is definitely needed even within the Allegheny region, and local modification may be appropriate. The basic procedures and framework of the decision making process are universally applicable. If local silvical knowledge is sufficient to permit the needed modification in decision variables, the system of stand inventory, analysis, and prescription described here can easily be adapted to any region.

We are most anxious to improve these guides and extend the region of applicability. Comments on problems encountered or suggestions on additional biological or ecological factors that need to be incorporated to improve the guides' validity in any northeastern location are welcome.

PART I--SYNOPSIS OF RECOMMENDED SILVICULTURAL PRACTICES

In this section, recommended silvicultural practices and important background information are described briefly. There are separate sections for even-aged regeneration, intermediate even-age culture, stand-maturity/rotation-length determination, all-age culture, and soil factors and soil protection.

EVEN-AGED REGENERATION

Regeneration practices for even-age silviculture are determined by several factors that follow.

Advance Seedling Regeneration

In all forest types under consideration, a lack of advance seedlings prior to final harvest usually results in unsatisfactory regeneration. Furthermore, the species composition of the advance regeneration largely determines the species composition of the next stand. Thus, it is extremely important that an adequate amount of advance regeneration be established before the final overstory removal.

The adequacy of advance regeneration depends upon the species being regenerated, the number of seedlings, their size, and the amount of deer browsing. In areas of high deer population, advance seedlings tend to be small; thus large numbers of seedlings are required to provide assurance that a few will grow out of the deer's reach. In areas of low deer population, advance seedlings tend to be larger. Fewer are needed in this situation, both because the larger seedlings survive exposure and competition better, and because fewer of them will be destroyed by deer browsing.

Black cherry advance seedlings survive better than most other species, and fewer cherry seedlings are required than maple or ash. This species difference is most pronounced where deer populations are high, because ash and maple are preferred browse species. Oak advance seedlings must usually be very large (4.5 feet tall or more) to ensure that they will be able to grow well after release and compete successfully with other vegetation, which tends to grow faster in the juvenile stage. Where large oak advance seedlings are present, very few stems are needed. Unfortunately, few stands in the Alleghenies contain oak seedlings as large as those specified in current guides. Many more oak seedlings are required if they are small, and even this may not suffice if regeneration of faster growing species occurs simultaneously.

Our guidelines on the numbers and sizes of advance seedlings required in Allegheny and northern hardwood stands in areas of high deer population are based on a series of studies in northwestern Pennsylvania (Grisez and Peace 1973, Marquis 1982, Marquis 1987, Marquis *et al.* 1975, Marquis and Bjorkbom 1982). Guides for advance regeneration of large oak are based on studies in the central states (Sander *et al.* 1976). Our guidelines for advance regeneration of small oak, and for Allegheny and northern hardwoods in areas of low deer population are based on experience and judgment.

Sprouting Potential

Stump sprouts can be an important supplement to regeneration of many hardwood species. In the oaks, stump sprouts are often the primary source of regeneration, and special guidelines on the sprouting potential of oak stems (based on species and diameter) have been developed. Thus, potential oak stump sprouts can be substituted for oak advance seedlings, reducing the amount of oak advance regeneration required.

Stump sprouts are very attractive to deer, and may be completely destroyed in areas of high deer populations. Thus, sprouting potential is given considerably less weight as a source of regeneration in areas of high deer population.

Our guidelines on oak sprouting potential are based on studies in the central states (Sander *et al.* 1976), and modified by experience and judgment to fit the higher deer populations of the Alleghenies.

Sapling and Pole Advance Regeneration

Although we usually think of advance regeneration as being seedling-size material, some stands contain saplings and small poles that will also form a part of the next stand if not cut at the time of final harvest. Often these understory trees are poor quality or undesirable timber species, and the best practice is to remove them. However, there are several important exceptions.

Sugar maple, beech, or hemlock 3 to 10 inches d.b.h. will often survive well and maintain quality adequate for sawtimber if retained after the final overstory removal. Only shade tolerant species with good crowns and clean straight boles free of epicormic branches respond suitably. These species are often difficult to regenerate in even-aged mixtures with faster growing species such as black cherry and yellow-poplar unless they have a substantial head start. Where high-quality saplings or poles of these species occur, they can be retained as a supplement to seedling regeneration, reducing the amount of advance reproduction necessary.

Species other than shade-tolerant sugar maple, beech, and hemlock may also be retained to preserve minor species or to meet wildlife needs. Shade-intolerant species sometimes lose timber quality when exposed in this manner, but may still meet diversity and wildlife goals. When trees are retained for these other purposes, the total number of residuals should be limited to the density specified for timber residuals alone.

Another special situation involves stands that contain a dense sapling understory of any commercial species as a result of heavy cutting or disturbance over the past 10 to 25 years. Where such sapling understories exist, they can often be developed into the next stand simply by releasing them (cutting the remaining overstory). In this situation, the sapling regeneration must usually contain sufficient numbers to form a new stand by itself, since development of advance seedlings in the presence of such an understory is difficult.

Our guidelines on retention of residual tolerants are based on several long-term experiments in the cherry-maple type of northwestern Pennsylvania (Marquis 1981e, Marquis 1981f). The guidelines on sapling understories and intolerant residuals are based on experience and judgment.

Interfering Understory Plants

Herbaceous understory plants, such as hayscented and New York fern, and grasses and sedges of many species can interfere with the establishment of desirable tree seedlings, and can reduce the growth of these seedlings to the point that regeneration fails. Woody understory plants, such as striped maple, beech root suckers, dogwood, sassafras, sourwood, blackgum, hophornbeam, blue beech, mountain laurel, and rhododendron can have a similar effect. The interference may result from competition among species, and allelopathy is a factor as well with some of the herbaceous plants.

In general, established seedlings will develop satisfactorily in the presence of sparse to moderate amounts of interfering plants when the overstory is completely removed and the seedlings have enough sunlight for rapid growth. But under partial shade (as in a shelterwood cut), the interfering plants tend to spread rapidly and seedling growth is restricted, usually resulting in unsatisfactory seedling development. Thus, these interfering understories must be controlled when shelterwood cutting is to be employed. If the interfering plants are extremely dense, they may also have to be controlled even where advance seedlings are adequate for clearcutting.

The only practical way to control interfering understory plants at this time is through the use of herbicides. Herbaceous plants and woody stems less than about 20 feet tall can be controlled effectively using a skidder-mounted mistblower. Larger woody stems must generally be treated individually with a basal spray, frill, or injection.

Our guidelines on the amounts of interfering plants that will restrict regeneration are based on exploratory studies (Marquis *et al.* 1975). Information on allelopathic effects of these plants is based on a series of controlled experiments in northwestern Pennsylvania (Horsley 1977a, 1977b, 1978, 1983, Horsley and Marquis 1983).

Information about competitive effects of hay-scented fern on black cherry regeneration is also based on a series of controlled experiments in northwestern Pennsylvania (Horsley 1986). Recommendations on herbicide control of fern, grass, striped maple, and beech are based on a series of time-rate experiments conducted with a variety of herbicides in northwestern Pennsylvania, plus operational experience since 1979 in the same area (Horsley 1981, 1982, 1989, 1990a, 1990b, Horsley and Bjorkbom 1983, Horsley *et al.* 1985). Guides on herbicide treatment of individual woody stems are based on research throughout the Eastern United States (Kossuth *et al.* 1980, Lindmark 1965, Shipman and Farrand n.d., USDA, Forest Service 1969, Wendel and Kochenderfer 1982).

Site Limitations

Wet, saturated soils can result in regeneration failure. The excess moisture, lack of aeration, tendency toward frost pockets, tendency for lush growth of some types of interfering herbaceous vegetation, and possible buildup of allelochemicals all work to make seedling establishment difficult and growth slow. In areas of high deer population, the slow growth subjects regeneration to deer browsing for an extended period and further reduces the chance of success. Although regeneration is not impossible on such sites, the risk of failure is greater than on better-drained soils, and it is prudent to ensure that advance regeneration is well established, free of interfering plants, and large enough to survive well before the final overstory removal is made. Loss of advance seedlings due to logging damage also can be severe on wet soils (see section on Soil Factors and Site Limitations).

Those areas that are almost completely covered with a surface layer of stones and rocks also present difficulties for regeneration. Advance seedlings are often rooted only in the forest floor material that covers the stony layer, and not in the deeper underlying mineral soil. When the overstory is removed, the forest floor dries quickly, and small advance seedlings die from desiccation. The presence of surface stones becomes increasingly important on well-drained soils located on southern and southwestern exposures where slope steepness is 15 to 20 percent or more. As with wet soils, it is imperative that advance seedlings be well established and large enough to be rooted in mineral soil before final overstory removal.

Our guidelines on site limitations are based on experience and judgment. Regeneration failures in low-lying wet areas that act as frost pockets are documented by Hough (1945).

Deer Browsing

High deer populations are without question the major cause of regeneration failure in many parts of the Allegheny region. The most serious situations occur when the deer population is high, and the available food is scarce due to a long history of overbrowsing and/or to a lack of farmland interspersed with the forest land to provide alternative foods. It is imperative that those prescribing regeneration treatments estimate the deer browsing pressure on the tract of land under consideration, and that this pressure be considered in arriving at a recommended prescription. The key to successful regeneration when a large deer herd is present is to provide so much deer food within the home range of the local population that the deer cannot consume all of it, and some seedlings will escape to form the next stand. This is accomplished by selecting areas with abundant advance regeneration, stimulating advance regeneration through shelterwood cutting, using herbicides for site preparation where needed, and maximizing the area in a high deer-food-producing condition (thinning and harvest cutting in surrounding stands).

In areas of extremely high population, it may be necessary to invest in protection against browsing. Electric fencing is the most promising and economical form of protection available in most situations, though standard cattle fencing or individual seedling protectors have advantages in some situations. All types of protection require a commitment to maintenance over a 5- to 10-year period if they are to remain effective.

An alternative to fencing in areas of high deer population in the cherry-maple type is fertilization about 2 years after clearcutting to force rapid growth and get the seedlings above the reach of deer quickly. Aerial applications of nitrogen and phosphorus fertilizers have been effective in getting black cherry seedlings above the reach of deer in a few years, thus circumventing browsing damage.

Our information on the impact of deer browsing comes from a series of experiments conducted over many years, in northwestern, south central, and northeastern Pennsylvania, and northern New York (Gottschalk 1987, Grisez 1959a, Hough 1949, Jordan 1967, Kelty and Nyland 1981, Marquis 1974, 1975a, 1978b, 1981a, Marquis and Brenneman 1981, Marquis and Grisez 1978, Marquis *et al.* 1976, Redding 1987, Shafer *et al.* 1961, Tilghman 1984, 1987, 1989). Guidelines on cutting methods and cultural practices to use in areas of high deer population come from studies in northwestern Pennsylvania and northern New York (Gottschalk and Marquis 1982, Kelty and Nyland 1981, Marquis 1973, 1979b, 1981d, 1987).

Information on techniques of protecting regeneration from deer browsing come from studies by several agencies in Pennsylvania (Brenneman 1982, Grisez 1959b, 1960, Marquis 1977a, Tully 1985, Wingard *et al.* 1981). Information and guidelines on fertilization come from experiments with black cherry in northwestern Pennsylvania (Auchmoody 1982, 1983, 1985, Auchmoody and Filip 1973, Nelson and Auchmoody, 1987).

Seed Supply

When advance seedlings are sparse, shelterwood cutting is the recommended procedure for all species. This provides conditions favorable for seedling establishment over a period of 5 to 10 years, and minimizes concern about timing of cuts to coincide with bumper seed crops. Even so, an adequate seed source is required to provide the number of advance seedlings required. Because the amount of seed produced is closely related to the basal area of overstory trees of that species, the adequacy of seed production can be estimated from overstory data.

The amount of seed required (really the amount of advance reproduction required) also depends on the amount of deer browsing. Areas that have poor seed sources and high deer populations are extremely difficult to regenerate. We recommend special caution in prescription of regeneration treatments when this combination of difficulties is present.

Our knowledge of seed production and seed storage in the forest floor comes from a series of studies in northwestern Pennsylvania, West Virginia, and the Southern Appalachians (Auchmoody 1979, Bjorkbom 1979, Bjorkbom *et al.* 1979, Downs 1949, Grisez 1975, Marquis 1975b, Wendel 1977), as do the guidelines on adequacy of seed sources (Bjorkbom 1979).

A few species, such as the birches and aspens, reproduce in large numbers from seed blown into the area after cutting. Yellow-poplar often reproduces from seed stored in the forest floor. We have been unable to predict regeneration from these sources reliably from basal area of these species in the overstory. Therefore, regeneration may be more abundant than our guides predict in stands where these species occur.

Cutting Methods

If adequate numbers and sizes of advance seedlings of desired species are present, clearcutting will satisfactorily regenerate a new stand in all forest types under consideration here. The only exceptions are stands with extremely dense understories of interfering plants (rare in combination with adequate advance regeneration), or sites with poor soil drainage or rocky surface soil.

If advance seedlings are inadequate, it may be possible to increase their numbers and/or size through shelterwood cutting. If seed sources are adequate, site not limiting, and interfering understory plants sparse, a two-cut shelterwood sequence (seed cut followed in 3 to 10 years by a removal cut) will usually produce a satisfactory new stand in the Allegheny and northern hardwood types. In the oak type, development of advance regeneration often takes longer, and measures to control the other vegetation and favor the oaks over their competitors may be required. Procedures to accomplish this are still under study. Woody understory vegetation in the sapling sizes should usually be treated in the oak type.

Where interfering understory plants are dense, they should be treated with herbicide before the seed cut of the shelterwood sequence to ensure that these plants do not expand further and prevent establishment of desired seedlings. In the oak type, removing interfering plants does not guarantee that oak regeneration will become established. The reason for the absence of oak advance regeneration should be determined before attempts are made to regenerate the stand.

If poor soil drainage or rocky soils are present on the area to be regenerated, a three-cut shelterwood sequence is recommended. The seed cut is made as above, but the removal is spread over two cuts to allow the advance seedlings to reach large size, and ensure that they are well-enough established to survive under the difficult environmental conditions that follow complete overstory removal. This three-cut sequence also can be used in areas where management goals make it desirable to have the new stand tall enough to avoid the appearance of a fresh clearcut when the final overstory removal is completed. However, if deer browsing is severe, the three-cut procedure, which requires the seedlings to grow under partial shade for an extended period, often will not work.

All shelterwood cuts depend on the presence of an adequate seed source. Extremely large amounts of seeds (advance seedlings) are required where deer populations are high. Where seed sources are inadequate, special measures such as underplanting, fencing, or a combination of the two may be required to ensure that the area will be regenerated satisfactorily.

Our recommendations on clearcutting and two-cut shelterwood cutting with and without herbicide treatment come from a series of experiments in the eastern hardwoods. (Bjorkbom and Walters 1986, Gottschalk 1983, Gottschalk and Marquis 1982, Horsley 1982, 1990b, Horsley and others 1985, Hough 1937, Husch 1954, Kelty and Nyland 1981, 1983, Marquis 1973, 1977b, 1978c, 1979a, 1979b, 1981d, 1983a, 1983b, Nyland *et al.* 1983, Ostrom 1938, Roach and Gingrich 1968, Wolf 1980). The recommendations on three-cut shelterwoods are based on theoretical considerations (Marquis *et al.* 1980) that have not been tested in the field.

INTERMEDIATE EVEN-AGE CULTURE

Cultural practices in even-aged stands are based on the belief that maximum value from the timber-growing enterprise comes from the production of high-quality sawlogs and veneer. Although considerable volumes of pulpwood and other bulk products will be obtained as byproducts, primary attention will be focused on maximizing the quantity and quality of sawtimber-size material.

Thinnings can increase the total yield of all products by salvaging volume in trees that would otherwise die; thinning also can increase value yield by increasing growth (reducing rotation length) and concentrating growth on the highest value stems in the stand.

Philosophy of Thinning Practices

The basic philosophy of hardwood sawtimber culture recommended here is the establishment of new stands at high density, and maintenance of that high density throughout the juvenile years. This stimulates the early pruning of lower limbs, minimizes the tendency for forking, and develops a clean bole with knots and other defects confined to a small core. Once an adequate length of clean bole has developed on the crop trees, the stand density can be reduced to stimulate more rapid diameter growth and hasten development of the residual trees toward maturity.

Although diameter growth of the crop trees in young stands can be increased by noncommercial thinning or cleaning, this growth advantage is at least partially offset by value lost in quality. There are no analyses of the combined growth-quality effects to suggest that the investments in precommercial thinning are economically advantageous. At this time, we recommend precommercial thinning only in those stands where the most valuable stems are overtopped and in danger of being crowded out by noncommercial species or poor-quality stems (for example, where poor-quality residuals from the previous stand are overtopping the new stand).

Instead, we recommend that the first thinning should occur at about the time that height growth begins to slow down. By then, most trees will have developed a clear bole on the first log or two, and the smaller trees in the stand that are to be removed will have reached merchantable size, so the thinning will at least pay for itself. Normally, this first thinning will occur when sapling basal area drops below 20 square feet, usually when the stand is between 40 and 60 years of age.

The first thinnings should remove the smaller and poorer quality trees in the stand, and have the objective of concentrating growth on the biggest and best quality trees. Such thinnings raise the average stand diameter and reduce the time required for trees to reach sawtimber size. Thinnings can be repeated at 15- to 20-year intervals, when density has increased enough for crowding to reoccur and the volumes available for cutting will support a commercial sale. Most of the products removed from these early thinnings will be small trees suitable only for bulk products. Such products have relatively low value; thus early thinnings from below sacrifice some immediate yield (by leaving larger trees to grow) in exchange for much larger yields that will be obtained later in the rotation as the residuals grow into large diameter, high-quality sawtimber and veneer.

As the stand grows older, some of the faster growing trees will achieve large diameter and individual maturity before the stand as a whole reaches financial maturity. In some mixed stands, a whole species group may reach mature size before the stand as a whole does. For example, black cherry often reaches maturity in 80 to 90 years, while sugar maple in the same stand may require 120 years or more. It is usually desirable to harvest at least some of these mature individuals, while continuing to thin from below in the balance of the stand.

Thus, later thinnings shift from the traditional thinning from below to a combination thinning-harvest cutting. Trees are removed primarily from the smallest and the largest sizes, retaining those that are in the small sawtimber-size class since these are the ones increasing most rapidly in value as they grow into sizes where they qualify for grade 1 sawtimber or veneer.

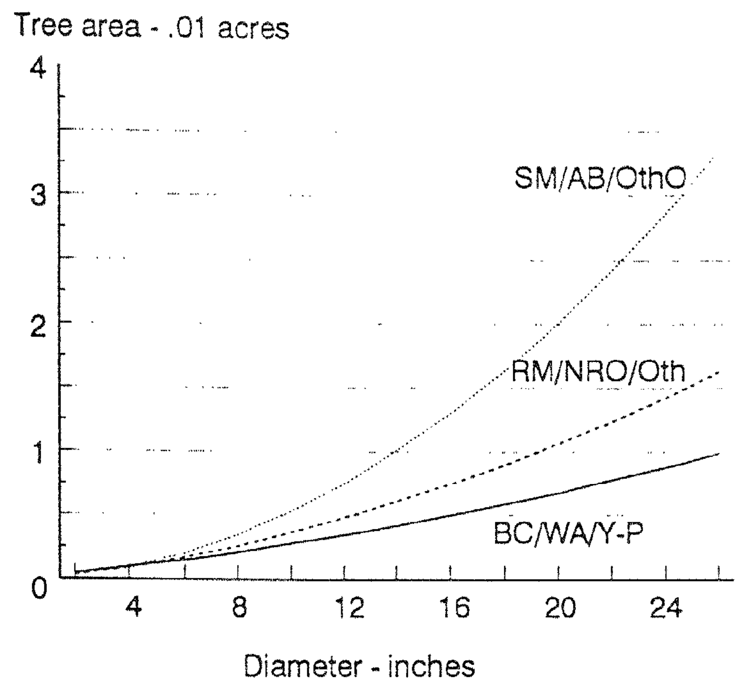
This thin-harvest must be done cautiously, however, and can usually be applied only during the last one or two thinnings. Consideration must be given to maintenance of an adequate seed source of species desired in the next stand, and care must be exercised to avoid negative genetic selection, by removal of the fastest growing stems prior to the period of regeneration establishment. But, since advance regeneration can be established 15 or more years prior to the final overstory removal, it is usually possible to harvest at least a portion of the mature individuals during later thinnings without detrimental effect on the next rotation.

Application of Thinning Practices

To achieve the desired objectives from any thinning, it is necessary to regulate stand density, stand structure, stand quality, and species composition.

Evaluating Stand Density

Absolute densities (as measured in basal area per acre or other quantities) vary widely as a function of tree size (diameter) and species composition. Maximum basal areas found in undisturbed hardwood stands of the Alleghenies are higher in older stands and in stands of species such as black cherry or yellow-poplar than they are in stands of smaller trees or stands dominated by sugar maple, beech, or oak. Thus, absolute measures of density are difficult to use as guides for thinning, because the appropriate absolute residual density varies widely from stand to stand.



The **SM/AB/OthO** group contains sugar maple and striped maple, American beech, and all oaks except northern red oak.

The **RM/NRO/Oth** group contains red maple, northern red oak, and all species not specifically included in another group.

The **BC/WA/Y-P** group contains black cherry, white ash, and yellow-poplar.

Figure 1. Tree area curves for relative density determination.

Relative measures of density have been developed to overcome this problem. Several stocking guides are available that show the average maximum basal area expected in stands of varying diameter in the oak, Allegheny hardwood, and northern hardwood types. This average maximum density is considered a reference level or 100 percent relative density. Two stands of markedly different basal area are thought to have about the same degree of crowding if both are at the same relative density (if both are at 60 percent of their reference levels, for example). Thus, relative density provides a means of regulating density that can be applied uniformly in all stands, regardless of tree size or species composition.

Because stands in the Allegheny region often contain a wide mixture of species, and sometimes represent transitions between several forest types, stocking charts developed for each specific type or species combination are needed. It is confusing to know which chart to use in a particular stand,and often, the chart needed is not available. A more convenient procedure is to evaluate relative density utilizing tables or graphs that show the average area occupied by individual trees of each species and diameter at the reference level (Fig. 1). These values for all trees sampled in the stand can be added together to get the relative density for the stand.

Relative density information comes from stocking charts developed for oaks in the central states and for Allegheny and northern hardwoods in Pennsylvania (Gingrich 1967, Roach 1977, Roach and Gingrich 1962, 1968). These data were combined and expanded to provide a more universal procedure for density evaluation throughout the Allegheny region (Stout 1987, Stout and Nyland 1986, Stout *et al.* 1987.)

Stand Density Manipulation

The optimum density to retain after thinning is a compromise. Best individual tree growth occurs at low densities (perhaps 30 percent), but there are too few trees to fully utilize the available growing space at that density. As a result, maximum stand growth occurs at higher

STAND MATURITY–ROTATION LENGTH

Rotation lengths in the several hardwood forest types of the Alleghenies range from 70 or 80 years up to 150 years or more. There are no fixed rotation lengths, even within a single forest type, because the species composition, site productivity, and amount and type of intermediate thinning can dramatically affect the number of years required to reach financial maturity. The several species groups within a single stand may mature at markedly different times as well, making the use of fixed or standard rotation ages of little value. Therefore, we recommend that stand maturity be calculated for each stand each time that the stand is examined or treated.

Stands reach financial maturity when the increase in total stand value begins to slow down–usually when a high proportion of trees have reached diameters that qualify for grade 1 sawtimber or veneer. This point can be calculated from the summation of the financial maturities of the individual trees. As a crude rule of thumb, stands tend to reach this point when the medial diameter (diameter at the midpoint of the basal area distribution) of the merchantable-size trees reaches 18 inches. At this point, a final cut is prescribed to harvest the old stand and regenerate a new one.

Stands that have relatively few trees of potential sawtimber quality are also financially mature, even if not of large diameter. It is more profitable to start over and regenerate a new stand of higher quality than to devote the site to production of low-value material. As a general rule, stands with less than 35 percent relative density in acceptable quality growing stock are financially mature for this reason. This assumes that desirable regeneration can be obtained.

Our guidelines on financial maturity are based on studies of individual tree financial maturity in New York, Pennsylvania, and West Virginia (Grisez and Mendel 1972, Mendel *et al.* 1973), plus unpublished results of computer simulator runs in Allegheny hardwood stands of varying species composition. Financial maturity of the stands in these computer runs was defined as the culmination of mean annual increment in dollar value. No interest rates or present net worth calculations were involved.

ALL-AGE CULTURE AND REGENERATION

Appropriate Conditions for Use

All-age silviculture is most appropriate in areas where goals other than timber management impose special restrictions on cutting. All-age silviculture maintains a forest canopy on the area at all times, avoiding large regeneration openings with the exposed stumps, slash, and soil disturbance that are common after even-aged regeneration cuttings. Because all-aged cuttings are less noticeable, they are better suited for timber harvesting in areas where the maintenance of an undisturbed or natural appearance is desired. Examples are areas in or near heavily used recreation sites, or along scenic highways or rivers on public forest lands, or forested areas surrounding camps or vacation homes on private ownerships.

All-age silviculture may also be a good choice on areas without special visual needs when site and stand conditions make even-age silviculture difficult. Areas that now support stands dominated by tolerant species such as hemlock, beech, and sugar maple are amenable to all-age procedures. This is especially true if there are multiple age classes present and if the site conditions make regeneration after clearcutting difficult. Wet sites with a tendency toward hemlock are an especially good example of areas that can produce good volumes of timber under all-age silviculture, but that are difficult to convert to even-aged stands of intolerant species.

Although there are variations of all-age silviculture, such as group selection, that permit regeneration of intolerant species, the long-term tendency under all-age silviculture is toward domination by shade tolerant species. In the forest types of the Alleghenies, the intolerants are the higher value, faster growing species, so financial returns from timber production will almost always be less under all-age than even-age silviculture. In addition, the reduction in variety of habitats (lack of larger openings), loss of mast (especially in the oak type), and loss of other sun-loving wildlife plants resulting from all-age silviculture will tend to produce less diversity of wildlife as well. These are the trade-offs that must be weighed against the above-mentioned advantages of all-age silviculture.

In some situations, use of all-age silviculture may be precluded entirely in the Alleghenies. Oak stands cannot be regenerated or maintained in this region through all-age techniques. Traditional all-age procedures should not be used in oak stands unless the gradual conversion of these stands to red maple and more tolerant species is acceptable.

In parts of the Alleghenies where deer browsing is severe, all-age silviculture may fail to provide adequate regeneration, even if desirable shade tolerant species such as sugar maple and hemlock are present in the overstory. Under all-age procedures, regeneration must develop following each cut; these seedlings must grow in the understory for an extended period before they finally move into the main crown canopy. During this extended period, they are subject to browsing which results in elimination of all but the less palatable beech, or sometimes in the elimination of all regeneration. Although the lack of regeneration may go unnoticed for a few cutting cycles, the long-term result is a depletion of growing stock and loss of production from the stand. For this reason, all-age silviculture is not recommended in areas of high deer population.

Our information on the appropriate use of all-age silviculture comes from a wide variety of studies throughout the eastern hardwood region (Hansen and Nyland 1987, Marquis 1977b, 1978a, 1981c, Nyland and Marquis 1979, USDA Forest Service 1979, 1983).

All-aged Regeneration

Regeneration under all-age silviculture must be obtained in every stand after every cut. Since considerable overstory is always present, regeneration will be dominated by the shade tolerant species. To maintain as many of the faster growing, more valuable intolerants in the stand as possible, we recommend that residual densities be kept low and that small openings up to about a half acre be created whenever stand conditions permit. Thus, for maximization of timber yields under all-age silviculture, we recommend a combination of single-tree and group selection cutting practices.

No attempt need be made to map or otherwise record these openings. Usually, openings will represent less than 10 percent of the stand area, meaning that less than half of the stand will be included in an opening over a 100-year period assuming a 20-year cutting cycle. Single-tree selection is therefore the primary cutting method, supplemented with small group openings.

Our information on hardwood regeneration under all-age silviculture comes from New Hampshire, New York, West Virginia, and the central states (Leak and Wilson 1958, Mader and Nyland 1984, Minckler *et al.* 1973, Sander and Clark 1971, Trimble 1965, 1970, Trimble and McGee 1973).

All-age Culture

Each cutting under all-age silviculture should create and maintain a residual stand that contains all sizes of trees in each stand at all times. To be successful, a residual stand structure goal must be established and each cut must remove only trees in each size class that are excess to that goal. In this way, regular sustained yields are assured.

As with thinning, each selection cut must regulate stand density, stand structure, tree quality, and species composition.

Residual stand density affects growth in all-aged stands in the same general way as it does in even-aged stands. Relative densities of about 60 percent provide good individual tree growth and net stand growth without loss of tree quality due to excessive exposure. With 60 percent relative density between openings, and zero density within group openings, overall residual stand density will average about 50 percent.

Stand structure goals for all-aged stands may be calculated using various mathematical distributions. One common technique is to use the ratio (q) between the number of trees in adjacent diameter classes. Although there is theoretical evidence that more complex distributions may be desirable, they have not been adequately field tested. For now, we recommend the use of "q", with ratios of between 1.3 and 1.5 (for 2-inch d.b.h. classes) in most hardwood stands in the Allegheny region.

In addition to the ratio or distribution, maximum tree size must be specified in defining all-aged structure. We recommend maximum sizes of between 22 and 30 inches. A maximum of 22 inches works well for timber production, since it results in an average diameter of 16 to 18 inches for the sawtimber trees harvested--close to the estimates of financial maturity for individual trees. A maximum of 28 to 30 inches (combined with a low q ratio) will produce stands that contain many large trees and have an appearance somewhat like a primeval or virgin forest where that visual goal is desired and timber production is less critical.

As with thinning, tables showing the relative density by size class are used for the calculation of residual structure, and these make the development of marking instructions easy. We recommend that cutting be done in all merchantable size classes (poletimber and larger), but that no cutting be done in the unmerchantable sapling sizes.

Tree quality is a major factor affecting timber value in all-age silviculture, just as it is in even-age silviculture. Thus, poor-quality trees are removed first, even if this means that structure goals cannot be achieved.

Species composition in all-aged stands will gradually shift toward a preponderance of shade-tolerant species, and the system used to distribute the cut among size classes will automatically move the stand in that direction.

Our guidelines on all-age silviculture are based on literature from throughout the Northeast, with adaptations based on judgment and experience to fit the Alleghenies (Marquis 1978a).

SOIL FACTORS AND SOIL PROTECTION

Soil types can have a major influence on the selection of a silvicultural prescription. Restrictions on the types of logging equipment used, the seasons in which logging is permitted, and the pattern of skidding may also be necessary on some soils to protect advance regeneration from damage and maintain site productivity.

Soils and geology vary widely throughout the Allegheny region and it is not possible to provide specific forestry interpretations for the entire region in this publication. However, Table 1 illustrates specific forestry interpretations developed for related soil types on the Allegheny Plateau of northwestern Pennsylvania. We encourage the development and use of similar soils interpretations in conjunction with the prescription procedures used here. County soils maps and interpretations provided by the Soil Conservation Service can be combined with local forest soils experience for this purpose.

In northwestern Pennsylvania, soil drainage is the major factor affecting silvicultural prescriptions and practices. Soils with dormant season water tables less than 12 inches below the soil surface may have lower productivity than better-drained soils, and they are vulnerable to damage during forest operations. Use of silvicultural systems that encourage species suited to these sites, and restrictions on equipment operations are appropriate. Specific recommendations depend on the soil type; the footnotes in Table 1 illustrate the range of recommendations that are appropriate in northwestern Pennsylvania. A general guide to the influence of soil factors on site productivity can be found in Auchmoody (1987).

Table 1. Soil limitations to forest practices on selected Allegheny Plateau soils. (Source: Auchmoody, Luther R. 1984. Soil Interpretation for the Allegheny National Forest. unpublished. On file, Forestry Sciences Laboratory, Warren, PA.)

Forest Practice	Soil Name: Brinkerton	Cavode	Chenango	Cookport	Ernest	Hazelton	Nolo
Even-age management	Severe[1]	Moderate	Slight	Slight	Moderate	Slight	Severe
Uneven-age management	Moderate[2]	Slight	Slight	Slight	Slight	Slight	Moderate
Natural Regeneration	Severe[3]	Moderate	Slight	Slight	Slight	Slight	Severe[3]
Artificial Regeneration	Severe	Moderate	Slight	Slight	Slight	Slight	Severe
Equipment Use	Severe[6]	Severe[6]	Slight[4]	Moderate[5]	Moderate[5]	Slight[4]	Severe[6]
Windfirmness[7]							
Uncut Stands	Moderate	Moderate	Slight	Slight	Slight	Slight	Moderate
Thinned Stands	Severe	Severe	Slight	Moderate	Moderate	Slight	Severe
Wildlife Patches	Severe	Severe	Slight	Moderate	Moderate	Slight	Severe
Residual Trees	Severe	Severe	Slight	Moderate	Moderate	Slight	Severe
Forest Fertilization	Severe	Slight	Slight	Slight	Moderate[8]	Slight	Severe
Herbicide Application	Moderate[9]	Moderate[9]	Slight	Slight	Slight	Slight	Moderate[9]
Log Decks	Severe	Severe	Slight	Moderate	Moderate	Slight	Severe
Road Location	Severe	Severe	Slight	Moderate	Moderate	Slight	Severe
Road Material Source	Severe	Severe	Slight	Severe	Severe	Slight[10]	Severe
Recreation Development	Severe	Severe	Slight	Moderate	Moderate	Slight	Severe
Off-Road Vehicle Trails	Severe	Severe	Slight	Moderate	Moderate	Slight	Severe
Oil Well Locations	Severe	Severe	Slight	Moderate	Moderate	Slight	Severe
Brine Pits	Severe	Moderate	Moderate[11]	Slight	Moderate	Severe[11]	Severe
Buildings	Severe	Severe	Slight	Moderate	Severe*	Slight	Severe

Table 1. Continued

*Limitations: **Slight** - Few or no limitations for use. **Moderate** - Some problems can be expected; extra precaution is sometimes needed.
Severe - Severe limitations for use; extra precautions always needed.

1	Even-age management should not be attempted on these soils due to poor soil drainage, general lack of advance regeneration, undesirable ground cover (ferns), and frequent location in frost pockets. <u>These sites generally fail to regenerate after clearcutting.</u>
2	Extensive uneven-age management is suggested on these soils. Extra precautions are needed to avoid soil compaction, rutting, and reduced internal drainage. Damage during logging can be minimized by infrequent entry, use of low bearing-pressure equipment, and only logging when soils are driest.
3	Hemlock/red maple/yellow birch associations should be encouraged on these soils.
4	These soils will compact and rut during logging if more than several passes are made under wet conditions, even during the summer. Soils having a high coarse-fragment content, such as Hazelton, will rut less than others. When logging on these soils, <u>traffic should be dispersed over as much area as possible</u> to avoid loss of future productivity.
5	The future productivity of these soils can be severely degraded if logging is allowed when perched water tables exist (from about November 1 to June 1). These soils should generally be logged during the summer: (1) If dry, traffic should be dispersed as much as possible; (2) If wet, skidding should be confined to a few primary trails and to the least sensitive areas that are well-drained. If logging between November 1 and June 1 cannot be avoided, track-type equipment should be specified and used.
6	These soils have severe limitations for equipment use during all seasons due to poor drainage and low bearing capacity. Only low bearing-pressure equipment should be used. Skidding should be confined to a few primary trails only.
7	Topographic position and exposure to wind must be used with a knowledge of soil conditions to determine windfirmness. The potential for windthrow is greatest on exposed ridges with poorly drained soils, decreasing as drainage and rooting becomes better and with decreasing exposure. Windthrow hazard is greatest for large scattered individuals, intermediate for groups of large trees, and least for small scattered residuals intentionally left to improve species composition of the emerging stand. In soils having severe limitations, thinning should be conservative to reduce the risk of windthrow.
8	These colluvial soils should be scheduled for fertilization later than others to avoid loss of nitrogen fertilizer via subsurface flow.
9	Low bearing-pressure equipment should be used for herbicide application to avoid soil compaction. Runoff hazard is high after heavy summer rains.
10	Frost shattered sandstone occurs at shallow depths, and when these soils occur on members of the Pottsville geologic group (determined from geology maps), the probability of finding good road building material is high.
11	Liner required.

LITERATURE CITED

Allen, Rufus H.; Marquis, David A. 1970. **Effect of thinning on height and diameter growth of oak and yellow-poplar seedlings.** Res. Pap. NE-174. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 11 p.

Auchmoody, L. R. 1979. **Nitrogen fertilization stimulates germination of dormant pin cherry seed.** Canadian Journal of Forest Research. 9: 514-516.

Auchmoody, L. R. 1982. **Response of young black cherry stands to fertilization.** Canadian Journal of Forest Research. 12(2): 319-325.

Auchmoody, L. R. 1983. **Using fertilizers to regenerate Allegheny hardwoods.** In: Finley, J.; Cochran, R. S.; Grace, J. R., eds. Regenerating hardwood stands: Proceedings; 1983 March 15-16; University Park, PA. University Park, PA: The Pennsylvania State University, School of Forest Resources, Cooperative Extension Service: 160-170.

Auchmoody, L.R. 1985. **Response of young black cherry to thinning and fertilization.** In: Dawson, Jeffrey O.; Majerus, Kimberly A., eds. Proceedings, Fifth Central Hardwood Forest Conference; 1985 April 15-17; Urbana-Champaign, IL. Urbana-Champaign, IL: University of Illinois: 53-61.

Auchmoody, L. R. 1987. **Soil-site relations for northern hardwoods.** In: Nyland, Ralph D., ed. Managing northern hardwoods: Proceedings of a silvicultural symposium; 23-25 June 1986; Syracuse, NY. Faculty of Forestry Miscellaneous Publication No. 13 (ESF 87-002). Syracuse, NY: State University of New York and Society of American Foresters: 14-24.

Auchmoody, L. R.; Filip, S. M. 1973. **Forest fertilization in the Eastern United States: hardwoods.** Gen. Tech. Rep. NE-3. In: Forest fertilization symposium proceedings, 1972 August 22-25; Warrensburg, NY. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 211-225.

Bjorkbom, John C. 1979. **Seed production and advance regeneration in Allegheny hardwood forests.** Res. Pap. NE-435. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 10 p.

Bjorkbom, John C.; Auchmoody, L. R.; Dorn, Donald. 1979. **Influence of fertilizer on seed production in Allegheny hardwood stands.** Res. Pap. NE-439. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 5 p.

Bjorkbom, John C.; Walters, Russell S. 1986. **Allegheny hardwood regeneration response to even-age harvesting methods.** Res. Pap. NE-581. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 13 p.

Brenneman, Ronnie. 1982. **Electric fencing to prevent deer browsing on hardwood clearcuts.** Journal of Forestry. 80: 660-661.

Church, Jr., Thomas W. 1955. **Weeding - an effective treatment for stimulating growth of northern hardwoods.** Journal of Forestry. 53: 717-719.

Dale, Martin E. 1972. **Growth and yield predictions for upland oak stands - 10 years after initial thinning.** Res. Pap. NE-241. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 21 p.

Dale, Martin E.; Sonderman, David L. 1984. **Effect of thinning on growth and potential quality of young white oak crop trees.** Res. Pap. NE-539. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 12 p.

Della-Bianca, Lino. 1983. **Effect of intensive cleaning on natural pruning of cove hardwoods in the Southern Appalachians.** Forest Science. 29: 27-32.

Downs, Albert A. 1949. **Trees and food from acorns.** In: Trees: The Yearbook of Agriculture. Washington, DC: U.S. Department of Agriculture: 571-573.

Erdmann, Gayne G.; Godman, Richard M. 1981. **Tending young northern hardwood stands.** In: Proc. National Silviculture Workshop, Hardwood Management; 1981 June 1-5; Roanoke, VA. Washington, DC: U.S. Department of Agriculture, Forest Service, Timber Management: 124-150.

Ernst, Richard L. 1982. **Computerized prescription for Allegheny hardwoods.** In: Proc. Microcomputers: A new tool for foresters; 1982 May 18-20; West Lafayette, IN. SAF Publ. 82-05. West Lafayette, IN: Purdue University and Society of American Foresters: 103-105.

Ernst, Richard L. 1987. **Growth and yield following thinning in mixed-species Allegheny hardwood stands.** In: Nyland, Ralph D., ed. Managing northern hardwoods: Proceedings of a silvicultural symposium; 23-25 June 1986. Faculty of Forestry Miscellaneous Publication No. 13 (ESF 87-002). Syracuse, NY: State University of New York and Society of American Foresters: 211-222.

Ernst, Richard L; Walter H. Knapp. 1985. **Forest stand density and stocking: concepts, terms, and the use of stocking guides.** Gen. Tech. Rep. WO-44. U.S. Department of Agriculture, Forest Service. 8 p.

Gingrich, S. F. 1967. **Measuring and evaluating stand density in upland hardwood forests in the central states.** Forest Science. 13: 38-53.

Gingrich, Samuel F. 1971. **Management of young and intermediate stands of upland hardwoods.** Res. Pap. NE-195. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 26 p.

Godman, R. M.; Books, D. J. 1971. **Influence of stand density on stem quality in pole-size northern hardwoods.** Res. Pap. NC-54. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 7 p.

Gottschalk, K. W. 1983. **Management strategies for successful regeneration: Oak-hickory.** In: Finley, J.; Cochran, R. S.; Grace, J. R., eds. Regenerating hardwood stands: Proceedings; 1983 March 15-16; University Park, PA. University Park, PA: The Pennsylvania State University, School of Forest Resources, Cooperative Extension Service: 190-213.

Gottschalk, K.W. 1987. **Effect of deer on oak regeneration following thinning and clearcutting in central Pennsylvania.** In: Deer, forestry, and agriculture: Interactions and strategies for management: Proceedings of a symposium; 15-17 June 1987; Warren, PA. Erie, PA: Plateau and Northern Hardwood Chapters, Allegheny Society of American Foresters: 2. Abstract.

Gottschalk, K. W.; Marquis, D. A. 1982. **Survival and growth of planted red oak and white ash as affected by residual overstory density, stock size, and deer browsing.** In: Muller, R. N., ed. 4th Central Hardwood Forest Conference; 1982 November 8-10; Lexington, KY. Lexington, KY: University of Kentucky: 125-140.

Grisez, Ted J. 1959a. **The Hickory Run deer exclosure.** For. Res. Note No. 87. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 4 p.

Grisez, Ted J. 1959b. **A low-cost deer fence.** Journal of Forestry. 57: 42-43.

Grisez, Ted J. 1960. **Slash helps protect seedlings from deer browsing.** Journal of Forestry. 58: 385-387.

Grisez, Ted J. 1975. **Flowering and seed production in seven hardwood species.** Res. Pap. NE-315. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 8 p.

Grisez, Ted J.; Mendel, Joseph J. 1972. **The rate of value increase for black cherry, red maple, and white ash.** Res. Pap. NE-231. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 26 p.

Grisez, Ted J.; Peace, Maurice R. 1973. **Requirements for advance reproduction in Allegheny hardwoods - an interim guide.** Res. Note NE-180. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 5 p.

Hansen, Gerald D.; Nyland, Ralph D. 1987. **Effects of diameter distribution on the growth of simulated uneven-aged sugar maple stands.** Canadian Journal of Forest Research. 17: 1-8.

Hilt, Donald E. 1983. **Individual-tree diameter growth model for managed, even-aged, upland oak stands.** Res. Pap. NE-533. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 15 p.

Horsley, Stephen B. 1977a. **Allelopathic inhibition of black cherry by fern, grass, goldenrod, and aster.** Canadian Journal of Forest Research. 7(2): 205-216.

Horsley, Stephen B. 1977b. **Allelopathic inhibition of black cherry II. Inhibition by woodland grass, ferns, and club moss.** Canadian Journal of Forest Research. 7(3): 515-519.

Horsley, Stephen B. 1978. **Chemicals from herbaceous plants maintain forest openings.** Pennsylvania Forests. 68: 12-13, 24.

Horsley, Stephen B. 1981. **Control of herbaceous weeds in Allegheny hardwood forests with herbicides.** Weed Science. 29: 655-662.

Horsley, Stephen B. 1982. **Development of reproduction in Allegheny hardwood stands after herbicide-clearcuts and herbicide-shelterwood cuts.** Res. Note NE-308. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 4 p.

Horsley, S. B. 1983. **Interference with desirable northern hardwood regeneration by herbaceous and woody plants.** In: Finley, J.; Cochran, R. S.; Grace, J. R., eds. Regenerating hardwood stands: Proceedings; 1983 March 15-16; University Park, PA. University Park, PA: The Pennsylvania State University, School of Forest Resources, Cooperative Extension Service: 81-93.

Horsley, S. B. 1986. **Evaluation of hayscented fern interference with black cherry.** American Journal of Botany. 73:668-669.

Horsley, S. B. 1989. **Control of understory vegetation in Allegheny hardwood stands with Oust.** Northern Journal of Applied Forestry. 5: 262-262.

Horsley, S.B. 1990a. **Control of grass and sedge in Allegheny hardwood stands with Roundup-residual herbicide tank mixes.** Northern Journal of Applied Forestry. 7(3):124-149.

Horsley, S.B. 1990b. **Tank mixing Roundup with adjuvants and other herbicides for striped maple control.** Northern Journal of Applied Forestry. 7: 19-22.

Horsley, S. B.; Bjorkbom, J. C. 1983. **Herbicide treatment of striped maple and beech in Allegheny hardwood stands.** Forest Science. 29: 103-112.

Horsley, S. B.; Marquis, D. A. 1983. **Interference by weeds and deer with Allegheny hardwood reproduction.** Canadian Journal of Forest Research. 13: 61-69.

Horsley, S. B.; Wills, D.; Johncour, R.; Shaffer, W.; Ostergard, D.; Worrall, J. 1985. **Development of spray equipment for weed control in eastern hardwood forests.** In: Proceedings, 39th Northeastern Weed Science Society. 39: 227.

Hough, A. F. 1932. **Some diameter distributions in forest stands of northwestern Pennsylvania.** Journal of Forestry. 30: 933-943.

Hough, A. F. 1937. **A study of natural tree reproduction in the beech-birch-maple-hemlock type.** Journal of Forestry. 35: 376-378.

Hough, A. F. 1943. **Methods of harvesting sawtimber from forests in the high plateaus section of Pennsylvania.** Journal of Forestry. 41: 898-903.

Hough, A. F. 1945. **Frost pocket and other microclimates in forests of the northern Allegheny Plateau.** Ecology. 26: 235-250.

Hough, A. F. 1949. **Deer and rabbit browsing and available winter forage in Allegheny hardwood forests.** Journal of Wildlife Management. 12(1): 135-141.

Hough, A. F. 1954. **Growth response in Allegheny hardwood forest after diameter-limit pulpwood cuttings.** Stn. Pap. No. 68. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 18 p.

Hough, A. F.; Taylor, R. F. 1946. **Response of Allegheny northern hardwoods to partial cutting.** Journal of Forestry. 44: 30-38.

Husch, Bertram. 1954. **The regeneration of *Prunus serotina* in northwestern Pennsylvania following cutting.** Ecology. 35: 11-17.

Jordan, James S. 1967. **Deer browsing in northern hardwoods after clearcutting.** Res. Pap. NE-57. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 15 p.

Kelty, Matthew J.; Nyland, Ralph D. 1981. **Regenerating Adirondack northern hardwoods by shelterwood cutting and control of deer density.** Journal of Forestry. 79: 22-26.

Kelty, Matthew J.; Nyland, Ralph D. 1983. **Hardwood browse production following shelterwood cutting.** Journal of Wildlife Management. 47: 1216-1220.

Kossuth, S. V.; Young, J. F.; Voeller, J. E.; Holt, H. A. 1980. **Year-round hardwood control using the hypo-hatchet injector.** Southern Journal of Applied Forestry. 4: 73-76.

Lamson, Neil I. 1983. **Precommercial thinning insures diameter growth of Appalachian hardwood stump sprouts.** Southern Journal of Applied Forestry. 7: 93-97.

Leak, William B.; Wilson, Robert W. 1958. **Regeneration after cutting of old-growth northern hardwoods in New Hampshire.** Stn. Pap. No. 103. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 8 p.

Lindmark, Ronald D. 1965. **Removing undesirable trees from hardwood stands - A literature review.** Columbus, OH: U.S. Department of Agriculture, Forest Service, Central States Forest Experiment Station. 23 p.

McCauley, Orris D.; Marquis, David A. 1972. **Investment in precommercial thinning of northern hardwoods.** Res. Pap. NE-145. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 12 p.

Mader, Stephen F.; Nyland, Ralph D. 1984. **Six-year response of northern hardwoods to the selection system.** Northern Journal of Applied Forestry. 1: 87-91.

Marquis, David A. 1969. **Thinning in young northern hardwoods; 5-year results.** Res. Pap. NE-130. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 22 p.

Marquis, David A. 1973. **The effect of environmental factors on advance regeneration of Allegheny hardwoods.** New Haven, CT: Yale University. 147 p. Ph.D. dissertation.

Marquis, David A. 1974. **The impact of deer browsing on Allegheny hardwood regeneration.** Res. Pap. NE-308. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 8 p.

Marquis, David A. 1975a. **The Allegheny hardwood forests of Pennsylvania.** Gen. Tech. Rep. NE-15. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 32 p.

Marquis, David A. 1975b. **Seed germination and storage under northern hardwood forests.** Canadian Journal of Forest Research. 5: 478-484.

Marquis, David A. 1977a. **Devices to protect seedlings from deer browsing.** Res. Note NE-243. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 7 p.

Marquis, David A. 1977b. **Silviculture of eastern hardwoods.** In: The scientific base for silviculture and management decisions in the national forest system; 1976 March 22-23; Washington, DC. Washington, DC: U.S. Department of Agriculture, Forest Service: 29-38.

Marquis, David A. 1978a. **Application of uneven-aged silviculture and management on public and private lands.** In: Uneven-aged silviculture and management in the United States; Proceedings; 1975 July 15-17; Morgantown, WV; 1976 October 19-21; Redding, CA. Gen. Tech. Rep. WO-24. Washington, DC: U.S. Department of Agriculture, Forest Service: 25-61.

Marquis, David A. 1978b. **Tree regeneration and deer.** No. 61. University Park, PA: The Pennsylvania State University, Cooperative Extension Service. 4 p.

Marquis, David A. 1978c. **The effect of environmental factors on the natural regeneration of cherry-ash-maple forests in the Allegheny Plateau region of the eastern United States.** In: Establishment and treatment of high-quality hardwood forests in the temperate climatic region; Proceedings of a symposium; 1978 September 11-15; Nancy, France. Champenoux F-54280 Seichamps, France: International Union of Forestry Research Organizations: 90-99.

Marquis, David A. 1979a. **Ecological aspects of shelterwood cutting.** In: Proceedings, National silviculture workshop; 1979 September 17-21; Charleston, SC. Washington, DC: U.S. Department of Agriculture, Forest Service: 40-56.

Marquis, David A. 1979b. **Shelterwood cutting in Allegheny hardwoods.** Journal of Forestry. 77: 140-144.

Marquis, David A. 1981a. **Effect of deer browsing on timber production in Allegheny hardwood forests of northwestern Pennsylvania.** Res. Pap. NE-475. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 10 p.

Marquis, David A. 1981b. **Even-age development and management of mixed hardwood stands: Allegheny hardwoods.** In: Proceedings, National Silviculture Workshop, Hardwood Management; 1981 June 1-5; Roanoke, VA. Washington, DC: U.S. Department of Agriculture, Forest Service, Timber Management: 213-226.

Marquis, David A. 1981c. **Hardwood silviculture and management systems: Modification for special objectives.** In: Proceedings, national silviculture workshop, Hardwood Management; 198l June 1-5; Roanoke, VA. Washington, DC: U.S. Department of Agriculture, Forest Service, Timber Management: 77-87.

Marquis, David A. 1981d. **Management of Allegheny hardwoods for timber and wildlife.** In: Proceedings, XVII IUFRO World Congress; 1981 September 7-12; Kyoto, Japan. Ibaraki, Japan: Japanese IUFRO Congress Committee: 369-380.

Marquis, David A. 1981e. **Removal or retention of unmerchantable saplings in Allegheny hardwoods: Effect on regeneration after clearcutting.** Journal of Forestry. 79(5): 280-283.

Marquis, David A. 1981f. **Survival, growth, and quality of residual trees following clearcutting in Allegheny hardwood forests.** Res. Pap. NE-477. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 9 p.

Marquis, David A. 1982. **The effect of advance seedling size and vigor on survival after clearcutting.** Res. Pap. NE-498. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 7 p.

Marquis, D.A. 1983a. **Management strategies for successful regeneration: Northern hardwoods.** In: Finley, J.; Cochran, R.S.; Grace, J.R., eds. Regenerating hardwood stands: Proceedings; 1983 March 15-16; University Park, PA. University Park: The Pennsylvania State University, School of Forest Resources, Cooperative Extension Service: 214-238.

Marquis, David A. 1983b. **Regeneration of black cherry in the Alleghenies.** In: Proceedings, 11th annual hardwood symposium of the Hardwood Research Council; 1983 May 10-13; Cashiers, NC. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 106-119.

Marquis, David A. 1986a. **Thinning Allegheny pole and small sawtimber stands.** In: Smith, H. Clay; Eye, Maxine C., eds. Guidelines for managing immature Appalachian hardwoods: Proceedings of a symposium; 18-20 May 1986; Morgantown WV. Morgantown, WV. West Virginia University: 68-84.

Marquis, David A. 1986b. **SILVAH: a stand analysis, prescription, and management simulator program for hardwood stands in the Alleghenies.** In: Wiant, Harry V. Jr.; Yandle, David O.; Kidd, William E., eds. Forestry Microcomputer Software Symposium: Proceedings of a symposium; 29 July - 2 June 1986; Morgantown, WV. Morgantown, WV. West Virginia University: 224-240.

Marquis, David A. 1987. **Assessing the adequacy of regeneration and understanding early development patterns.** In: Nyland, Ralph D., ed. Managing northern hardwoods: Proceedings of a silvicultural symposium; 23-25 June 1986. Faculty of Forestry Miscellaneous Publication No. 13 (ESF 87-002(. Syracuse, NY: State University of New York and Society of American Foresters: 143-159.

Marquis, David A. 1987. **Silvicultural techniques for circumventing deer damage.** In: Deer, forestry, and agriculture: Interactions and strategies for management: Proceedings of a symposium; 1987 June 15-17; Warren, PA. Erie, PA: Plateau and Northern Hardwood Chapters, Allegheny Society of American Foresters:125-136.

Marquis, David A.;Bjorkbom, John C. 1982. **Guidelines for evaluating regeneration before and after clearcutting Allegheny hardwoods.** Res. Note NE-307. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 4 p.

Marquis, David A.; Brenneman, Ronnie. 1981. **The impact of deer on forest vegetation in Pennsylvania.** Gen. Tech. Rep. NE-65. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 7 p.

Marquis, David A.; Eckert, Philip L; Roach, Benjamin A. 1976. **Acorn weevils,, rodents, and deer all contribute to oak regeneration difficulties in Pennsylvania.** Res. Pap. NE-356. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 5 p.

Marquis, David A.; Grisez, Ted J.; Bjorkbom, John C.; Roach, Benjamin A. 1975. **Interim guide to regeneration of Allegheny hardwoods.** Gen. Tech. Rep. NE-19. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 14 p.

Marquis, David A.; Grisez, Ted J. 1978. **The effect of deer exclosures on the recovery of vegetation in failed clearcuts on the Allegheny Plateau.** Res. Note NE-270. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 5 p.

Marquis, David A.; Somerville, James; Johnson, Eli. 1980. **Northern hardwoods.** In: National forest landscape management, volume 2, chapter 5, Timber. Agric. Handb. 559. Washington, DC: U.S. Department of Agriculture, Forest Service: 117-145.

Marquis, David A.; Ernst, Richard L. 1991. **The effects of stand structure after thinning on the growth of an Allegheny hardwood stand.** Forest Science. 37(4):1182-1200.

Mendel, Joseph J.; Grisez, Ted J.; Trimble, Jr., G.R. 1973. **The rate of value increase for sugar maple.** Res. Pap. NE-250. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 19 p.

Minckler, Leon S.; Woerheide, John D.; Schlesinger, Richard C. 1973. **Light, soil moisture, and tree reproduction in hardwood forest openings.** Res. Pap. NE-89. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 6 p.

Nelson, Brad; Auchmoody, L.R. 1987. **Fertilization of young clearcuts.** In: Deer, forestry, and agriculture: Interactions and strategies for management: 15-17 June 1987. Warren, PA. Erie, PA: Plateau and Northern Hardwood Chapters, Allegheny Society of American Foresters: 108-ll7.

Nyland, Ralph D.; Abrahamson, Lawrence; Adams, Kenneth. 1983. **Use of prescribed fire for regenerating red and white oak in New York.** In: America's hardwood forests--opportunities unlimited: 1982 Convention of SAF; 19-22 September 1982; Cincinnati, OH. SAF Publ. 83-04. Washington, DC: Society of American Foresters: 163-167.

Nyland, Ralph D.; Marquis; David A. 1979. **Appropriate silvicultural systems for northern hardwoods.** In: North America's forests: Gateway to opportunity: 1978 joint convention of Society of American Foresters and Canadian Institute of Forestry. St.Louis, MO. Washington, DC: Society of American Foresters: 334-338.

Ostrom, C. E. 1938. **Clearcutting of young northern hardwood stands.** Journal of Forestry. 36: 44-49.

Redding, Jim. 1987. **Impact of deer on forest vegetation and timber production in northern Pennsylvania.** In: Deer, forestry, and agriculture: Interactions and strategies for management: Proceedings of a symposium; 15-17 June 1987; Warren, PA. Erie, PA: Plateau and Northern Hardwood Chapters, Allegheny Society of American Foresters: 23-32.

Roach, Benjamin A. 1977. **A stocking guide for Allegheny hardwoods and its use in controlling intermediate cuttings.** Res. Pap. NE-373. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 30 p.

Roach, B. A.; Gingrich, S. F. 1962. **Timber management guide for upland central hardwoods.** Columbus, OH: U.S. Department of Agriculture, Forest Service, Central States Forest Experiment Station and North Central Region. 33 p.

Roach, Benjamin A.; Gingrich, Samuel F. 1968. **Even-aged silviculture for upland central hardwoods.** Agric. Handb.355. Washington, DC: U.S. Department of Agriculture, Forest Service. 39 p.

Sander, Ivan L; Clark, F. Bryan. 1971. **Reproduction of upland hardwood forests in the Central States.** Agric. Handb. 405. Washington, DC: U.S. Department of Agriculture, Forest Service. 25 p.

Sander, Ivan L; Johnson, Paul S.; Watt, Richard F. 1976. **A guide for evaluating the adequacy of oak advance reproduction.** Gen. Tech. Rep. NE-23. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 7 p.

Shafer, Jr., E. L; Grisez, T. J.; Sowa, Ed. 1961. **Results of deer exclosure studies in northeastern Pennsylvania.** For. Res. Note No. 121. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 7 p.

Shipman, R. D.; Farrand, E. P. [n.d.] **Forest resources and herbicides - a guide to control of undesirable woody plants.** Spec. Circ. 206. University Park, PA: The Pennsylvania State University, College of Agriculture, Extension Service; Natural Resources Series. 13 p.

Smith, H. Clay. 1977. **Results of precommercial thinning in very young Appalachian hardwood stands.** Northern Logger and Timber Processor. 26(6): 24-25.

Smith, H. Clay. 1983. **Growth of Appalachian hardwoods kept free to grow from 2 to 12 years after clearcutting.** Res. Pap. NE-528. Broomall, PA; U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 6 p.

Sonderman, David L.; Rast, Everette D. 1987. **Changes in hardwood growing-stock tree grades.** Res. Pap. NE-608. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 8 p.

Sonderman, David L.; Rast, Everette D. 1988. **Effect of thinning on mixed-oak stem quality.** Res. Pap. NE-618. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 6 p.

Stout, Susan L. 1983. **Computer program helps foresters write prescriptions for Allegheny hardwoods.** Allegheny Society of American Foresters; Allegheny News, Spring 1983: 14-15

Stout, Susan L. 1987. **Planning the right residual: Relative density, stand structure, and species composition.** In: Nyland, Ralph D., ed. Managing northern hardwoods: Proceedings of a silvicultural symposium; 23-25 June 1986. Faculty of Forestry Miscellaneous Publication No. 13 (ESF 87-002). Syracuse, NY: State University of New York and Society of American Foresters: 176-190.

Stout, Susan L; Marquis, David A.; Ernst, Richard L. 1987. **A relative density measure for mixed species stands.** Journal of Forestry. 85(6): 45-47.

Stout, Susan L.; Nyland, Ralph D. 1986. **Role of species composition in relative density measurement in Allegheny hardwoods.** Canadian Journal of Forest Research. 16:574-579.

Tilghman, Nancy G. 1984. **Deer densities and forest regeneration.** In: Harris, Margaret M.; Spearing, Ann M. eds. Research in forest productivity, use, and pest control; Proceedings of a symposium; 1983 September 16-17; Burlington, VT. Gen. Tech. Rep. NE-90. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 45-50.

Tilghman, Nancy G. 1987. **Maximum deer populations compatible with forest regeneration, an estimate from deer enclosure studies in Pennsylvania.** In: Deer, Forestry, and Agriculture: Interactions and strategies for management: Proceedings off a symposium, 15-17 June 1987; Warren, PA. Erie, PA: Plateau and Northern Hardwood Chapters, Allegheny Society of American Foresters: 71. Abstract.

Tilghman, Nancy G. 1989. **Impacts of white-tailed deer on forest regeneration in northwestern Pennsylvania.** Journal of Wildlife Management. 53(3):524-532.

Trimble, George R. 1965. **Species composition changes under individual tree selection cutting in cove hardwoods.** Res. Note NE-30. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 6 p.

Trimble, George R. 1970. **Twenty years of intensive uneven-aged management.** Res. Pap. NE-154. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 12 p.

Trimble, Jr., G.R. 1972. **Response to crop-tree release by 7-year-old stems of yellow-poplar and black cherry.** Res. Pap. NE-253. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 10 p.

Trimble, Jr. G. R. 1974. **Response to crop tree release by 7-year-old stems of red maple stump sprouts and northern red oak advance reproduction.** Res. Pap. NE-303. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 6 p.

Trimble, George R.; McGee, C. E. 1973. **Natural regeneration of central Appalachian hardwoods in West Virginia.** In: Proceedings, 1st annual hardwood symposium of the Hardwood Research Council; 1973 May 2-5; Cashiers, NC. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 45-57.

Tuley, Graham. 1985. **The growth of young oak trees in shelters.** Forestry. 58:181-195.

U.S. Department of Agriculture, Forest Service. 1969. **Suggested guide for weed control - 1969.** Agric. Handb. 332. Washington, DC: U.S. Department of Agriculture, Forest Service. 70 p.

U.S. Department of Agriculture, Forest Service. 1979. **Uneven-aged silviculture and management in the United States.** Washington, DC: U.S. Department of Agriculture, Forest Service, Timber Management Research. 234 p.

U.S. Department of Agriculture, Forest Service. 1983. **Silvicultural systems for the major forest types of the United States.** Agric. Handb. 445. Washington, DC: U.S. Department of Agriculture, Forest Service. 191 p.

Wendel, G. W. 1977. **Longevity of black cherry, wild grape, and sassafras seed in the forest floor.** Res. Pap. NE 375. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 6 p.

Wendel, G. W.; Kochenderfer, J. N. 1982. **Glyphosate controls hardwoods in West Virginia.** Res. Pap. NE-497. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 7 p.

Wingard, R. G.; George, J. L.; Palmer, W. L. 1981. **Alleviating deer damage to Pennsylvania agriculture.** Final Report. University Park, PA: Report to Pennsylvania Department of Agriculture, School of Forest Research; Pennsylvania State University. 48 p.

Wolf, Wilber E. Jr. 1980. **One approach to hardwood forest regeneration.** Pennsylvania Forests. 70:8-9, 20.

PART II--SILVICULTURAL GUIDELINES

This section provides guidelines, decision charts, and step-by-step instructions for determining silvicultural prescriptions in hardwood stands in the Allegheny Plateau and Allegheny Mountain sections of Pennsylvania, New York, Maryland, and West Virginia. The process involves three distinct steps:

1. stand examination--to determine present condition of the overstory and understory and possible site limitations;

2. stand analysis--to assess the stand's density, structure, stage of maturity, and potential for future growth or regeneration; and

3. stand prescription--to select the silvicultural techniques to be used to meet the management objectives, and to provide detailed instructions on the application of those treatments to the particular stand.

STAND EXAMINATION

Sample Cruise

Determine Stand Boundaries

The first step in examining a stand is to determine the stand boundaries. They should be set primarily to keep the stand as uniform as possible in composition, age, structure, regeneration potential, and site quality. Consideration should also be given to ease of future management. If the boundaries coincide with easily recognized features of the terrain, field work will be more efficient and the stand more readily reidentified in the future. Stand units are usually identified first from aerial photographs and later are checked and adjusted on the ground as needed.

Stand area is dictated largely by the stand conditions--the amount of uniform condition available in one block. It is desirable to have each stand large enough to provide a reasonably efficient field operation by itself. On large ownerships, stands less than 10 acres may prove inefficient, but stands as small as 3 to 5 acres may be practical on small properties. There are seldom areas of uniform stand condition covering more than 50 to 100 acres, and stands larger than this may be undesirable under even-age management since very large reproduction cuts are undesirable for visual reasons.

In areas of heavy deer browsing, very small stands should generally be avoided, as should long, narrow ones, for these tend to be browsed very heavily.

Select Sampling Scheme

After determining the stand boundaries, select a sampling scheme. The sampling scheme should ensure that the plots are well distributed throughout the stand and that plot locations are set without bias. A systematic sample using predetermined cruise lines, with sample plots at fixed intervals along the lines, is usually easiest.

Cruise lines should generally cross topographic features, rather than be parallel to them. A single cruise line through a stand seldom provides adequate coverage; two or more lines are usually required to ensure a representative sample. Cruise lines should be kept at least 75 feet from open boundaries such as roads and power lines, and overstory plots should be at least 100 feet apart to avoid overlap.

The number of cruise lines, the spacing between them, and the spacing between plots on a line must be set so as to obtain enough samples to provide accurate estimates for the stand. The number of plots required to keep the standard error within desired limits can be calculated if data on variances are available. However, we have found that the critical overstory parameters (total basal area, species composition, stand diameter, relative density) can usually be estimated within 10 percent standard error, 95 times out of 100, with between 10 and 25 plots, depending upon variability in the stand. Adequate assessments of regeneration (numbers of desirable advance seedlings, amount of undesirable understory) are more variable, requiring about twice as many understory plots as overstory plots.

As a rule of thumb, we suggest a minimum of 10 overstory plots in stands that have relatively uniform conditions (such as young, previously uncut and fully stocked stands), and a minimum of 15 overstory plots in stands that have less uniform conditions (such as previously cut, older, or understocked stands). For stands greater than 20 acres, take an additional overstory plot for every additional 8 to 10 acres.

The easiest way to obtain the desired number of understory plots is to locate the cruise lines and overstory plot centers first. Each overstory plot center will also be an understory plot center. In addition, take an extra understory plot half-way between each of the combined overstory-understory plot locations. This will provide twice as many understory plots as overstory plots, and ensure an adequate sample.

An extra hour or so spent in the office laying out cruise lines on a map or aerial photograph of the property will often save many miles and hours of unproductive walking. Attempt to select a stand or group of stands that make a logical day's work, then lay out the cruise lines so that the end point of one stand corresponds to the beginning point of the next stand. Often, it is also possible to lay out the entire day's work in a circular route so that you finish the day near the starting point and your vehicle.

In laying out cruise lines, look for checkpoints such as road intersections, well openings, utility right-of-ways, streams, and other features that can be used to verify your location. Try to begin each cruise line from such a checkpoint that is easily identifiable both on the ground and on the photo or map. Avoid extremely long cruise lines that cannot be tied into checkpoints of some type every 15 to 20 chains (1,000 to 1,500 feet). It is surprising how far off course you may wander if you do not plan and check yourself carefully.

Once the cruise lines and plots have been drawn on a map or photo of the stand, the field work can begin. A hand compass and pacing are adequate surveying tools to locate the actual on-the-ground plot locations. Be sure to take the plot wherever it falls--do not move plot locations to avoid thick patches of beech brush, slash piles, or other unpleasant conditions, as this would bias the data. Do not move it into areas of good timber either, for the same reason.

Overstory Data Collection

Overstory data collection involves the sampling of overstory basal area by species, size, and quality. For most purposes, we recommend a variable-radius (prism) cruise. Two tally forms that provide spaces for these and all other data to be collected in the stand inventory are shown in Figures 2a and 2b. Figure 2a is used when the data summary is to be done by computer. Figure 2b is used when the data summary is to be done manually. If in doubt, use the computer tally form, since data on it can be transferred to the manual tally form, but the reverse is not true.

Basal Area Tally

At each overstory plot, a wedge prism (10-factor prism is recommended) is used to obtain a basal area tally of all trees 1.0 inch d.b.h. or larger. Trees intercepted by the prism are recorded by species, diameter, and quality. If the data are to be processed by computer and accurate sawlog volume estimates are desired, merchantable sawlog height, grade, and defect should also be recorded for all sawtimber-size trees.

Computer Overstory Tally Form - On the computer tally form, each tree intercepted by the prism is recorded on a separate line. For ease in computer data entry, species is coded. Species codes are shown in Table 2.

Figure 2a.

SILVAH - Computer Overstory Tally Form

USDA, Forest Service, NEFES, Warren, PA 1/91

Overstory Data

Stand ID ____________________ Sheet ____ of ____

Species	dbh	Quality	Ht. or Count	Grade	Defect	Crown	Wildlife	Species	dbh	Quality	Ht. or Count	Grade	Defect	Crown	Wildlife	Species	dbh	Quality	Ht. or Count	Grade	Defect	Crown	Wildlife

Figure 2b.

SILVAH - Manual Overstory Tally Form

Stand ID

USDA, Forest Service, NEFES, Warren, PA 1/91

AGS Size class		Black cherry	White ash	Yellow poplar	Red maple	N. Red oak	Eastern hemlock	All others	Sugar maple	Amer. beech	Striped maple	Other oaks, hickory
Saplings 1.0 – 5.5"	Dot											
	BA											
Poles 5.5 – 11.5"	Dot											
	BA											
Small Saws 11.5 – 17.5"	Dot											
	BA											
Medium Saws 17.5 – 23.5"	Dot											
	BA											
Large Saws 23.5" +	Dot											
	BA											
Total Basal area Poles & larger												

UGS Size class		Black cherry	White ash	Yellow poplar	Red maple	N. Red oak	Eastern hemlock	All others	Sugar maple	Amer. beech	Striped maple	Other oaks, hickory
Saplings 1.0 – 5.5"	Dot											
	BA											
Poles 5.5 – 11.5"	Dot											
	BA											
Small Saws 11.5 – 17.5"	Dot											
	BA											
Medium Saws 17.5 – 23.5"	Dot											
	BA											
Large Saws 23.5" +	Dot											
	BA											
Total Basal area Poles & larger												
AGS + UGS BA Poles & larger												

Plot	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Conversion factor
Count																					BAF/# plots

BA = Dots * Conversion factor

Table 2. Species Codes.

Species	Forest survey	Mnemonic	User-defined	Species	Forest survey	Mnemonic	User-defined
Other Softwoods	1	OSW	0	Mountain Magnolia	654	MM	0
Other Hardwoods	4	OHW	88	Tupelo	690	T	0
Balsam Fir	12	BF	0	Water Tupelo	691	WT	0
E. Red Cedar	68	ERC	0	Black Gum	693	BG	66
Larch	70	L	0	American Sycamore	731	AS	0
Tamarack	71	TAM	0	Aspen	740	ASP	63
Spruce	90	S	0	Balsam Poplar	741	BP	0
Norway Spruce	91	NS	0	E. Cottonwood	742	EC	0
White Spruce	94	WS	0	Bigtooth Aspen	743	BTA	0
Black Spruce	95	BS	0	Quaking Aspen	746	QA	0
Red Spruce	97	RS	0	Black Cherry	762	BC	76
Pine	100	P	0	Oak	800	O	0
Jack Pine	105	JP	0	White Oak	802	WO	40
Red Pine	125	RP	0	Swamp White Oak	804	SWO	0
Pitch Pine	126	PP	0	Scarlet Oak	806	SO	32
White Pine	129	WP	1	N. Pin Oak	809	NPO	0
Virginia Pine	132	VP	0	S. Red Oak	812	SRO	0
Southern Pine	170	SP	0	Cherrybark Oak	813	CBO	0
N. White Cedar	241	NWC	0	Overcup Oak	822	OO	0
Eastern Hemlock	261	EH	6	Burr Oak	823	BRO	0
Maple	310	M	0	Blackjack Oak	824	BJO	0
Red Maple	316	RM	21	Swamp Chestnut Oak	825	SCO	0
Silver Maple	317	SVM	0	Chinkapin Oak	826	CKO	0
Sugar Maple	318	SM	20	Pin Oak	830	PNO	0
Buckeye	330	BUC	0	Chestnut Oak	832	CO	48
Birch	370	B	50	N. Red Oak	833	NRO	30
Yellow Birch	371	YB	0	Shumard Oak	834	SHO	0
Sweet Birch	372	SB	0	Post Oak	835	PO	0
Paper Birch	375	PB	0	Black Oak	837	BO	31
Hickories	400	H	60	Black Locust	901	BL	0
Bitternut Hickory	402	BH	0	Willow	920	W	0
Pignut Hickory	403	PH	0	American Basswood	951	BAS	58
Pecan	404	PCN	0	Elm	970	E	61
Shellbark Hickory	405	SLH	0	American Elm	972	AE	0
Shagbark Hickory	407	SGH	0	Slippery Elm	975	SE	0
Mockernut Hickory	409	MH	0	Rock Elm	977	RE	0
Hackberry	460	HAC	0	Boxelder Maple	313	BEM	0
Yellowwood	481	YW	0	Striped Maple	315	STM	99
Persimmon	521	PER	0	Devils Walkng. Stick	353	DWS	89
American Beech	531	AB	54	Serviceberry	355	SVB	91
Ash	540	A	0	Blue Beech	391	BB	90
White Ash	541	WA	55	Dogwood	491	DOG	81
Black Ash	543	BA	0	Hawthorn	500	HAW	94
Green Ash	544	GA	0	Ironwood	701	OST	92
Honey Locust	552	HL	0	Pin Cherry	761	PC	95
Butternut	601	BUT	71	Choke Cherry	763	CC	0
Black Walnut	602	BW	0	Sassafras	931	SAS	96
Sweetgum	611	SG	0	Mountain Ash	935	MTA	97
Yellow-Poplar	621	YP	59	Ailanthus	999	OHC	98
Cucumbertree	651	CUC	84	Other Non-Comm	998	AIL	0

Diameter breast height may be measured or estimated. If measured, either 1- or 2-inch d.b.h. classes may be used. If estimated, we recommend the use of 2-inch d.b.h. classes. Accurate estimation of diameters requires practice--often inexperienced workers find it necessary to measure diameters for a day or two until their eye becomes calibrated. Thereafter, occasional checks should suffice, except for larger trees, which are hard to estimate and represent substantial value. On the computer tally form, d.b.h. is written in the column after the species code.

Three quality classes are recognized for use with computer data summary. Definitions and computer codes for these quality classes are given in Table 3a. Acceptable growing stock trees are those that have the potential to qualify for sawtimber either now or in the future. Sapling- and pole-size trees should be classed acceptable if they are expected to grow into acceptable trees in the future. Do not discriminate because of size--assume that every tree will be allowed to grow to medium sawtimber size and judge quality on that basis. Sapling-size trees are difficult to judge effectively; if in doubt, consider them acceptable unless they are of extremely poor form.

Unacceptable growing-stock trees are trees that either do not have the potential to contain a sawlog or that have some damage, disease, or other condition that makes them a poor risk to survive for future management. All noncommercial species are considered unacceptable growing stock. Recording dead trees is optional. This information may be recorded if volume determination of dead trees is desired, as for a salvage sale. On the computer tally form, quality class is written in the column following d.b.h.

If accurate sawlog volumes are to be calculated from the inventory data, merchantable sawlog heights (in numbers of 8-foot bolts) should also be recorded for each tree that now contains a sawlog. These merchantable heights will then be used in sawlog-volume calculations. If no heights are recorded for sawlog trees, heights will be estimated from equations based on average sawlog heights encountered in stands in northwestern Pennsylvania (Fig. 3). Estimates of merchantable height should be to a point where diameter drops below minimum merchantability standards in your area, or the height at which the bole breaks up. Merchantable sawlog height is written in the column after quality class.

Merchantable heights can also be used to get a crude estimate of site productivity, by comparing measured heights to the average heights previously mentioned. However, the site class obtained in this way may be inaccurate if the best trees have already been removed, or if the present vegetation does not reflect the site potential.

For accurate volume determination, there are several options for recording more complete quality information in the grade and defect columns of the computer tally form. Grade and defect are recorded in columns 5 and 6, respectively. Codes for tree grades are shown in Table 3b. Defect is estimated to the nearest 10%, and the tens digit recorded (50% defect is recorded as 5). Column 7 is used to record crown condition, specifically with regard to defoliation and dieback. It is used in conjunction with special silvicultural prescriptions for stands affected by gypsy moth (*Lymantria dispar*). Trees with special value to wildlife may be recorded in column 8--see Table 3c. Further information about computer codes useful on the computer tally form is found in the SILVAH User's Guide.[2]

If merchantable sawlog heights are not collected, column 4 can be used to record a count of trees with the same species, diameter class, and quality. If column 4 is used for counts, be certain that the overstory cruise type code in the identification block reflects this.

[2] Marquis, David A.; Ernst, Richard L. User's Guide to SILVAH: A stand analysis, prescription, and management simulator program for hardwood stands of the Alleghenies. In preparation.

Table 3. Codes for quality, tree grade, and wildlife

Table 3-A. Growing stock quality classes.

Code	Description
1	Acceptable Growing Stock (AGS) – These trees are suitable for retention in the stand for at least the next 15-year period. They are trees of commercial species and of such form and quality as to be salable for sawtimber products at some future date. In making this determination, judge each tree on its own merits; assume that every tree will be allowed to grow to sawtimber size even though it is now a small tree in an older stand. Saplings are especially difficult to judge; most knots, bumps, and stoppers will be confined to a small core if the sapling actually grows to larger size, so consider most saplings acceptable. If in doubt about the correct quality class for any tree, consider it acceptable. Many acceptable trees will be removed if a partial cutting is prescribed for the stand, so do not consider the quality determination a cut-leave tally.
2	Unacceptable Growing Stock (UGS) – These trees do not have the potential to make salable sawtimber products in the future. They may be high risk trees--trees with disease, damage, or dieback that threatens their survival--or trees of such poor form that they just have to be removed regardless of the effect that removal will have on stand structure and species composition.
3	Dead – Standing dead trees.

Table 3-B. Grade specifications*

Code	Description
1	Factory-lumber log grade 1
2	Factory-lumber log grade 2
3	Factory-lumber log grade 3
4	Locally-defined log product (such as pallet log, local use log, etc.)Construction log grade
5	Locally-defined bulk product (such as boltwood)
6	Pulpwood (contains a minimum of two contiguous 4-foot bolts with minimum top ID of 4.0" and at least 50% sound)
7	Fuelwood (same as pulpwood, but minimum top ID of 1.0")
8	Cull. Tree less than 50% sound, or does not qualify for any of the grades or products listed
9	Veneer log

* Factory log grades are defined in :

Hanks, Leland F., Glenn L. Gammon, Robert L. Brisbin, and Everett Rast. 1980. Hardwood log grades and lumber grade yields for factory lumber logs. USDA For. Serv. Res. Pap. NE-468, 92p.

Rast, Everett D., David L. Sonderman, and Glenn Gammon. 1973. A guide to hardwood log grading. USDA For. Serv. Gen. Tech. Rep. NE-1, 32p.

Table 3-C. Wildlife Tree Codes

Code	Description
1	Potential den tree – live tree with large dead branch or broken top that represents a potential den cavity, but tree does not now contain a cavity.
2	Existing den trees – live trees with natural or artificially created hole for den (do not include shallow food excavations made by pileated woodpeckers.
3	Snag with potential cavities – dead or nearly dead tree at least 4 inches dbh and at least 10 feet tall, but with no visible cavities.
4	Snag trees with existing den – dead or nearly dead trees of same minimum size as 3 above, but containing an existing den cavity.

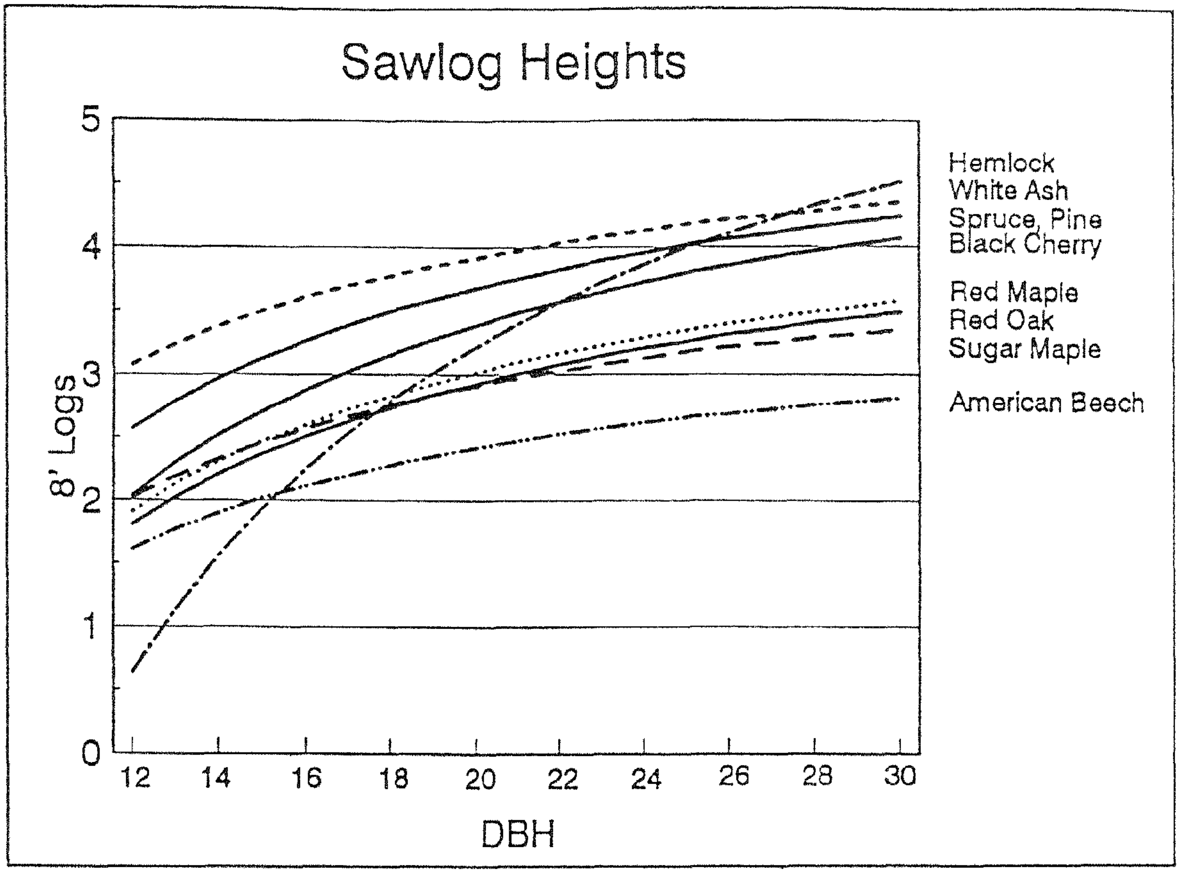


Figure 3. Sawlog heights. Top diameter inside bark for hardwoods is 10.5", for softwoods, 8.5".

On the computer tally form, a zero entered in the species column of the tally form separates one plot from the next. A negative 1 (-1) in the species column indicates the end of the last plot in the stand. Record this code after the zero. By maintaining each plot separately in this way, it is possible to calculate variances and estimate sampling error.

Manual Overstory Tally Form - On the tally sheet for manual data summary (Fig. 2b), trees intercepted by the prism are dot-tallied by species or group, size class, and quality class.

Although it is not necessary to record each species individually on the manual tally form, they must be separated into groups that permit calculation of relative stand density, sprouting potential, seed source index, and shade tolerant composition. The required species, within each species group are shown on the tally form in Figure 2b.

Five size classes are recognized on the manual tally form. When using this form, we recommend use of size class breaking points that correspond to 1-inch diameter classes. Thus, saplings are trees 1.0 inch d.b.h. to 5.50 inches d.b.h. (1- through 5-inch classes). Poles are trees 5.51 to 11.50 inches d.b.h. (6- through 11-inch classes). Small sawtimber trees are 11.51 to 17.50 inches d.b.h. (12- through 17-inch classes). Medium sawtimber trees are 17.51 inches d.b.h. to 23.50 inches d.b.h. (18- through 23-inch classes). Large sawtimber trees are 23.51 inches d.b.h. and larger (24-inch class and larger).

Two quality classes are recognized on the manual tally sheet. Acceptable growing-stock (AGS) trees are those defined as code 1 from

Table 3a. Unacceptable growing-stock trees (UGS) are those defined as code 2 from Table 3a.

There is no convenient way to record merchantable heights on the manual tally form. If accurate merchantable heights are needed, we recommend that the data be tallied on the computer tally form, and that the basal area data later be transferred to the other form for manual summary.

No provision is made for separating plots on the manual tally form; data from all plots are combined in the dot tally. But the number of plots sampled must be recorded. Make a check mark (or record total number of trees intercepted by the prism) in the boxes provided for this purpose. If numbers of trees per plot are recorded rather than a check mark, sampling error for total basal area can be calculated.

Overstory Procedural Errors

Even though most foresters are experienced in wedge prism tallies, procedural errors often lead to inaccurate overstory data. Although the procedures are simple, they are also exacting. Most wedge prism errors tend to be cumulative, rather than compensating. Some common errors to avoid are:

- *Inaccurate prism.* Many nominal 10-factor prisms, especially less expensive ones, are not actually 10 factor. Some are off by more than a whole factor, so check yours for accuracy and do not use one that is not correctly calibrated. You can check a 10-factor prism quickly by sighting on a target that is exactly 12 inches wide. The target should look like a borderline tree at exactly 33 feet.

- *Sloppy procedure.* The prism and not the observer must be kept over the center point of the plot. It usually helps to rest the prism on a range pole (the plot center pole) and rotate around it. The prism must also be held level and vertical (except where tilted purposely to compensate for slope or leaning trees). If the prism is tilted side to side or front to back on level ground, horizontal deflection is altered and a cumulative error is introduced.

- *Overfamiliarity.* Experienced foresters sometimes go through the motions of making a prism count without actually looking through the prism. Avoid subconsciously deciding whether the tree is in or out until you have checked it with the prism.

- *Borderline trees.* Improper classification of borderline trees (trees that you cannot positively identify as in or out through the prism) seems to be a major source of error. The most accurate procedure is to measure the distance to the tree centerline and its d.b.h. With a 10-factor prism, if the distance in feet is more than 2.75 times the diameter in inches, the tree is out; otherwise it is in. A 75-foot automatic return tape that can be clipped to the belt will facilitate such checks. If pressures to get the job done preclude checking the borderline trees, we recommend counting each such tree as a half-tree.

  Half-trees may be recorded on the computer tally form by adding 5 to the quality class. Thus, an acceptable growing-stock borderline tree is tallied as 6 in the quality column. The computer summarization program will interpret this as a half-tree. On the manual tally form, record half-trees with an X rather than a dot.

- *Small trees.* In tallying the basal area, one precaution is especially important: Do not overlook the small trees. The guide to relative stand density is based on all trees that are 1.0 inch in d.b.h. or larger, and decisions on appropriate thinning procedures require knowledge of the proportion of the stand in this size class. If the small trees are overlooked or deliberately ignored, the guides will give you a wrong answer. Including these small trees does not add appreciably to the time required for the overstory tally, since relatively few such trees are picked up in the 10-factor prism cruise, especially in stands more than 40 years old.

Understory Data Collection

Understory data are collected at the same time and using the same plot centers as for the overstory. Additional plots located between overstory plots will also be needed to obtain an adequate sample. At locations where both overstory and understory data are collected, tally the understory data first to avoid errors in estimation resulting from trampling of vegetation. Understory data are recorded on the ID & Regen Tally Form (Fig. 3), regardless of which form is used for overstory data collection.

Most of the understory data will be collected on a 6-foot radius plot. This size was selected because it approximates the ground area occupied by a single tree when the tree first reaches merchantable (pulpwood) size. Guides to the numbers of seedlings required per 6-foot plot at various times in the regeneration process have been developed to assure that there is at least one stem per 6-foot plot when the stand first reaches merchantable size--thus assuring full stocking.

Although it may seem necessary at first to make a time-consuming count to determine the number of appropriate-size seedlings on each plot, this is seldom necessary. With a little experience, the numbers can be estimated on most plots without actual counting. Many plots will be either abundantly stocked or extremely sparse, and seedlings that are large enough to count will be readily visible from a standing position. Those that you must kneel down to find are generally too small to count anyway.

Because fern and grass coverage is often spotty, and evidence of site limiting factors is not always obvious, it is best to use a larger plot size for evaluations of these items. A plot size of one-twentieth of an acre (26.4-foot radius) is convenient.

There are two ways in which understory data can be collected: a condensed, or checkmark, tally and an expanded, or estimated count, tally.

Expanded regeneration tally

The expanded regeneration tally, which includes estimates of seedling numbers, (Regeneration Cruise Type Code 2 on the Identification Block) is the recommended understory data collection procedure. With this procedure, data are collected in the form of estimated weighted counts, by species groups. These data can be interpreted at different levels of deer density, so that the entire range of prescriptions described here, including prescriptions for fencing to reduce deer pressure on regeneration, can be evaluated.

The variables to be recorded are described below. The shaded rows on the regeneration tally form (rows 4, 6, 8, 14) are not used during the tally, but are completed as part of the data summary process as described beginning on p 47.

<u>Small Advance Regeneration</u> -- Small advance regeneration will be recorded as the weighted number of established seedlings in each of several species groups. These groups include: black cherry, small oak (oak seedlings less than 4.5' tall), other desirable species, and large oak (oak seedlings over 4.5' tall). Other desirable species usually include sugar maple, red maple, white ash, yellow-poplar, cucumbertree, and basswood. In some localities, beech, birch, hickory, hemlock, white pine, and other species may be added to the list of desirable species. Likewise, red maple, chestnut, scarlet, and black oaks may <u>not</u> be considered desirable in some localities. While the list of species that are considered desirable may vary slightly among geographic areas and ownerships, it is important that such a list be developed and applied consistently so that results are comparable from stand to stand.

Figure 4.

SILVAH - ID & Regen Tally Form

Identification Data

USDA, Forest Service, NEFES, Warren, PA 1/91

Sheet ____ of ____

Owner/Agency									
Forest/Property									
County/District									
Compartment/Unit		Stand No.							
Remarks									
Species Codes		dbh classes		Tally month		Year			
Overstory Cruise	Type		# plots		BAF/plot size				
Regen Cruise	Type		# plots		Plot size				
Acreage in stand		Stand age							
Cover Type		Habitat type		Soil type		Site class			
Site species		Site Index		Height adjustment					
Elevation		Aspect		Slope %		Topo. position			
Operability		Access		Water code		Water code			
Acres W/I 1 mi.	Clearcuts		Cultivation		Open		Water code		
Management goal		Mgmt. value		Deer impact index		Gypsy moth		Stress	

Notes

Regeneration Data

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	#	%
1 Black cherry																						
2 Small oak																						
3 Other desirables																						
4 All desirables 1+2+3																						
5 Large oak																						
6 Any small regen 1, 2, 4, or 5																						
7 Residuals																						
8 Any regen or Res. 6 or 7																						
9 Sapling regen																						
10 Woody interference																						
11 Laurel & Rhododendron																						
12 Ferns																						
13 Grasses																						
14 Any interfc. 10, 11, 12, or 13																						
15 Grapevines																						
16 Site limitations																						

Advance seedlings of the first three species groups are weighted by height and vigor. Seedlings that are less than 2 inches tall, have fewer than two normal-size leaves, or that still bear cotyledons should not be counted. Larger and more vigorous seedlings between 2 inches and 1 foot tall are counted as one seedling, and seedlings over 1 foot tall are counted as two seedlings. Thus, 10 black cherry seedlings, 2" to 1' tall, plus 5 seedlings over 1' tall would be recorded as 20 seedlings (10 plus 5 x 2). Weighting is not used for the large oak category.

Exact counts are not required. When there are relatively few seedlings of a particular species group present on a plot (perhaps 10 or less), a quick count is possible. But with larger numbers, counting is time-consuming and unnecessary. Furthermore, the accuracy required is less when there are large numbers of seedlings. For example, the difference between 10 and 20 seedlings is quite important, but the difference between 100 and 110 seedlings is inconsequential. We suggest that you strive to estimate and record to the following numbers: 5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 200, 200+. To record an estimate of 15, there should be at least 15 seedlings, but fewer than 20 seedlings.

We have found that it requires a day or two of counting seedlings to gain enough experience to estimate weighted numbers accurately. Thereafter, an experienced person can record all understory information in a few minutes on most plots.

Understory conditions are highly variable in many stands. Often, the numbers of advance seedlings will span the range from totally absent to abundant in a single stand that has a reasonably uniform overstory. Because of this, it is far more important to use a large number of understory plots well-distributed over the stand area than it is to achieve great accuracy in the counts on each individual plot. The proportion of stand area with critical levels of understory vegetation is the important factor. So estimates of numbers taken quickly will provide adequate data if the number and distribution of plots is adequate.

Residuals -- If there is a sugar maple, beech, or hemlock tree 3 to 10 inches d.b.h of acceptable quality to retain as a timber residual, record the species code of that tree in the residuals box. Acceptable quality trees for timber residuals have at least moderately good crowns in the intermediate or higher crown class, and clear straight boles free of branches, epicormics, or other defects for at least the first 17 feet. Particular attention should be paid to epicormic branches; trees with more than one or two epicormics on the butt log should not be considered acceptable quality for timber residuals. Less tolerant species 8 to 12 inches d.b.h that meet the standards above may also be recorded here by species code if they are desired as timber residuals.

Do not record trees that might be left for wildlife or other purposes here, unless they qualify for timber residuals as described above. Residuals for these other purposes will be evaluated from the overstory data.

Sapling Regeneration -- If there are at least 2 stems of commercial species 0.5 to 2 inches d.b.h, or at least one stem 2 to 6 inches d.b.h on the 6-foot-radius plot, record the species code of the dominant stem in the sapling regeneration box. Saplings to be counted here are stems of a distinctly different age than those in the overstory -- usually ones that originated after a heavy cutting within the past 25 years or so.

Do not count 0.5- to 2-inch stems of species that would be considered woody interference. Small beech root suckers are a prime example. Trees that qualify as both residuals and as sapling regeneration may be counted in both places.

When there is more than one stem that qualifies as sapling regeneration, record the species code of the one that is most likely to become the dominant tree if the overstory is removed. This will usually be the tree that is currently the largest.

Woody Interference -- Woody interference is recorded as the weighted number of stems of all species of woody interfering plants. These include: beech, striped maple, sourwood, dogwood, sassafras, blackgum, elm, hophornbeam, and blue beech.

Weighting is done in a manner similar to that used for small advance regeneration. Count all stems less than 1 foot tall as 1 stem; count all stems over 1 foot tall as 2 stems. Count clumps of beech root suckers that originate from the same node as one stem.

Laurel and Rhododendron – Record the presence of laurel and rhododendron on the 6-foot-radius plot in one of four categories. 1 = Laurel or Rhododendron present, but less than 1 foot high and covering less than half of the plot area; 2 = present on less than half the plot area, but more than 1 foot tall; 3 = present on more than half of the plot area but less than 1 foot tall;4 = present on more than half the plot area and more than 1 foot tall.

Fern – Record an ocular estimate of the percentage of the 1/20 acre plot surface area covered by fern foliage, when viewed from directly above the plot. Count all ferns that grow as individual fronds from the ground level. Ferns that grow in solitary clumps may be ignored, or if abundant, may be recorded at half their actual value. Thus, spinulose wood fern clumps covering 30 percent of the plot surface could be recorded as 15, while hayscented or New York fern fronds, which arise as individual fronds from an underground rhizome, would be recorded at the observed value.

Grass – Record an ocular estimate of the percentage of the 1/20 acre plot surface covered by foliage of any grass or sedge.

Grapevines – Record the number of grapevines in the crowns of any tree on the 1/20-acre plot.

Site Limitations – Record a code value in the Site Limits row for each 1/20-acre plot on which there is any evidence of either poor soil drainage or high stone content in the surface soil. Use a code of 1 for poor drainage, 2 for rocky surface. A blank or 0 indicates that there are no site limitations on that plot.

Soil samples are neither feasible nor necessary for this determination. Site limitations should be evaluated on the basis of surface conditions.

Poorly drained soils are those where a water table persists very close to the soil surface during all or most of the dormant season. Such soils usually have prominent mottling at depths ranging from 1 to 8 inches beneath the surface. But since soil examination is usually not feasible during the stand inventory, drainage must be estimated from landscape position, relief, and indicator plants. Some indicators of poorly drained soils are:

- *Landscape position and relief.* On the Plateau, look for poor soil drainage in concave positions of broad flat plateau tops, in upland bottoms, and at the base of slopes. Low topography is more likely to be poorly drained than high topography. Convex topographic configuration generally indicates well- or moderately well-drained soils. In valley bottoms, soil drainage becomes poorer from the stream channel towards the base of slopes. Concave and low-lying areas in bottoms are especially likely to be poorly drained, as are toes of slopes with many seeps.

- *Standing water* in depressions and wet surface soils during the dormant season, and during periods of normal rainfall in the summer and early fall.

- *Presence of wet-site plants* such as sedges, rushes, sphagnum moss, sensitive fern, interrupted fern, cinnamon fern, skunk cabbage, false hellebore, and marsh marigold.

- *Very deep spongy humus layers at the soil surface.*

Stony areas can be recognized after a little experience. Look for the stone layer beneath the forest floor in road cuts. Large sandstone outcrops will generally be present somewhere up slope as well. The hard and uneven feel of the soil surface when walked upon is a sure indicator of many surface stones.

Checkmark Regeneration Tally

Some users may prefer to make some understory data summary judgments in the woods, thus reducing inventory time. The checkmark regeneration tally procedure (coded as Regen Cruise Type 1 in the Identification Data block) is designed for these users. Because judgments about the adequacy of stocking at each plot are made in the woods for the ambient deer pressure, users who choose this option forego fencing prescriptions. Prescriptions including fencing are based on a reevaluation of the expanded regeneration tally data for a Deer Impact Index of 1.

At each understory plot, make a judgment about the adequacy of advance regeneration and the severity of interference problems. This judgment is made using the criteria in Tables 4 (p. 45) and 5 (p. 46), for the appropriate level of deer pressure. These are the criteria used for summarizing data collected using the expanded regeneration tally procedure. If the stocking of the plot exceeds the critical value in these tables, make a checkmark.

Small Advance Regeneration - The expanded regeneration tally procedures explain how to arrive at an estimated weighted count of advance regeneration for each category on the ID & Regen Tally Sheet. Table 4 (p. 45) gives the critical values for each advance regeneration species group (Rows 1 - 5 of the Regeneration Data form) for each level of deer pressure. All desirables include the black cherry, small oak, and other desirables group. If the Deer Impact Index is 4, for example, make a checkmark in the black cherry row for any plot with a weighted count of 25 or more black cherry seedlings. If the Deer Impact Index is 3, make a checkmark in the other desirable row for any plot with a weighted count of 50 other desirable seedlings.

Any small regen - For each plot that receives a checkmark in row 1, 2, 4, or 5, make a checkmark in the Any small regen row (row 6).

Residuals - Make a checkmark in the Residuals row (row 7) for each plot that contains at least one acceptable residual tree. The criteria for identifying acceptable residual trees are listed in the procedures for the expanded regeneration tally.

Any regen or Res - Make a checkmark in this row (row 8) for each plot that contains a checkmark in row 6 or row 7.

Sapling Regeneration - Make a checkmark in the sapling regeneration row (row 9) for each plot that contains at least 2 stems of commercial species between 0.5 and 2.0 inches d.b.h. or at least one stem 2.0 through 6.0 inches. The criteria for identifying trees to be counted as sapling regeneration are listed in the procedures for the expanded regeneration tally.

Interference - The determinations for these checkmarks are based on a 1/20-acre plot. Table 5 (p. 46) gives the critical values for each category of interference (Rows 10 - 13 and 15 of the Regeneration Data form). Make a checkmark in the fern row, for example, if 30 percent of the surface area of the larger plot is covered by fern foliage. For laurel and rhododendron (row 11) make a checkmark if the plot qualifies for a code 4 or an X if the plot qualifies for a code 2 or 3 (see codes on p 39). This alternate mark (X) represents "half-stocking" with this form of interference.

Any interference - Make a checkmark in the Any interference row (row 14) for any plot that has a checkmark in rows 10 - 13. If the only checkmark in these rows is a half-stocking mark for laurel and rhododendron, make a half-stocking mark in the Any interference row.

Site limitations - Make a checkmark in this row (row 16) for each 1/20-acre plot on which there is any evidence of either poor soil drainage or high stone content in the soil. See the expanded regeneration tally for a complete discussion of the conditions to be tallied in this row.

Identification Data

The identification data block contains information needed to identify the stand, information on the cruise procedures used, and basic data on stand and site factors and management goals. Some of these items come from other sources, such as management plans, soil-site maps, aerial photographs, and wildlife agency reports. The identification block is the same for both Tally Forms. Many of the items in the Stand Identification block of the Tally Forms are optional. These are recorded for the use of the landowner or land manager only. In the text that follows, these items are described in smaller type.

Stand Identification

Owner/Agency --List the owner or administering agency. For example: USDA Forest Service; Pennsylvania Bureau of Forestry; Hammermill Paper Company; John Doe.

Forest/Property -- List the name or identification of the property. For example: Allegheny National Forest; Elk State Forest; McKean-15; South Woodlot.

County/District -- List county or district in which property is located, if desired, or other information needed to identify it.

Compartment/Unit -- List compartment or other subdivision unit number or name, if there is one.

Stand Number -- List stand number, if there is one.

Remarks -- Add further identification or description of the stand, up to 70 characters.

Cruise Information

Species codes -- Enter code for type of species codes used (see Table 2, p. 31):

1 - mnemonic codes
2 - user-defined codes
3 - Forest Survey codes

d.b.h classes -- Enter code for d.b.h. classes used:

1 - 1 inch classes
2 - 2 inch classes
3 - 5 major size classes (saplings, poles,small sawtimber, medium sawtimber, large sawtimber)

Tally Month and Year -- Enter month and year of inventory.

Overstory cruise Type -- Enter code value for overstory cruise type:

1 - Prism cruise, individual trees, height recorded in column 4, plots recorded separately. Either record grades for all trees or record grades for none of the trees. See also code 7.
2 - Prism cruise, individual trees, counts recorded in column 4, plots recorded separately.
3 - Prism cruise, dot tally, all plots tallied together. Useful for computer processing of data recorded on Overstory Tally - Manual Summary form.
4 - Fixed area cruise, individual trees, height recorded in column 4, plots recorded separately. Either record grades for all trees or record grades for none of the trees. See also code 8.
5 - Fixed area cruise, individual trees, count recorded in column 4, plots recorded separately.
6 - Fixed area cruise, dot tally, all plots tallied together (stand table).
7 - Prism cruise, individual trees, height recorded in column 4, plots recorded separately. Record only major products, that is, cull (grade 8) and sawtimber with only pulp volume (grade 6). Similar to code 1, but used where you want accurate volumes and values without grading all trees.
8 - Fixed area cruise, individual trees, height recorded in column 4, plots recorded separately. Record only major products, that is, cull and sawtimber with only pulp volume. Similar to code 4, but used where you want accurate volumes and values without grading all trees.
0 - No overstory data

plots -- Enter number of overstory plots tallied in this stand.

BAF/plot size -- Enter basal area factor of prism used for prism cruises, or plot size (in acres) for fixed area cruises. For prism cruises, a 10-factor prism is the default.

Regen cruise Type – Enter code for type of regen cruise:
1 - checkmark regen input
2 - expanded regen input (default)
0 - no regen data

\# plots – Enter number of regeneration plots tallied.

Plot size – Enter code for regeneration plot size.
1 - 6' radius plot (default)
2 - milacre plot

Acreage in Stand – List total number of acres in the stand.

Stand Age – List stand age in years. If stand age is unknown, enter 0. If stand is uneven-aged, enter 999.

Stand, Site, and Management Information

Cover type – List code for cover type, if desired (may be left blank).
1 - forest (default)
2 - forest (seedling stand in process of regeneration)
3 - opening
4 - pasture
5 - cropland
6 - wetland
7 - water
8 - urban
9 - unproductive

Habitat type – List code for habitat or ecological land type. (reserved for use in future wildlife enhancement – any value entered here will simply be printed on the output)

Soil type – Record a code for soil type. (reserved for use in future soils enhancement – any value entered here will simply be printed on the output)

Site class – record a subjective estimate of site quality here, if desired. The coded values are:
0 - none (default)
1 - high site
2 - average site
3 - low site

Site species – record species code for species used in site index determination. Use the same species codes as used for overstory data.

Site Index – record site index value for this stand, based upon age and height measurements of at least 10 dominant and codominant trees of the site species listed above. Site index is required only if the stand is to be projected (growth simulated) in the computer, and only for oak species.

Ht. Adj. – If merchantable heights are not recorded, and the merchantable heights calculated by SILVAH do not appear to be representative for this site (see Figure 4), the user may insert a value between 0.5 and 1.5 to adjust the merchantable heights and thereby adjust volumes.

Elev. – Record elevation of stand, in feet above sea level.

Aspect – Record direction toward which the slope faces as an azimuth (degrees from true north) to the nearest degree (if aspect is due north, use 360°).

Slope % – Enter slope percent to nearest 1 percent.

Topo. position – Record topographic position as one of the following codes:
1 - ridge
2 - upper slope
3 - mid-slope
4 - lower slope
5 - bench
6 - upper flat (Plateau)
7 - bottom

Operability – Record a subjective estimate of operability of the stand for timber harvest and other mechanized activities.
1 - no limitations
2 - slope, rockiness, or poor drainage limit use of mechanical equipment

Access – Record a subjective estimate of the accessibility of the stand as it may affect timber and wildlife management.
1 - road within or at edge of stand suitable for travel by two-wheel drive vehicles and log trucks
2 - road within or at edge of stand passable only by 4-wheel drive vehicles
3 - no existing roads within or at edge of stand, but there are roads within 1 mile of stand
4 - no roads within 1 mile of stand

Water code – Record the presence of water courses that may be of value to wildlife within the stand, as follows. There is space to record two codes if more than one type of water course is present. If more than two are found, record the two most important.
1 - spring seep
2 - creek/stream <15' across
3 - creek/stream >15' across
4 - marsh (little or no open water)
5 - swamp (standing live trees)
6 - pond (<1 acre)
7 - lake (>1 acre)

W/I 1 mile – Record the acreage or presence of the following habitat types within 1 mile of the stand perimeter:

CC - acreage in clearcut areas (stands cut within past 10 years and still in the process of regenerating to trees)
cultivation - acres in cultivated farm crops
open - acres in pastures, failed clearcuts, and similar openings
water - code for type of open water (ponds, lakes, streams > 15' wide - see codes above)

Management Goals -- It is assumed that timber production is an important goal of management for any stands being prescribed under the SILVAH system. Visual goals are also considered. Enter one of the following codes to indicate restrictions that visual goals may impose on timber cutting activities.

1 - no restrictions on cutting methods for visual reasons (default)
2 - either even- or uneven-age silvicultural systems may be used, but clearcutting is not acceptable as a final harvest cutting method for visual reasons
3 - uneven-age silvicultural systems are desired to maintain mature forest canopy at all times, but maximum timber production feasible under this system is desired.
4 - uneven-age silviculture is desired to maintain a mature forest cover at all times. Timber production is less important than above, and visual goals call for the maintenance of very large trees on the area at all times, and the avoidance of canopy openings.

Selection of goals 1 or 2 above will usually lead to an even-age silvicultural system, and will tend to maximize timber production by maintaining a high proportion of shade intolerant species. Although wildlife goals are not specifically stated, these goals will tend to favor wildlife species that depend on early successional vegetation, and will generally maximize wildlife diversity.

Selection of goals 3 or 4 will lead to an uneven-age silvicultural system, and will tend to produce moderate timber yields by favoring a high proportion of shade tolerant species. These goals will also tend to favor wildlife species that depend on late successional vegetation.

Management Value -- Relative value of this stand for the management goal listed. **This management value is used only in prescriptions that involve gypsy moth damage, where expenses for spraying may be justified in stands of high value. Gypsy moth prescriptions are not currently implemented in the SILVAH program.**
0 - not observed
1 - high value
2 - medium value
3 - low value

Deer Impact Index -- An estimate of the amount of browsing pressure that deer are likely to exert on regeneration is essential for proper prescription. This deer pressure is an index that may be read from Figure 5 which shows deer impact as a function of deer population and amount of available food in the one square mile area surrounding the stand in question.

Data to use this chart can be obtained in a number of ways. Deer populations are best obtained from a pellet count census in the vicinity of the stand. Such censuses are time consuming, and can only be done in the spring, making it impractical to do on an individual stand basis. However, a few sample censuses done once every 3 or 4 years will provide a useful guide to deer populations within the working area of a forest district or county. If pellet-count data are not available, estimates of the deer population within a deer management zone can usually be obtained from the state game agency.

Estimates of deer food availability must be made on a subjective basis at present. Evidence of low deer food availability include: a distinct browse line; substantial numbers of browsed stems; large areas dominated by browse-resistant or less-preferred browse species (beech, striped maple, fern, asters, etc.); extensive areas of unbroken forest with little or no cultivated cropland within one mile of the stand; a preponderance of pole-sized and unthinned sawtimber stands and a limited area in regenerating clearcuts within a mile of the stand; limited diversity of plant species in the understory or in regenerating harvest cuts; limited presence of woodland

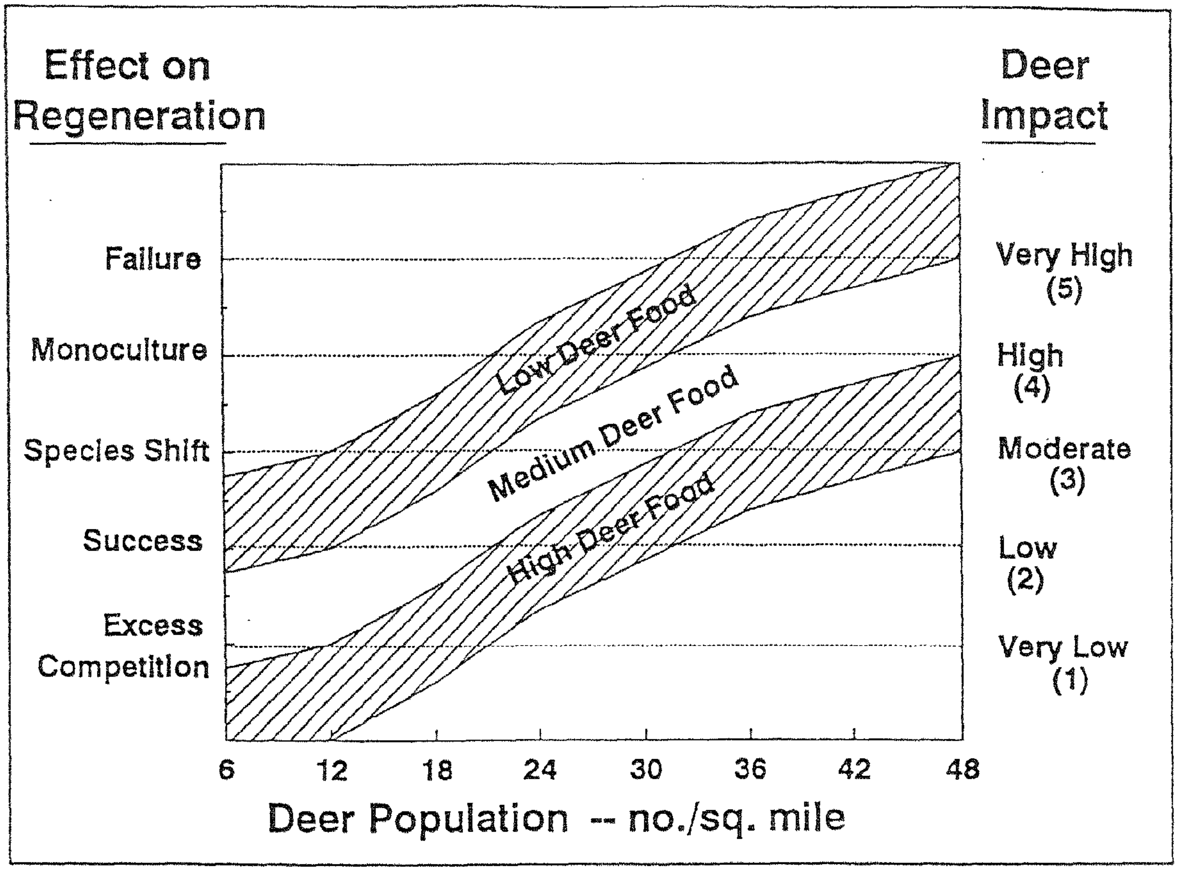


Figure 5. Deer impact index.

flowering plants; historical knowledge of deer problems in the area; evidence of poor antler development, low deer weight, an average of 1.2 fawns per doe or less, and significant winter starvation. If deer food availability is low, but a large amount of harvesting will be scheduled within 1 mile of the stand in question, use the medium deer food availability level in determining deer impact. Combinations of final removal cuts and thinnings that qualify as a large amount of harvesting include the following percentages of the total area: a) 5% final removal cuts plus 45% thinning; b) 10% final removal cuts plus 30% thinning; c) 15% final removal cuts plus 15% thinning; d) 20% final removal cuts.

Evidence of high deer food availability are the opposite of those described above: lush understories and vigorous regeneration of a wide variety of species, including preferred browse species; abundant woodland flowers; a preponderance of recent harvest cuts and thinned sawtimber stands within a 1 mile radius (with areas in these two types of harvesting that meet or exceed the area combinations given above); cultivated cropland nearby; and a healthy deer herd with high deer weights, trophy antler development, and a preponderance of twins and triplets during fawning.

Code deer impact index as follows:

1 - very low (as in a well-maintained deer exclosure)
2 - low
3 - moderate
4 - high (default)
5 - very high

Gypsy Moth – An estimate of the imminence of gypsy moth defoliation is necessary if prescriptions are to incorporate integrated pest management recommendations for gypsy moth. Gypsy moth prescriptions are not currently implemented in the SILVAH program. The categories are:

0 - unknown or unimportant (default)
1 - defoliation not expected for 3 to 5 years or more
2 - defoliation expected within 3 to 5 years
3 - defoliation has already occurred within past 1 to 3 years

Stress – An estimate of the kind and degree of stress that this stand may have experienced during the past 5 to 10 years.

1 - none (default)
2 - thinning, or minor drought-ice-storm damage, or minor insect-disease outbreak that reduced stand density to no less than 50 percent
3 - thinning, drought-ice-storm damage, or insect-disease outbreaks that reduced stand density below 50 percent

STAND ANALYSIS

Once the stand examination is finished, the data can be summarized to get a complete picture of present stand condition and provide the basis for writing a prescription. Computer programs are available to do the entire data summary and prescription writing chore. However, a computer is not necessary–the data can be readily summarized on a hand calculator. Both manual and computer data summary procedures are described in the following sections, beginning with the manual summary.

Manual Data Summary

Understory Data Summary

The understory data from both the checkmark regeneration tally and the expanded regeneration tally can be summarized directly on the ID & Regen Tally Form (Fig. 4) in the summary columns provided.

Expanded regeneration tally data summary – Note the total number of understory plots and the deer impact index appropriate for this stand.

Now, compare the critical levels shown in Table 4 below for this deer impact index to the observed value for each of the small advance regen criteria. Count the total number of plots that meet or exceed the critical value, and record it on the tally form in the # column.

Table 4. Number of seedlings required for regen plots to be stocked for different levels of deer pressure.

Deer Impact Index	Advance Regen Species Group				
	Black cherry	Small oak	Other Desir-able species	All Desir-able species	Large Oak
	Weighted no. per plot				
5	50	60	200	200	1
4	25	40	100	100	1
3	20	30	50	50	1
2	15	20	30	30	1
1	10	10	15	15	1

For example, in an area with deer impact index of 4, 25 black cherry seedlings are required for a 6-foot-radius plot to be considered adequately stocked. Scan the field tally sheet and count the plots that have 25 or more black cherry seedlings. You may find it convenient to circle the numbers of seedlings on any plot that have the required stocking; then count the numbers of plots with circles. Record this number in the black cherry advance seedling row, under the # column. Do the same for small oak, other desirables, and large oak.

Also, count the number of plots that have entries in the residuals or sapling regen rows, and record the totals in the # column.

Now compare the critical levels of interference shown in Table 5 to the observed values for each of the interference categories. Count the number of plots that meet or exceed the critical values, and record the totals in the # column. If any of the plots were coded 2 or 3 in the Laurel and Rhododendron row (row 13), you should count those plots as half-stocked. Again, you may wish to circle the values that exceed the critical level to make counting easier.

Table 5. Amount of interference required to consider a plot stocked.

Type	Counting Criteria
Woody Interference	All plots with 12 stems or more
Fern	All plots with at least 30% coverage
Grass	All plots with at least 30% coverage
Laurel and Rhododendron	Count plots coded 4 as 1; count plots coded 2 or 3 as 1/2
Grapevine	All plots with at least 1 vine

Next, record the number of plots that have either a 1 or 2 in the site limitations row, and record the total in the # column.

There are four shaded rows on the tally form. These are calculated in the office, as described below.

The All desirables category (row 4) is the total of the numbers in the black cherry, small oak, and other desirables categories. Some plots may not have sufficient numbers in any one category to be considered stocked in that category, but the total weighted number of black cherry, small oak, and other desirable seedlings may be large enough to consider that plot stocked with all desirable seedlings. To make this determination, simply sum the values in rows 1, 2, and 3 in each column, and write the sum in the All desirables row (row 4). Then compare this value with the critical value in Table 4 for the appropriate deer impact index. Record the total number of plots that meet the All desirables criterion in the # column.

The other three shaded rows on the tally form are categories that are combinations of observed values. These are Any small regen (row 6), Any regen plus residuals (row 8) and Any interference (row 14).

The tally sheet shows which rows make up each combination. The Any small regen row is a combination of rows 1, 2, 4 and 5 - the Black cherry, Small oak, All desirables and Large oak rows. Any plot that is stocked with any one of these four criteria, is stocked with Any small regen. If you circled the stocked plots earlier, simply count the number of plots that have a circle in <u>any</u> of the included rows. Enter this number in the # column.

The Any regen plus residuals row (row 8) is a combination of Any small regen (row 6) and Residuals (row 7). Any plot that is stocked with either of these categories is stocked with Any regen plus residuals. Record the number of stocked plots in the # column.

The Any interference row (row 14) is a combination of Woody Interference (row 10), fern (row 11), grass (row 12), and laurel and rhododendron (row 13). Any plot that is stocked with any of these categories of interference is stocked with Any interference. If the only interference on a plot is half-stocking with laurel or rhododendron (codes 2 or 3), then the plot is considered half-stocked with Any interference. Record the number of plots stocked with Any interference in the # column.

Now, calculate the <u>percentage</u> of plots meeting the minimum criterion for each factor. Simply divide the number of plots observed as meeting the criterion (in the # column) by the total number of plots, and multiply by 100. Record the result in the % column.

There is one final determination needed for some prescriptions. This is the small regen stocking that would be achieved if deer were not a problem; that is, if a fence were erected to exclude deer. Fewer advance seedlings are required inside a fence, since none are lost to deer browsing there. To determine the Any small regen stocking at very low deer impact, go back through rows 1, 2, 3, 4, and 5 to determine how many plots are stocked using the criteria for a deer impact index of 1. Record this number, and calculate the percentage as before. Do the same for any regen or residuals using the lower deer impact index. Record these percentages on the Prescription Summary Worksheet (Fig. 7).

Checkmark regeneration tally summary -- When the understory tally has been conducted using the checkmark tally procedures, most of the summary has been completed at each plot. For all the unshaded rows on the tally sheet, simply count the number of checkmarks and record this number in the # column.

Now, calculate the percentage of plots meeting the minimum criterion for each factor. Simply divide the number of plots observed as meeting the criterion (in the # column) by the total number of plots, and multiply by 100. Record the result in the % column.

Overstory Data Summary

If field data were recorded on the Computer Tally Form (Fig. 2a), the first step is to transfer the basal area information to the Manual Overstory Tally Form (Fig. 2b) using a dot tally to accumulate the prism counts into species or groups, size classes, and quality classes. Check the transfer carefully, as we have found that many errors are made during this process.

On the Manual Overstory Tally Form, convert the dot tally totals to basal area per acre. First, calculate a basal area conversion factor. For prism plots, divide the prism factor (10 for a 10-factor prism) by the number of overstory sample points. For fixed area plots, divide the number of plots by plot size. Write this value in the space provided (3 significant digits are required for accuracy). Then, multiply the dot tally in each species-size class by this conversion factor to get basal area per acre in that class. Record these basal area values beneath the dot tally in each cell.

On this form, calculate the total basal area, poles and larger, for each species or group. Record the AGS subtotal below the AGS block and the UGS total below the UGS block, and accumulate these into the AGS+UGS total row near the bottom of the form.

The next set of overstory summary procedures are completed using the Manual Overstory Summary form (Fig. 6). The first step in these calculations is to transfer total basal areas for each size/quality/species group cell from the Manual Overstory Tally Form to the Manual Overstory Summary form. These values represent totals across the individual species that have the same relative density factor. For example, in the AGS/Saplings/BC-WA-YP cell, record the total basal area of any acceptable saplings of black cherry, white ash, and yellow poplar.

To calculate the average relative density in each species/size class, multiply the basal area per acre in that class by the relative density factor (RD f) for that class. The factor is shown in the RD column on the worksheet, below the space in which the relative density value is to be recorded. Repeat for each species-size class, entering the result in the corresponding relative density per acre (RD/a) cell.

To estimate board-foot volume per acre (International 1/4" Rule), multiply each BA/a times the board-foot conversion factor (BF f). The BF f is shown in the appropriate place on the worksheet. Be sure to multiply by **basal area** rather than the adjacent estimate of relative density. Note that the factors for the black cherry, white ash, and yellow-poplar group are larger than those for the other two groups. Also note that the factors for UGS are half those shown for AGS. The factors for UGS are approximations to take into account that some UGS will have sawtimber products and others will not.

Now, summarize rows and columns to get the appropriate subtotals and totals of basal area, relative density, and board foot volume. Sum these values over all size classes for each species/quality group. Then, within each quality class, sum the BA, RD, and BF volume across all species. Finally, sum the BA, RD, and BF volume down both qualities to derive the all species, AGS + UGS totals.

Finally, estimate total cordwood volumes by multiplying BA/a times the cordwood conversion factor (CW f) and enter in the column labeled CW/a. The CW f is shown in the total block on the worksheet. The cordwood values for the sawtimber sizes include the volume in sawlogs. To estimate total cordwood volume in the stand excluding the sawlogs, divide the total board-foot volume by 600 and subtract from the total cordwood volume.

These stand summary calculations are easier to do than they are to explain. Basically, the data summary involves conversion of a dot count to basal area per acre, then multiplication of the basal area values by conversion factors to get relative density and volume. Then, these values are summed by rows and columns. The math is simple, but repetitive.

Other Stand Parameters

There are a variety of other stand parameters that can be calculated from the overstory and understory data. Some of these are needed to determine the appropriate prescription for the stand.

To facilitate these additional calculations and later prescription determinations, a Prescription Summary Worksheet is used (Fig. 7). The right column on this worksheet lists 17 Prescription Variables. The left column contains worksheets that will be used to calculate some of the prescription variables. The stand parameters recorded as Prescription Variables on that worksheet are as follows:

Management Goal -- Enter code for management goal from ID & Regen Tally Form (Fig. 4).

Deer Impact Index -- Enter deer pressure index from ID & Regen Tally Form (Fig. 4).

Seed Source Index -- A helpful parameter that can be estimated from the overstory data is a seed source index, to indicate whether or not seed sources are likely to limit natural regeneration. The determination is made using the basal area in seed-producing trees (poletimber and larger if done manually, 8 inch and larger if summary is done by computer).

To calculate the seed source index, transfer the basal area in poletimber and larger trees from the Manual Overstory Tally Form (Fig. 2b) for each of the following species groups: black cherry, white ash, red maple, sugar maple, and all oaks. Write these values in the portion of the Prescription Summary Worksheet (Fig. 7) provided for this calculation.

Note that you must make a subjective decision on sugar maple seed production. In many stands in the Allegheny region, sugar maple occurs as the overtopped species in highly stratified stands in which black cherry is the dominant species. In these stands, sugar maple seed production is very limited. Maple decline has aggravated the seed production problem with sugar maple in many areas. This situation is most commonly found in northern Pennsylvania, and occasionally elsewhere. In such areas, record the sugar maple basal area in the row marked Sugar maple poor.

In areas where sugar maple is abundant in the dominant and codominant classes, and where maple decline has not affected seed production, use the row marked Sugar Maple good.

When all basal area values have been entered, multiply the basal area times the factor (f) in the preceding column, and record the results in the last column. Sum the last column to get an estimate of the number of advance seedlings per acre that might be expected to result over the next 5 years under favorable (shelterwood) conditions.

Finally, look up the seed source index in the lower portion of this work area using the expected number of seedlings per acre just calculated. Record this index in the Prescription Variables Column.

An index value of 1 indicates excellent seed production potential, while a value of 4 indicates very low seed production potential.

Site Limitations -- Enter the percentage of plots with site limits from the ID & Regen Tally Form (Fig. 4).

Any small Regen -- The percentage of plots stocked with any small advance regeneration has been calculated on the ID & Regen Tally form (Fig. 4). If there are no oaks present, enter this value in the Any small Regen space on the Prescription Summary Sheet. If there are oaks present, you can supplement the advance seedling regeneration with potential stump sprouts. Estimate the number of sprouts expected using the overstory data for oaks and the Oak Stump Sprouting portion of the Prescription Summary Worksheet (Fig. 7). Transfer the BA by size class of northern red oak and other oaks from the Manual Overstory Tally form (Fig. 2b). Multiply the basal area in each size class by the factor printed on the sheet, repeating this process for northern red oak and for all other oaks. Total these values to estimate the number of stumps per acre that will likely contribute sprouts to the new stand.

Then, estimate a new value for Any small Regen using the table in the Oak Stump Sprouting portion of the Prescription Summary Worksheet. Choose the row that reflects the appropriate level of deer pressure, then find the value closest to the number of sprouting stumps you just calculated. The number from the Adv. Regen Adjustment row of that column is added to the Any small Regen percent calculated on the ID & Regen Tally Form (Fig. 4). Enter the new value in the Any small Regen space in the Prescription Variables column.

Any regen or Residuals -- Enter percentage of plots stocked with any advance regeneration or residuals from the ID & Regen Tally Form (Fig. 4). If you made any adjustments to Any regen for oak stump sprouts, be certain to include the adjustment here as well.

Any small Regen, no deer -- Enter the percentage of plots that meet the stocking requirements for a stand with a very low deer impact index. Make the appropriate adjustment for Oak Stump Sprouting.

Any regen or Residuals, no deer -- Enter percentage of plots that meet the stocking requirements for a stand with a very low deer impact index. Make the appropriate adjustment for Oak Stump Sprouts.

Sapling Regen -- Enter the percentage of plots stocked with sapling regeneration from the ID & Regen Tally form (Fig. 4).

Any Interference -- Enter the percentage of plots stocked with any interfering plants from the ID & Regen Tally form (Fig. 4).

Sapling Basal Area -- Total basal area in sapling size trees (AGS + UGS, all species) has already been calculated; transfer the value from the Manual Overstory Summary form (Fig 6).

Shade Tolerant Basal Area -- Sum the basal area in eastern hemlock, American beech, and sugar maple. Include AGS and UGS, all size classes. The values to be summed are on the Manual Overstory Summary form (Fig. 6), and a worksheet is provided in the Shade Tolerant Composition portion of the Prescription Summary Worksheet (Fig. 7).

Relative Stand Density -- Relative density for all trees in the stand has already been calculated; transfer the value from the Manual Overstory Summary form (Fig. 6).

Relative density AGS -- Relative density of the acceptable growing stock trees only has already been calculated; transfer the value from the Manual Overstory Summary form (Fig. 6).

Figure 6.

SILVAH - Manual Overstory Summary

Stand ID

USDA, Forest Service, NEFES, Warren, PA 1/91

AGS		BC-WA-YP			RM-NRO-EH-Oth			SM-AB-StM-OO			All Species AGS		
Size class		BA	RD	BdFt	BA	RD	BdFt	BA	RD	BdFt	BA	RD	BdFt
Saplings	value												
	f		1.44			1.21			1.17				
Poles	value												
	f		0.60			0.76			0.99				
Small Saws	value												
	f		0.39	84		0.57	64		0.94	64			
Medium Saws	value												
	f		0.31	128		0.49	106		0.92	106			
Large Saws	value												
	f		0.27	148		0.44	120		0.91	120			
All Sizes AGS	value												

UGS		BC-WA-YP			RM-NRO-EH-Oth			SM-AB-StM-OO			All Species UGS		
Size class		BA	RD	BdFt	BA	RD	BdFt	BA	RD	BdFt	BA	RD	BdFt
Saplings	value												
	f		1.44			1.21			1.17				
Poles	value												
	f		0.60			0.76			0.99				
Small Saws	value												
	f		0.39	42		0.57	32		0.94	32			
Medium Saws	value												
	f		0.31	64		0.49	53		0.92	53			
Large Saws	value												
	f		0.27	74		0.44	60		0.91	60			
All Sizes UGS	value												

Multiply factor (f) by basal area (BA)

AGS + UGS		All Species							
Size class		MDM	MD	BA*f	BA*f	Cords	BA	RD	BdFt
Saplings	value								
	f				3.0				
Poles	value								
	f			8.5	8.5	0.18			
Small Saws	value								
	f			14.5	14.5	0.22			
Medium Saws	value								
	f			20.5	20.5	0.24			
Large Saws	value								
	f			26.5	26.5	0.28			
All Sizes	value	1/(3-4)	2/3	1	2	3			

Figure 7.

SILVAH - Prescription Summary Worksheet

Stand ID

USDA, Forest Service, NEFES, Warren, PA 5/90

Years to Maturity

Species	BA	BA Sums	f	BA*f
Black cherry				
White ash				
Yellow poplar				
Red maple			.20	
No. red oak				
Eastern hemlock				
All others				
Sugar maple				
American beech				
Striped Maple			.15	
Other oaks, hick.				
Total		1	2 2/1	3

Yrs. to Mat. = (18 − MDM)/growth factor (2)

Seed Source Index

Species	f	BA Poles +	M Seedlings BA*f
Black cherry	4.0		
Sugar maple good	2.4		
Sugar maple poor	1.2		
White ash	1.5		
Red maple	1.5		
Oaks	1.0		
Total			4

M Seedlings (4)	0 −32	33−83	83−134	135+
Seed Source Index	4	3	2	1

Shade Tolerant Composition

Species	Total basal area
Sugar maple	
American beech	
Eastern hemlock	
Total	

Oak Stump Sprouting

Species	Size	BA	f	Sprouting stumps BA*f
N.Red Oak	Saps		20.4	
	Poles		1.7	
	SSaw		0.4	
	MSaw		0.1	
	LSaw		0.0	
Other oaks	Saps		18.6	
	Poles		2.1	
	SSaw		0.4	
	MSaw		0.1	
	LSaw		0.0	
Total				5

Adv. Regen Adjustment	0	5	10	15	20
Stumps @ high deer (5)	0	45	97	147	198
Stumps @ low deer (5)	0	21	46	71	97

Prescription Variables

Site & Environmental Factors

Management Goal	
Deer impact index	
Seed source index	
Site limitations	

Understory Factors

Any small regen	
Any regen or residuals	
Any small regen − no deer	
Any regen or residuals − no deer	
Sapling regen	
Any interference	

Overstory Factors

Sapling basal area	
Shade tolerant basal area	
Relative stand density	
Relative density AGS	
Stand diameter (MD)	
Merch. stand diameter (MDM)	
Years to maturity	

Prescription:

Stand Diameter (MD) – The average diameter used throughout this manual is an average of the diameter or size-class midpoints, weighted by the proportion of basal area in that class. We have found it to be far more useful for stand management than more traditional average diameters, such as the arithmetic mean diameter or the quadratic mean diameter, as it better reflects the size of the crop trees and is less influenced by small understory trees. This diameter is approximately the same as the median diameter (the diameter at the midpoint of the basal area distribution).

Average diameter is calculated by multiplying the midpoint of each size class times the basal area in that class, summing those values for all size classes, and dividing by the total basal area:

$$MD = \frac{\sum_{i=1}^{n} (DBH_i * BA_i)}{\sum_{i=1}^{n} BA_i}$$

There is a worksheet for this purpose on the Manual Overstory Summary form (Fig. 6). Multiply basal area in each class by the factor shown underneath, sum, and divide by total basal area.

This average diameter can be calculated for the entire stand or for selected components such as selected species or size classes. When data have been summarized from the manual forms, use the following size-class midpoints to calculate stand diameter:

Saplings - 3 in.
Poles - 8.5 in.
Small Saw - 14.5 in.
Medium Saw - 20.5 in.
Large Saw - 26.5 in.

Merchantable Stand Diameter (MDM) – Enter the average stand diameter of the merchantable size trees only. This value is calculated as described for stand diameter, except that the sapling size class is omitted from summations in both the numerator and denominator. Record both diameters on the Prescription Summary Sheet. This diameter may also be calculated on the worksheet on Fig. 6.

Years to Maturity – It is helpful to know how close a stand is to maturity, and whether all species will mature at approximately the same time. Using data from about 200 plots, we have developed some simple procedures for estimating these parameters. A worksheet for calculating years to maturity is provided in the left column of the Prescription Summary Sheet (Fig. 7).

$$YRS = \frac{18 - MDM}{GF}$$

where:

YRS is the number of years to maturity for the species group or stand;

MDM is the average diameter of the merchantable-size trees in the species group or stand; and

GF is a growth factor. Use 0.20 for species in the black cherry, white ash, yellow-poplar, and red maple, red oak groups. Use 0.15 for species in the sugar maple, beech, and other oaks group. When calculating *Years to Maturity* for an entire stand containing both groups, use an average GF weighted by the proportion of the basal area in each species group. That is, transfer the basal area in trees of pole size and larger to the worksheet by species. Sum the basal area over all species within each group into the Total column on the worksheet. Then, multiply each group's total by its factor (f), and sum these values. Divide the sum by the total basal area in the stand. Use this as the stand growth factor in the above equation.

Record years to maturity in the Prescription Variables column.

You now have completed the manual stand analysis, and all of the information you will need to prepare a prescription has been recorded on the Prescription Summary Sheet.

Computer Data Summary

A computer program is available to do the entire data summary; it provides a great deal more information than is feasible to calculate manually. Raw data from the Computer Overstory Tally Form (Fig. 2a) and the ID & Regen Tally Form (Fig. 4) are entered into the program; output includes a complete data summary and recommended prescription.

Data Entry

Data are entered directly from the field tally sheet into a computer file using the interactive program SILVED simply by responding to the prompts made by the computer. In a similar manner, information on the many program options can be saved into a file using the interactive SILVAH program. Data summaries, stand analysis, stand prescription, stand projection, and other functions are also performed by SILVAH.

Data Output

Standard printouts include the following information:

- o Descriptive information on the stand; information on the type of cruise and estimates of the sampling error in overstory basal area, and an indication of the number of additional plots needed to reduce sampling error to within 10 and 15 percent of the mean. Warning messages are printed if the number of either overstory or understory plots is too small for accurate estimation.

- o A summary of understory data showing the percentage of plots stocked with each category of advance regeneration, plus information on factors affecting regeneration difficulty, interfering plants, and site limitations. There is also a summary of information on site quality, management goals, and wildlife attributes.

- o Various summaries of the overstory data, including a table by individual species and diameter classes showing basal area per acre. Similar tables of numbers of trees, relative density, cubic-foot volume, board-foot volume, and dollar value can be obtained as optional additional outputs, as can summaries by various species groups, size or product classes, and quality classes.

- o A narrative description of the stand, including a prescription and recommendations on its implementation. If partial cutting is recommended, a marking guide is provided indicating the amount to be cut from each size and quality class.

- o A summary of the major overstory parameters for the original, cut, and residual stands if a partial cut was prescribed.

Summary Interpretation

By using the summary data just calculated (either manually or by computer), you can objectively evaluate stand condition. Even a person who has not visited the stand can get a detailed picture of it by careful study of the data summary. For example, the summary shows:

- o Stand type and species composition.

- o Stand size class (based on stand diameter).

- o Stand structure (distribution of trees by size class).

- o Stage of maturity of the stand and each major species or species group.

- o Relative density and the need for thinning.

- o Basal areas and volumes per acre.

- o Stand quality.

- o Status of advance regeneration.

- o Possible plant or site factors that could interfere with regeneration after harvest cutting.

The Appendix contains both manual and computer data summaries of a sample stand that illustrate the kind of interpretations one can make from the stand summary analysis.

These data suggest that this sample is an Allegheny hardwood stand; that is, at least 65 percent of the basal area is contained in northern hardwood species and at least 25 percent is in black cherry, white ash, and yellow-poplar. Actually, black cherry and white ash represent 45 percent of total basal area. Furthermore, we can see that black cherry, red maple, and sugar maple are the predominant species, comprising 86 percent of the basal area. The balance is beech, ash, and birch.

The largest amount of basal area is contained in the small sawtimber size class. Medium sawtimber and poletimber are next in importance, with about equal amounts of basal area. The stand diameter of 13.1 inches confirms that this is a small sawtimber stand. Estimates show that the entire stand is about 20 years from maturity (merchantable-size trees will average 18 inches d.b.h. in about 20 years). The largest trees in the stand are 24 inches d.b.h. and are black cherry.

However, it is clear that the stand is stratified into crown and size classes by species, and the various species groups will not mature at the same time. The cherry average 16.4 inches d.b.h. and are only about 8 years from maturity. The merchantable sugar maple, beech, and birch are only 11.2 inches d.b.h. and are still 46 years from maturity. The merchantable red maple are intermediate, averaging 13.5 inches d.b.h. and 23 years from maturity.

When stand maturity is reached in 20 years, the black cherry will be 12 years overmature and red maple 3 years immature, while the sugar maple and beech will still be 26 years under maturity. Thus, the estimated maturity age for the stand is a compromise. Harvesting the stand at that time will sacrifice only a small percentage of the stand value in red maple, sugar maple, beech, and birch, and should result in very little loss due to the overmaturity of the cherry.

With 20 years to maturity, there is time to schedule a thinning now and an additional thin-harvest in about 10 years; a harvest-regeneration cut should then be considered in about 10 additional years.

The overstory includes a lower layer of saplings representing about 11 square feet of basal area--primarily sugar maple and beech. There are not enough saplings to worry about in any partial cuttings that might be made, but their abundance further illustrates the stratification that exists among the species.

The diameter distribution for black cherry plots as a bell-shaped curve, while that for sugar maple and beech plots as an inverse J (as does that for the stand as a whole). There are a few large sawtimber trees of tolerant species, but most of the tolerants are considerably smaller (large poletimber). Together, the species composition and diameter distributions suggest that this is an essentially even-aged stand that contains a few residual tolerants of an older age class.

Because the stand has an inverse-J structure now, and has considerable amounts of basal area in sawtimber-size trees up to 24 inches d.b.h. (including some in the more tolerant maple and beech species), it would be fairly easy to convert the stand to an all-age structure over 2 or 3 cuts, if this should be desired to meet some particular objective. However, the small proportion of stand stocking in tolerant species will require a long adjustment period and may limit ingrowth during the early part of the conversion period.

The total basal area of 158 square feet per acre represents about 97 percent of the average maximum density expected in undisturbed stands of similar size and species composition. This relative density is well above the optimum for best timber production. Growth rates of individual trees are probably less than maximum, and mortality due to crowding is fairly high. A thinning would improve growth of the stems that remain.

Total net cordwood volume of the stand is 40 cords per acre, and sawtimber volumes are 10,909 board feet per acre. These volumes should be more than adequate to support a commercial thinning and still leave a well-stocked residual stand. The present stand value is high--about $3,700 per acre. The value estimated here may vary appreciably from the actual stumpage value in a particular location at a specific time, but it is a useful parameter for comparison with other stands. Those who use the computer program to process inventory data may set stumpage prices appropriate to their area.

Trees of acceptable growing-stock quality occupy about 62 percent of the available relative density (70 percent of present basal area), while trees of unacceptable quality occupy 35 percent. Although trees of acceptable quality provide enough stocking to warrant stand management, thinning to remove the poorer quality trees is clearly needed. Most, if not all, trees to be removed in the first thinning should be from the unacceptable quality classes; one thinning may be sufficient to remove most such trees. Thinning in this stand is especially desirable, since it contains many high-value species, and thinning should permit a considerable improvement in overall stand quality, concentrating future growth on the better stems.

Although the stand is not yet mature, there is a modest amount of desirable Allegheny hardwood advance regeneration present. A thinning might very well increase both the number and size of advance seedlings, making it possible to clearcut the stand when it reaches maturity. However, 11 percent of the area also contains fern. Although this percentage of fern is not large enough to interfere with seedling development now, the thinning could produce an increase in fern that might cause problems later, especially if deer browsing on seedlings is heavy. Thus, thinning could make it necessary to use an herbicide to control the fern prior to harvest cutting. There are no other site or interfering plant problems that should limit regeneration.

All of the above information is either printed in the computer narrative, or can be deduced from a study of the manual data summary sheets.

STAND PRESCRIPTION

Stand prescription involves two distinct phases:

1. Deciding which silvicultural treatment, if any, should be applied in a particular stand to achieve the management objectives.

2. Preparing detailed instructions on how that treatment is to be carried out on the ground. If cutting is involved, this requires instructions to the markers on how many of what species and sizes of trees are to be cut to achieve the desired residual stand, estimates of the volume of various products to be harvested, and so on. It also requires details on how and when any other treatments are to be applied.

Determining Appropriate Treatment

The appropriate silvicultural treatment to apply in a particular stand can be determined by using the series of decision charts presented as Figures 8A-E.

These decision charts are grouped into three major types of prescriptions. Chart B is for stands or properties where management goals or site limitations dictate all-age silviculture. Chart C is for intermediate cuttings of stands that are not yet mature and are being managed under an even-age silvicultural system. Charts D and E are also for stands being managed under even-age silviculture, but are ready to be harvested and regenerated.

In all of the prescription charts, decision points are represented by a horizontal line with arrows to two or more rectangles below. The decision criteria are printed above the horizontal line and the values that determine the path are printed in the rectangles below the line. Using data summarized on the Prescription Summary Worksheet (Fig. 7), trace a path through the charts until you arrive at a prescription. All prescriptions are shown in circles or ovals.

The prescription ovals may be plain, lightly shaded, or heavily shaded. The legend explaining these degrees of shading is found on Chart B, but apply to all charts.

Unshaded prescriptions generally produce the desired result, require no investment, and are highly recommended.

Lightly-shaded prescriptions generally produce the desired results, but require an investment. When evaluated on the basis of maximizing annual income from the forest enterprise, these are good investments. However, these investments may not meet your organization's economic criteria if evaluated on the basis of net present worth or internal rate of return using high interest rates. The alternative to making the investment in these stands is to do nothing, since regeneration usually cannot be obtained. The no-cutting alternative may also fail to meet your organization's economic objectives. We generally recommend that these lightly-shaded prescriptions be adopted if forest management is to be continued in the stand.

Heavily-shaded prescriptions also require an investment (often a large one), but results are less likely to be satisfactory than those above. Stands in the condition represented by these prescriptions are very difficult to regenerate. We recommend no treatment in these stands, but the prescription is included to indicate the best treatments to try if you consider some action essential.

The first step in arriving at any prescription is to determine which of the three major categories of prescription (which of the several charts) is appropriate. Use Chart A to aid in this process, tracing a path through the management goals and stand characteristics decision points to the bottom of the chart, where the appropriate major category of prescription is specified. If management goals have been coded 3 or 4, uneven-age silvicultural systems are required, and a final prescription will be found on Chart B. If other management goals have been chosen, and the stand is immature, the final prescription will be found on Chart C. If the stand is mature, Chart D (and it's continuation chart E) is appropriate.

Figure 8A.

Chart A

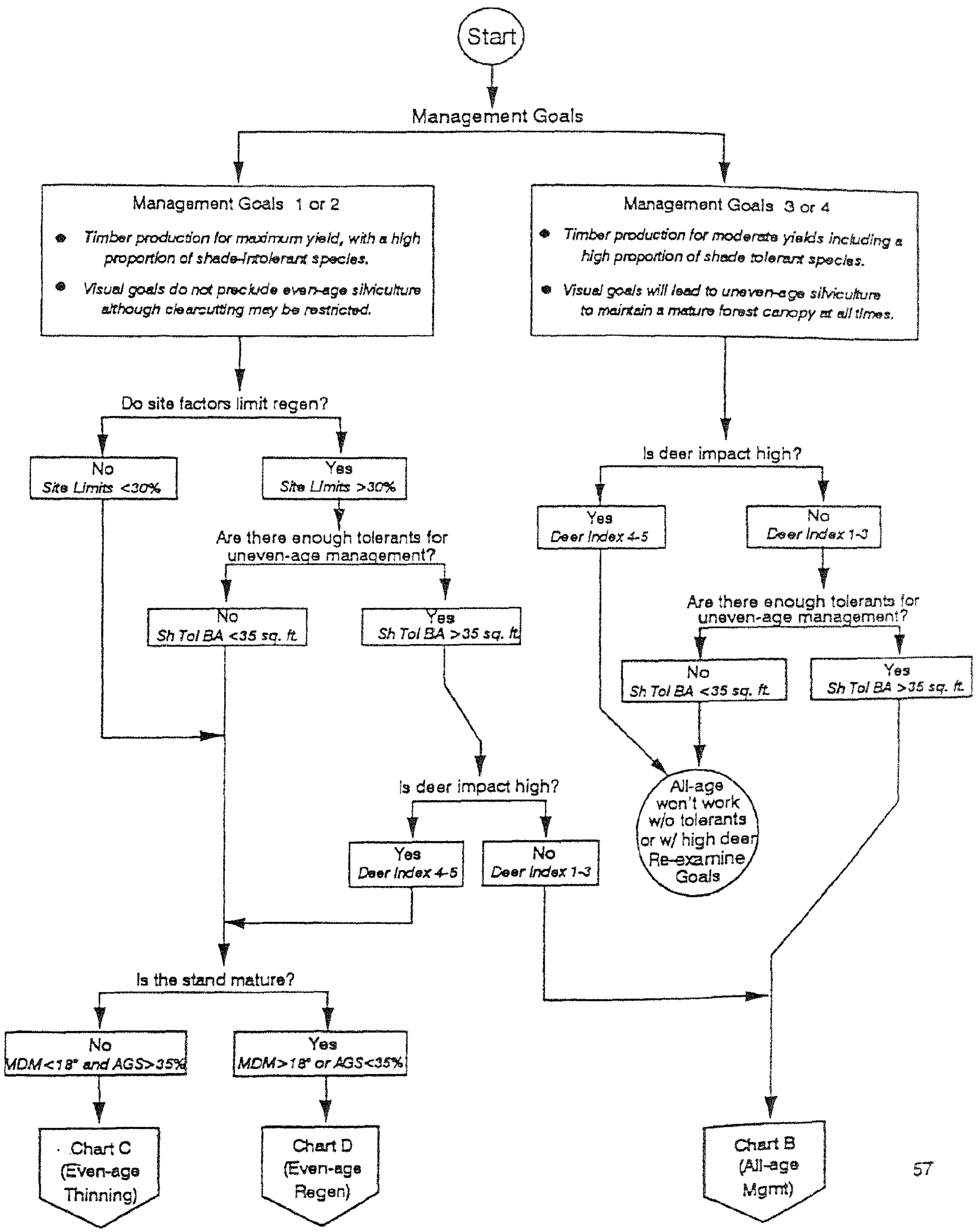
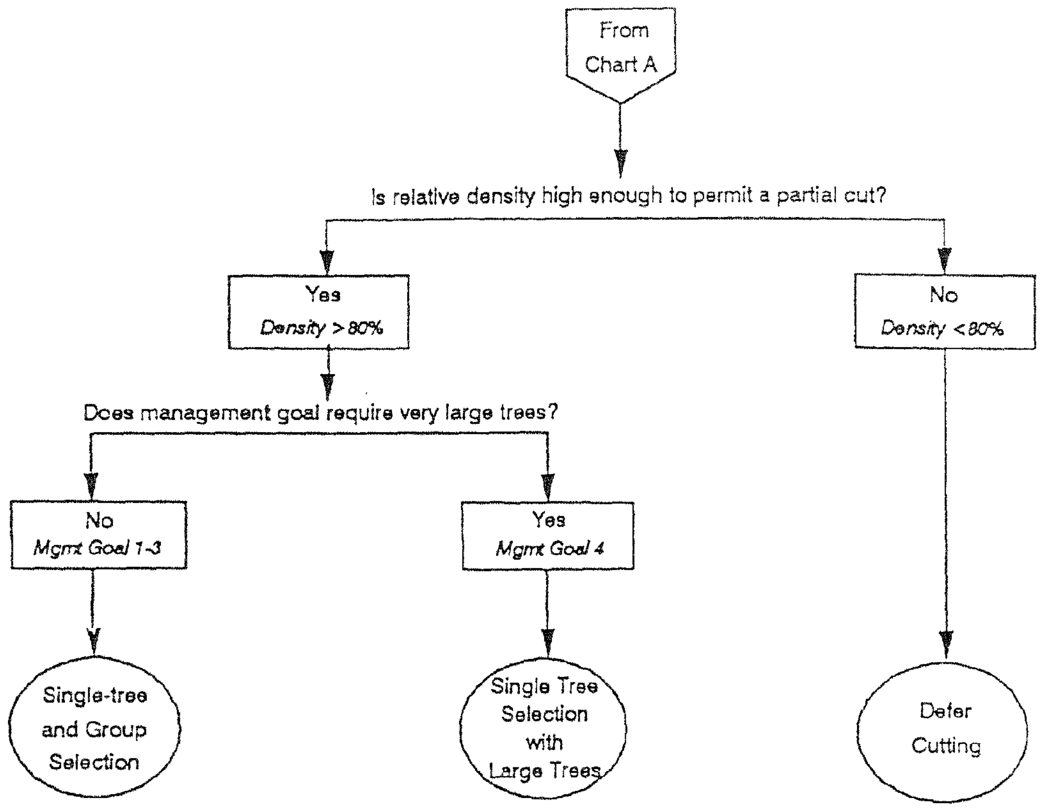


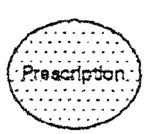
Figure 8B.

Chart B. All-age Management

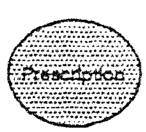


Prescription Type Legend

These prescriptions generally produce the desired results, and require no investment. We strongly recommend these treatments.



These prescriptions generally produce the desired results, but require an investment. If such investments meet your organization's economic criteria, we recommend them. If not, we recommend no cutting. In the case of regeneration prescriptions, stands generally will not reproduce without the recommended treatment.



These prescriptions are not recommended. An investment is required, and stands of this type are very difficult to regenerate. We recommend no treatment, but if some action is considered necessary, we suggest you consider the treatment shown.

Figure 8C.

Chart C. Even-age Thinning

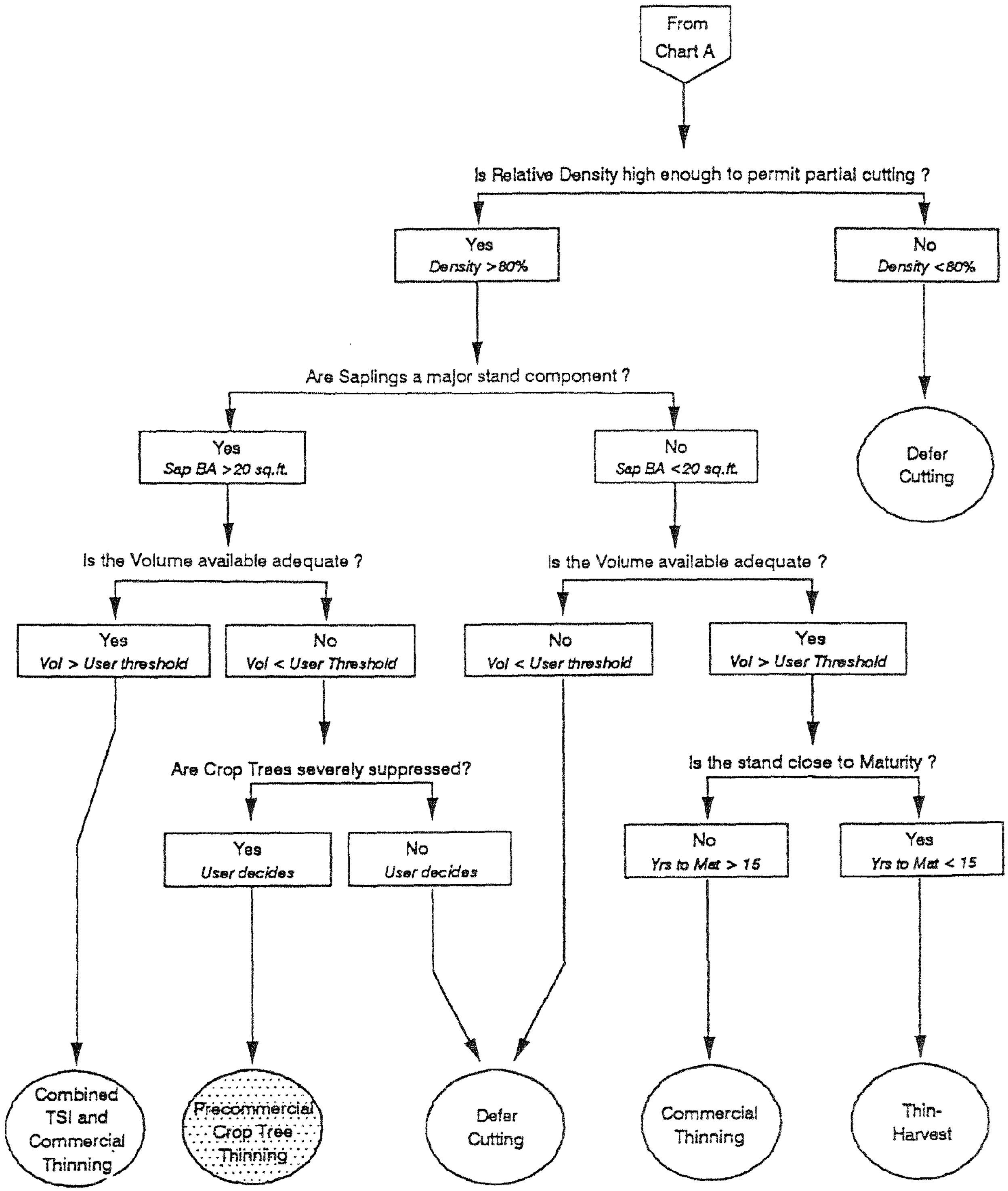


Figure 8D.

Chart D. Even-age Regeneration

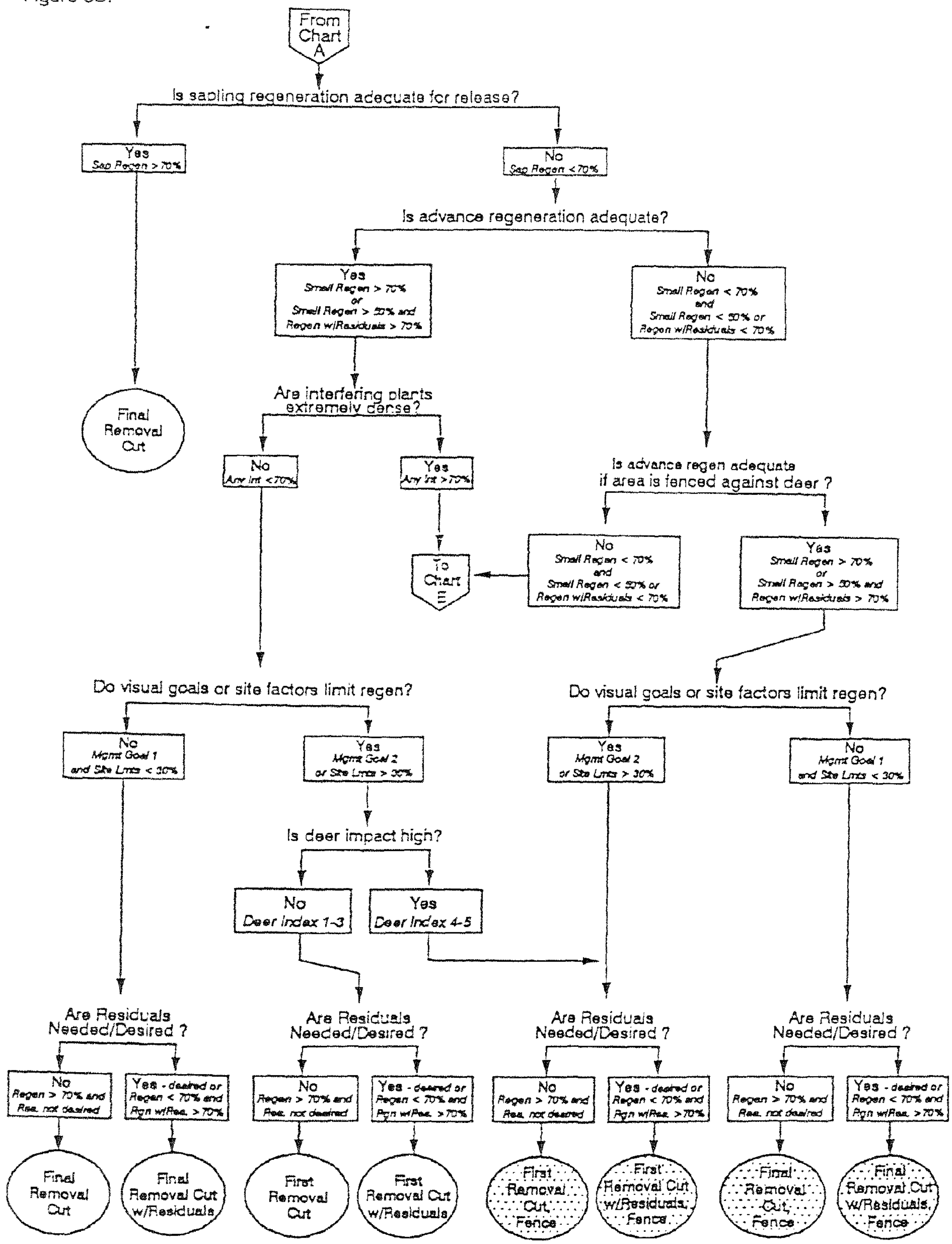
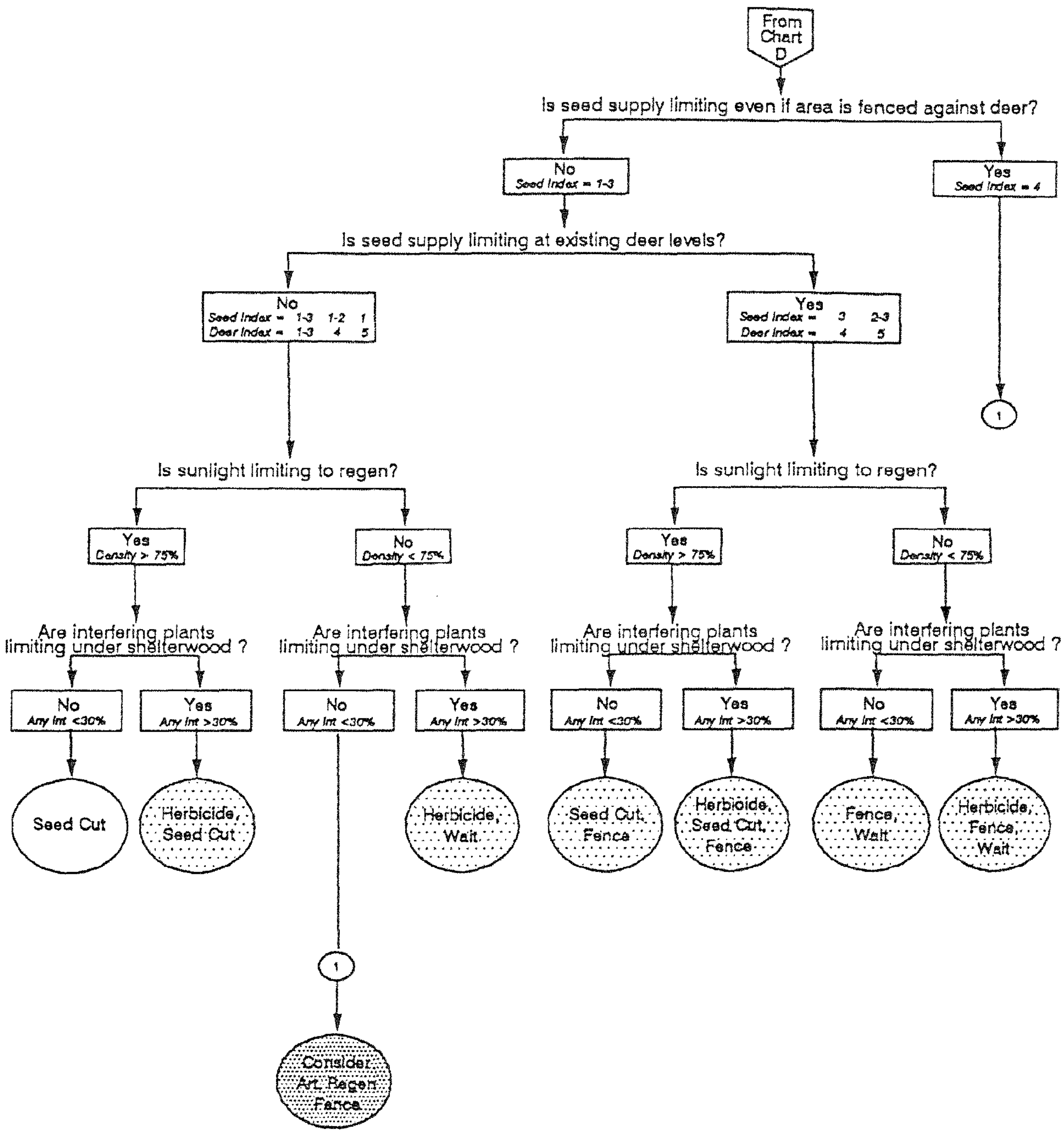


Figure 8E.

Chart E. Even-age Regeneration continued



Continue to chart B, C, or D as suggested in Chart A to determine a prescription. Trace a path through the decision points, taking the path that corresponds to the values on the Prescription Summary Sheet. That path will lead you to the recommended prescription.

Once the prescription has been determined, refer to the specific instructions for that prescription in the Prescriptions description section that follows.

Prescriptions

All-Age won't work, Re-examine Goals

This prescription may be encountered when management goals or site conditions suggest all-age management but other conflicting conditions make this impractical. Such conditions include excessive deer browsing pressure, or lack of shade-tolerant seed sources for regeneration. Re-examine the management goals, or devise some way to ameliorate the limiting conditions.

Single-Tree and Group Selection Cutting

This prescription is appropriate in those stands (or properties) where management goals dictate that a continuous forest cover be maintained at all times; even-aged regeneration practices (even using an extended regeneration period) are not considered acceptable. Timber production is generally more important than in the single-tree selection with maximum large trees prescription, but it is still secondary to the visual goal. An old-growth or virgin forest appearance is not as important as the avoidance of regeneration openings over several acres in size. This prescription may also be appropriate for stands on wet sites that contain a moderate to high proportion of shade-tolerant species, especially hemlock.

This goal is not likely to be achieved for any extended period of time where valuable, shade-tolerant species are lacking, nor in areas of excessive deer populations where browsing interferes with the establishment of a new age class after each cut.

Stands to be managed in this manner that currently have relative stand density of less than 80 percent should generally not be cut at this time. There is no need to reduce density to improve growth or reduce mortality; furthermore, there is not likely to be enough volume available to make a commercial cut without reducing relative density below the minimum recommended level.

Stands that are currently at or above 80 percent relative density should generally receive a cut at this time. A selection cut is made by establishing a residual stand structure goal that defines the amount of growing stock to be retained in each size class. All trees in excess of that goal are cut. If there are deficits in any size class, extra growing stock is retained in other sizes to compensate. No saplings need be cut. In calculating the cut and residual stands, use a stand structure goal that includes a maximum tree diameter of 22 inches, a "q" factor of 1.5, and an overall residual density of 60 percent (but do not remove more than 35 percent of the existing growing stock).

The cutting should be a combination of single-tree and group selection cutting. Efforts should be made to mark groups of trees that can logically be removed together, to create openings up to one-half acre in size for encouragement of intolerant regeneration. No effort is needed to map or record these openings, nor to achieve any particular area in openings. Single-tree selection cutting is practiced between openings, with residual density held at about 60 percent (the zero density in the openings combined with 60 percent between openings produces an overall density of about 50 percent). Refer to the Distribution of Cut section for development of specific marking instructions.

If at least 30 percent of the understory plots are stocked with at least one grape vine, grapevine control should be considered at this time. Refer to the Control Grapevine Prescription for complete description of practices to be used.

Single-Tree Selection Cutting with Maximum Number of Large Trees for Visual Goals

This prescription is appropriate in those stands (or properties) where the primary goal of management is to create a particular visual effect: a continuous high forest cover at all times with the maximum number of very large trees--a sort of old-growth or virgin forest appearance. Cutting is used to hasten the creation of this appearance. Timber production may also be important, but it is secondary to the visual goal.

This goal is not likely to be achieved for any extended period of time where long-lived shade tolerant species are lacking, nor in areas of excessive deer populations where browsing interferes with the establishment of a new age class after each cut.

Stands to be managed in this manner that currently have relative stand density of less than 80 percent should generally not be cut at this time. There is no need to reduce density to improve growth or reduce mortality; furthermore, there is not likely to be enough volume available to make a commercial cut without reducing relative density below the minimum recommended level.

Stands that are currently at or above 80 percent relative density should generally receive a cut at this time. A selection cut is made by establishing a residual stand structure goal that defines the amount of growing stock to be retained in each size class. All trees in excess of that goal are cut. If there are deficits in any size class, extra growing stock is retained in other sizes to compensate. No saplings need be cut. In calculating the cut and residual stands, use a stand structure goal that includes maximum tree diameter of 28 inches, a "q" factor of 1.3, and residual density of 60 percent, (but do not remove more than 35 percent of the existing growing stock). The cutting should be a single-tree selection cut in all merchantable sizes. Refer to the Distribution of Cut section for development of specific marking instructions.

If at least 30 percent of the understory plots are stocked with at least one grapevine, grapevine control should be considered at this time. Refer to the Control Grapevine Prescription for complete description of practices to be used.

Commercial Thinning

This prescription is appropriate in those stands being managed under even-age silviculture that have relative stand density of 80 percent or more, that do not contain a substantial share of their basal area in saplings, and that are more than 15 years from maturity.

Stands that currently have relative stand density of less than 80 percent should generally not be cut at this time. There is no need to reduce density to improve growth or reduce mortality; furthermore, there is not likely to be enough volume available to make a commercial cut without reducing relative density below the minimum recommended level.

Stands at or above 80 percent relative density should generally receive a commercial thinning at this time. In calculating the cut and residual stands, attempt to reduce relative stand density to 60 percent, but do not remove more than 35 percent of the stocking in any one cut. The cutting should be concentrated in the smaller, merchantable-size trees. Some larger trees should also be cut to open the canopy, improve spacing, and remove unacceptable growing stock. No unmerchantable saplings need to be cut. This type of thinning should tend to narrow the range of diameters and mold the stand structure (of the merchantable-size trees) into a more pronounced bell-shaped distribution.

If sawlog volumes are adequate, the sale can include both sawtimber and pulpwood. If sawlog volumes are small, it may be necessary to make a pulpwood only sale. In this case, good quality (AGS) sawtimber should generally not be cut, and the volume that would otherwise be allocated in those size classes should be taken from the poletimber size class. Although minimum volumes for an operable sale vary widely, we generally consider 1,500 board feet and 5 cords per acre to be the minimum volume for an integrated products sale, or 7 cords per acre total for pulpwood-only commercial sales. Users of the SILVAH computer program can set these minimum volumes in the program.

stumps, and soil disturbance often associated with clearcutting. Three-cut shelterwoods may be especially useful on small ownerships, or in visually sensitive areas along heavily used scenic corridors. In such areas, even-aged regeneration openings may be acceptable if they already contain sapling-size regeneration before the overstory is completely removed. In fact, the greater visual variety of such openings may be sought.

Excessively high deer populations can prevent the development of sapling-size advance regeneration where the partial shade extends the time that seedlings are subject to deer browsing. This prescription should not be used in high deer areas without fencing or other forms of protection.

The three-cut shelterwood usually consists of a seed cut that reduces relative stand density to between 50 and 60 percent (regardless of pre-cutting density) to provide for the establishment of advance seedlings. Once small seedlings are abundant (usually 3 to 10 years after the seed cut), the first removal cut is made, as described here. After an additional period of 10 to 15 years (during which the small seedlings grow to sapling size), the rest of the overstory is removed. In some situations, small advance regeneration may be adequate without making the first (seed) cut, and the sequence can begin with the first overstory removal.

The first removal cut should reduce stand density to between 30 and 35 percent to provide the high-sunlight conditions needed for rapid seedling growth. Low shade from saplings of undesirable species and poles of all species should be first priority for removal. The remainder of the cut will depend upon the volume and quality of the overstory.

If the overstory contains sufficient volume in good-quality merchantable trees to support two commercial operations, the cut can be distributed in much the same manner as a commercial thinning. If there is only enough volume to support a single commercial cut, it may prove desirable to remove most of the better trees now, leaving low value stems for a non-commercial final removal using stem-injected herbicides. The trees left must be at least large pole-size so that their shade is high and will not interfere with seedling development. This option has the advantage of avoiding logging damage to the saplings when the time comes for the final overstory removal.

If there is more than 5 square feet of basal area of saplings and poles in unmerchantable species (such as dogwood, sassafras, striped maples, and so on), they should be treated by stem injection of herbicide to eliminate them from the stand and minimize sprouting of these undesirable species. This is best done at the time of the seed cut, but if not done then, it should be done now during the first removal cut.

If at least 30 percent of the understory plots are stocked with at least one grapevine, grapevine control should be considered at this time. Refer to the Control Grapevine Prescription for complete description of practices to be used.

In stands that contain large saplings and poles of the shade-tolerant species, it may be desirable to retain 30 to 80 good quality stems per acre to ensure their representation in the next stand. In any shelterwood sequence, the trees to be retained after final harvest should be selected at the time of the seed cut and clearly marked so that they are not inadvertently cut or damaged during the several cuttings of the sequence. If not done at that time, residuals may be selected now at the time of the first removal cut, although the selection may be limited.

If residuals of other species are also selected for retention as timber trees, they should be 6 to 12 inches d.b.h. with the same crown and stem characteristics described above. If residual trees of other characteristics are retained for wildlife or similar purposes, they should be just as carefully selected to meet the criterion established for that use. In no case should more than 10 square feet of basal area be retained in all types of residual trees.

First Removal Cut with Residuals

This prescription is appropriate under conditions identical to those for the First Removal Cut prescription previously described, except that advance seedlings are adequate only if potential residuals are included in the advance regeneration counts.

In stands of this description, the first removal cut should be made as described for the First Removal Cut above, but retention of tolerant residuals is required (not optional). Retain 30 to 80 good quality trees per acre (a maximum of 10 square feet of basal area per acre) of sugar maple, American beech, or eastern hemlock to ensure their representation in the main canopy of the next stand. Trees retained should be 3 to 10 inches d.b.h., have moderately good crowns in the intermediate or higher crown class, and have clean, straight boles free of branches and epicormic branches for at least the butt 16-foot log. The trees to be retained should be conspicuously marked before cutting begins so that they are visible at a distance from any angle. This will help to prevent them from being inadvertently cut or damaged during logging.

If residuals of other species are also selected for retention as timber trees, they should be 6 to 12 inches d.b.h. with the same crown and stem characteristics described above. If residual trees of other characteristics are retained for wildlife or similar purposes, they should be just as carefully selected to meet the criterion established for that use. In no case should more than 10 square feet of basal area be retained in all types of residual trees.

If at least 30 percent of the understory plots are stocked with at least one grapevine, grapevine control should be considered at this time. Refer to the Control Grapevine Prescription for complete description of practices to be used.

See the description of First Removal Cut for a complete description of this prescription.

First Removal Cut, Fence

This prescription is appropriate under conditions identical to those for the First Removal Cut prescription previously described, except that advance seedlings are adequate only under conditions of very low deer pressure. In this situation, there is an option to proceed with the first removal cut and to erect a deer exclosure fence at the same time. Since this requires an investment, some organizations may choose to avoid cutting in this stand at the present time. Either prescription is appropriate, but we strongly advise against cutting unless the fence is erected. Regeneration is very likely to fail in this case.

If at least 30 percent of the understory plots are stocked with at least one grapevine, grapevine control should be considered at this time. Refer to the Control Grapevine Prescription for complete description of practices to be used.

See both the First Removal Cut Prescription and the Fencing Prescription for complete description of practices to be used.

First Removal Cut with Residuals, Fence

This prescription is appropriate under conditions identical to those for the First Removal Cut with Residuals prescription previously described, except that advance seedlings are adequate only under conditions of very low deer pressure. In this situation, there is an option to proceed with the first removal cut and to erect a deer exclosure fence at the same time. Since this requires an investment, some organizations may choose to avoid cutting in this stand at the present time. Either prescription is appropriate, but we strongly advise against cutting unless the fence is erected. Regeneration is very likely to fail in this case.

If at least 30 percent of the understory plots are stocked with at least one grapevine, grapevine control should be considered at this time. Refer to the Control Grapevine Prescription for complete description of practices to be used.

See the First Removal Cut Prescription, the First Removal Cut with Residuals prescription, and the Fencing Prescription for complete description of practices to be used.

Seed Cut

This prescription is appropriate in those stands to be managed under even-age silviculture that have reached maturity, where timber production is a major goal of management, where seed supply and deer pressure will permit seedling establishment, where overstory density is currently high, and where neither advance seedlings nor interfering understory plants are currently abundant.

In these stands, a shelterwood sequence will usually provide the best way to harvest the overstory and regenerate a new stand. The first (seed) cut should reduce relative stand density to 60 percent to provide for the establishment of a large number of additional advance seedlings, without allowing them to grow rapidly enough to become attractive to deer. In areas of low deer pressure, it may be desirable to reduce relative stand density a little lower (to 50 percent) to encourage slightly larger advance seedlings.

When advance reproduction is adequate (it usually requires between 3 and 10 years), the overstory removal cuts may be made. Overstory removal will usually occur in just one additional cut, creating a two-cut shelterwood sequence. However, in stands where site limitations require large advance regeneration, or in areas where visual goals require that regeneration be large enough to ameliorate the visual impact of the removal cutting, a three-cut shelterwood sequence may be desirable. The seed cut is done in the same way whether the sequence will involve two or three cuts.

If there is more than 5 square feet of basal area of saplings and poles in unmerchantable species (such as dogwood, sassafras, striped maple, and so on), they should be treated by stem injection of herbicide at the time of seed cut to eliminate them from the stand and minimize sprouting of these undesirable species. The growing stock in these trees must be considered in relative density calculations, so that residual relative density is at the appropriate level. Refer to the Distribution of Cut section for development of specific marking instructions.

If at least 30 percent of the understory plots are stocked with at least one grapevine, grapevine control should be considered at this time. Refer to the Control Grapevine Prescription for complete description of practices to be used.

Stands that lack adequate advance regeneration and in which the overstory density is already below 75 percent are not likely to respond to shelterwood cutting. Overstory density is already low enough for advance seedlings to have developed if some other factor were not limiting. Likewise, a combination of very high deer population and inadequate seed sources can make prompt and successful regeneration doubtful. In such situations, it is recommended that cutting be deferred until the limiting factor can be identified and corrected, or that measures such as artificial regeneration and protection from deer be used in conjunction with shelterwood cutting.

In stands that contain large saplings and small poles of the tolerant species, it may be desirable to retain 30 to 80 good quality stems per acre to ensure their representation in the main crown canopy of the next stand. In a shelterwood sequence, the trees to be retained after final harvest should be selected at the time of the seed cut and clearly marked so that they are not inadvertently cut or damaged during the several cuttings of the sequence.

Herbicide, Seed Cut

This prescription is appropriate under conditions identical to those for the Seed Cut of any shelterwood sequence, except that interfering understory plants such as beech root suckers, striped maple, dogwood, sassafras, laurel, fern, or grass are at least moderately abundant.

Follow instructions under the Seed Cut prescription, but treat the understory with an herbicide prior to the first cut (seed cut). See Herbicide Understory instructions in the section on Herbicide Understory prescriptions.

Herbicide, Wait

This prescription is appropriate under conditions identical to those for the Herbicide, Seed Cut prescription, except overstory relative density is already below 75 percent. Under these conditions, there should be enough sunlight available for the establishment of advance seedlings, and the volumes available for shelterwood cutting are likely to be marginal. Regeneration is not currently adequate, probably because of the moderate to high density of interfering plants. If seed supply and deer pressure are within limits that will permit establishment of new seedlings, the only treatment required is to remove the interfering understory plants with an herbicide.

Follow the instructions under the Herbicide Understory prescription.

Seed Cut, Fence

This prescription is appropriate under conditions identical to those for the Seed Cut prescription previously described, except that a combination of high deer pressure and poor seed supply limit the number of seedlings likely to become established under a shelterwood canopy. In this situation, there is an option to proceed with the seed cut and to erect a deer exclosure fence at the same time. Since this requires an investment, some organizations may choose to avoid cutting in this stand at the present time. Either prescription is appropriate, but we strongly advise against cutting unless the fence is erected. Regeneration is very likely to fail in this case.

See both the Seed Cut Prescription and the Fencing Prescription for complete description of practices to be used.

Herbicide, Seed Cut, Fence

This prescription is appropriate under conditions identical to those for the Seed Cut prescription previously described, except that a combination of high deer pressure and poor seed supply limit the number of seedlings likely to become established under a shelterwood canopy, and interfering understory plants such as beech root suckers, striped maple, dogwood, sassafras, laurel, fern, or grass are at least moderately abundant.

In this situation, there is an option to proceed with the seed cut if investments are made both in fencing and herbicide application. Since this requires a substantial investment, some organizations may choose to avoid cutting in this stand at the present time. Either prescription is appropriate, but we strongly advise against cutting unless the fence is erected. Regeneration is very likely to fail in this case.

See the Seed Cut Prescription, the Herbicide prescription, and the Fencing Prescription for complete description of practices to be used.

Fence, Wait

This prescription is appropriate when neither advance regeneration nor interfering plants are abundant, when overstory density is already low enough to permit seedling establishment, but a combination of high deer pressure and poor seed supply limit the number of seedlings that can become established.

In this situation, a deer exclosure fence may be all that is required to obtain adequate advance seedlings. Since this requires a substantial investment, some organizations may choose to avoid any activity in this stand at the present time. Either prescription is appropriate.

See the Fencing Prescription for complete description of practices to be used.

Herbicide, Fence, Wait

This prescription is appropriate when advance regeneration is limited, and overstory density is already low enough to permit seedling establishment, but a combination of interfering plants, high deer pressure and poor seed supply limit the number of seedlings that can become established.

In this situation, a combination of herbicide application and deer exclosure fence may be required to obtain adequate advance seedlings. Since this requires a substantial investment, some organizations may choose to avoid any activity in this stand at the present time. Either prescription is appropriate.

See the Fencing prescription and the Herbicide Understory prescription for complete description of practices to be used.

Grapevine Control

Grapevines that grow into the crowns of trees can cause extensive damage by interfering with growth and seed production, and by breaking out the tops of the trees. Damage can be especially severe in young, even-aged stands.

In stands with more than 30 percent of the understory plots stocked with grapevines, it is usually advisable to treat the vines. This can be done by cutting the vines close to the ground. Canopy shade will usually prevent the sprouts from surviving. Where canopy density is low, or where harvest cutting will occur within a few years, cut the vines and treat the cut stumps with an herbicide.

Herbicide Understory

In stands containing dense coverage of ferns, grasses and sedges or woody interfering plants, such as beech root suckers, striped maple, dogwood, sassafras, sourwood, black gum, rhododendron or mountain laurel, shelterwood cutting often stimulates these plants to the point where they interfere with desired reproduction. Such stands can be treated successfully if the undesirable understory plants are removed with an herbicide in conjunction with other measures to reestablish regeneration.

Two herbicides have proven useful in treating interfering understories in Allegheny hardwood stands: Roundup Herbicide, manufactured by Monsanto Agricultural Products Co., and Oust Weed Killer, manufactured by E. I. Du Pont de Nemours and Co.[3]

Roundup is effective in controlling ferns, grasses and sedges, striped maple, and beech when applied to actively growing foliage at the rate of 1 quart per acre (1 lb/acre active ingredient) in 20 to 25 gallons of water per acre. Ferns and grass should be treated from early July through leaf yellowing in mid-September; striped maple and beech should be treated from early August through mid-September. Herbicides with proven effectiveness for laurel and rhododendron are not available.

Oust is effective in controlling ferns and some grasses, but has no activity against striped maple or beech. It should be applied at the rate of 2 oz. of Oust per acre, between early July and leaf yellowing in mid-September.

Both herbicides can be applied from low pressure sprayers, backpack mist blowers, air blast sprayers or hydraulic sprayers. In large forest applications, tracked or rubber-tired vehicles are used to move the sprayer through the stand.

Oust and Roundup are useful either alone, or in mixture with each other.

Roundup is required where woody interference is to be removed since Oust is ineffective on these plants. Roundup will also remove fern and grass, but it will not completely kill ferns where rhizomes are broken off by treads on the vehicles used to carry the sprayer. This often results in reinvasion by fern from the unkilled rhizomes in the track area. Roundup has no effect on seed buried in the forest floor, so it will not prevent grass and sedge reinvasion on areas that have a large buried seed supply. Soil disturbance from skidding can result in reinvasion of grasses and sedges after herbicide treatments that are followed by cutting.

Oust has characteristics that complement Roundup. It is taken up both by foliage and roots, and has short term residual activity. So it is effective on ferns even in areas where the fern rhizomes have been broken by the spray vehicle. And it will reduce grass reinvasion for two years after spraying. Since it is relatively ineffective on woody plants, Oust may not kill desirable advance seedlings intermixed with interfering ferns and grasses.

---

[3] The use of trade firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture or the Forest Service of any product to the exclusion of others that may be suitable.

Where the target vegetation is woody interference alone, and where buried grass seed is not likely to be a problem, we recommend the use of Roundup alone. Where the target vegetation is fern alone, we recommend the use of Oust alone, to kill the ferns while preserving some of the advance regeneration. Where the target species include both groups of interfering plants, we recommend applying a tank mix of both Roundup and Oust.

Much of the cost of herbicide application is in the labor and equipment required to make the application. The additional cost of a second herbicide in tank mix, while important, is considerably less than the cost of two separate applications. The additional cost of the second herbicide can usually be justified if the proportion of plots stocked with interfering species not killed by the first herbicide exceeds 15 percent.

Fencing Against Deer

Area-wide fencing has been used extensively in the Allegheny Plateau of Pennsylvania to protect regeneration against deer browsing. Although it requires a substantial investment, it is often the only way to ensure adequate regeneration in the presence of excessive deer populations. It is recommended alone or in combination with other cultural practices in several prescriptions.

There are two major types of fencing that may be used. Standard woven-wire fences must generally be 8 feet tall and carefully sealed at the ground line, but they can be very effective at excluding deer and require relatively infrequent maintenance. The cost of woven-wire fencing is very high. If used, it is best to install the bottom 4-foot section so that about 6 inches of it rests flat on the ground, bent towards the outside of the fence. Rocks and logs piled on this ground section make an effective seal, although ravines and depressions require special attention. This fence should be stretched tight to minimize damage from falling trees and limbs.

Electric fencing can also be effective if installed properly, but it can be totally ineffective if not installed carefully or if inadequately maintained. Electric fencing is considerably cheaper than woven-wire fencing, but it requires regular maintenance to change batteries, test for electrical continuity, etc. Either vertical or slant designs are effective. We have found a 6-wire vertical design to be the easiest to install and maintain in a reliable way. The wires should be installed so that alternate wires serve as a ground, and so that lower wires can be disconnected when snow builds up around them in the winter. Appropriately-sized solar panels with high-quality, deep discharge batteries, in combination with a charger can considerably reduce battery maintenance. We recommend this type of fencing for operational protection against deer damage.

Fencing has traditionally been installed after the final overstory removal, and its use in that manner is recommended here. However, the benefits of fencing are even greater if applied earlier in the regeneration process. Fences erected at the time of the shelterwood seed cut will not only help ensure adequate numbers of advance seedlings, but will greatly increase the diversity of species that become established. The ability to favor highly preferred species and to increase species diversity, coupled with direct protection from browsing failure, make fencing an especially effective treatment in areas of excessive deer.

Fertilization of Regeneration

Aerial fertilization is a way to circumvent deer browsing in some circumstances. It is generally applied during the second or third year after final overstory removal. Fertilizer prescriptions will be encountered as a part of regeneration follow-up procedures. If surveys of regeneration 2 years after final overstory removal cutting reveal that there are adequate numbers of seedlings present, but that deer browsing is delaying their development, or threatening their survival, fertilization with 200 pounds of nitrogen (as 600 pounds of Ammonium Nitrate) and 43 pounds of phosphorous (as 217 pounds of triple super phosphate) will often stimulate the seedlings to grow rapidly out of the reach of deer. These elements may be mixed together and applied by helicopter.

Fertilization has the added advantage of getting the stand off to a quick start, reducing rotations somewhat in the process. Fertilization circumvents browsing damage not only by stimulating rapid growth, but by producing an abundance of other deer food that takes the pressure off the developing seedling regeneration.

Consider Artificial Regeneration and Fencing

There are several possible treatments that will be encountered in stands that are exceptionally difficult to regenerate. Our recommendation is that activity in these stands be deferred for the present. The substantial investments required in combination with considerable risk that adequate regeneration will not develop make these questionable investments. Instead, we suggest that attention and investment be concentrated in other stands that are more likely to succeed. However these treatments are offered as an alternative if some action is considered necessary in these stands. All of these treatments are heavily shaded in Prescription Chart E to call attention to the fact that they are treatments to be considered, not recommended prescriptions.

Most of these questionable treatments arise in stands that have very poor seed supplies, or moderately poor seed supplies in combination with high deer pressure. This situation is common in stands that lack good seed producing species. In oak stands that have limited oak seed sources, and where regeneration dominated by species other than oaks is unacceptable, these treatments may also be appropriate to consider.

In oak stands in particular, the use of individual tree shelters, rather than area fencing, is worthy of consideration. Tree shelters have been shown to increase oak seedling growth in addition to protecting against browsing. Since slow initial growth of oak seedlings relative to other species is an important factor in oak regeneration failure, use of these shelters in areas of high deer pressure may help to get the oaks out above both the deer and their competition. Like the other treatments in this group, however, this treatment is presented as one to be considered rather than as a prescription.

Artificial regeneration may be done either by seeding or planting. Seeding is usually best done as spot seeding on prepared seedbeds, with seed buried, or at least pressed into, the soil. Oaks have been seeded successfully if the acorns are adequately protected against rodents.

Hardwoods can be planted on cutover sites or in shelterwood situations successfully if protected against animal damage, and if large, vigorous, stock in good condition is used. Control of any interfering plants is essential, and fertilizer applied at the time of planting is usually a good supplementary investment.

Regeneration Follow-up

When a final regeneration treatment is prescribed, it is important that periodic checks be made to ensure that the regeneration actually develops after the treatment is applied. As before, a survey of the regeneration using 6-foot-radius sample plots is recommended (Fig. 9). In even-age silviculture, the first inventory should be made about 2 years after cutting, and additional surveys should be made as indicated by the results of the first one.

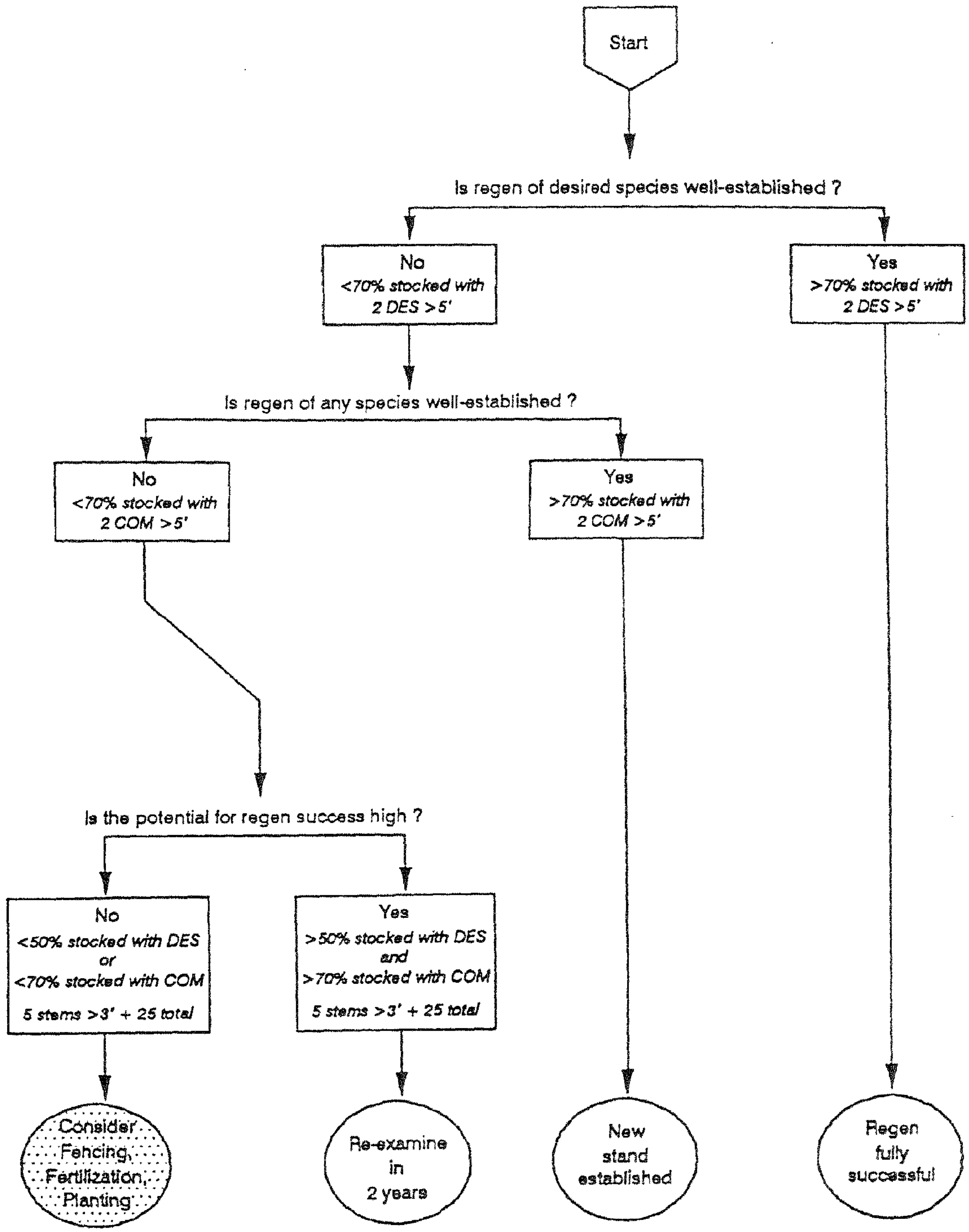
At this stage of development, plots are judged as stocked if they have: (a) 25 stems per plot total, (b) 5 stems over 3 feet tall, or (c) 2 stems over 5 feet tall. Only when at least 70 percent of the plots have 2 stems over 5 feet tall can the new regeneration be considered successful. At that point, most of the regeneration will be above the reach of deer and the stand is safely established. Before that time, the average proportion of the other two stocking measures provide an indication of the probable outcome.

If the probable outcome is not satisfactory, fertilization or fencing should be considered. If failure is apparent, planting (probably with herbicide control of herbaceous plants) might be required. Planting should almost always be accompanied by protection and fertilization.

Obviously, the costs of reclaiming failed regeneration cuts can be very high, and should be avoided. The guidelines described for advance reproduction, interfering plants, site limitations, and choice of cutting methods should minimize such failures and provide reasonable assurance of success in most situations.

Figure 9.

Chart F. Regeneration Follow-up



Distribution Of Cut

In any partial cutting, trees should be selected for cutting or retention to achieve the desired density, structure, and quality in the residual stand. The desired structure, in particular, varies with the type of partial cutting prescribed. To decide which trees should be cut, use the following guidelines.

First priority is to maintain the desired residual stand density. Second priority is to remove all unacceptable growing stock trees before better quality trees are cut. And third priority is to cut so as to achieve the desired stand structure (size-class distribution). Species composition--a factor in both stand quality and structure--may also be altered by cutting. All else being equal, stand markers should generally favor the most valuable species, or with all-aged cuttings, the most valuable shade-tolerant species. However, no special consideration is given to species composition in distributing the cut, since the procedure used automatically favors the larger trees, which are usually the more valuable species in the stand.

In selection cuts and thinnings, residual stand density should be 60 percent, except where this would mean removal of more than 35 percent of the relative density in one cut. In these cuts, residual stand density should be 65 percent of the existing density. Residual densities in even-aged regeneration cuts are not subject to the above limitation. Seed cuts should be made to leave the prescribed 50 or 60 percent relative density regardless of how much must be removed to achieve it. The first harvest cut of a three-cut shelterwood should likewise reduce relative density to 30-35 percent all at one time to achieve desired results.

Stand structure goals in thinnings and shelterwood cuts are achieved indirectly. We do not know exactly what stand structure we should try to create in these mixed hardwood stands, many of which do not exhibit the textbook type of even-aged bell-shaped curve. So, we attempt to move the structure toward the theoretical ideal by cutting more heavily from the smaller trees than the larger ones. This increases stand diameter, reduces time to maturity, and reduces the diversity of diameter classes present, altering the distribution of diameters toward a bell-shaped curve without assuming any particular curve as ideal. A table showing the proportion of the cut that should come from each major size class is used to distribute the cut (Table 6). The values in this table were calculated using the assumption that two-thirds of the cut basal area (three-fourths of the cut relative density) should come from below the stand diameter, and the rest from above the stand diameter.

Stand structure goals are achieved in selection cuttings by setting up a residual structure goal based on the maximum tree size, q factor, and residual density prescribed. A table of appropriate goals are used for this purpose (Table 6). Then, any trees that are in excess of those goals (within each major size class) are cut. However, no saplings are cut--the structure goals are set up so as to exclude saplings and achieve the desired structure within the merchantable size classes only.

Quality goals are achieved as an adjustment to the structural goal. After the initial structural goal for a thinning, shelterwood cut, or selection cutting has been established, the goal is compared, by size class, with the inventory data on tree quality. If acceptable quality trees are being cut in one size class while unacceptable quality trees are being left in another, an adjustment that does not alter the residual density is made.

In commercial thinnings, a minor deviation from the procedure above is made in those stands that contain substantial amounts of large sawtimber (trees 24 inches and larger). Since such trees are generally mature, up to 50 percent of them may be removed, allowing more of the smaller sawtimber sizes that are increasing more rapidly in value to remain.

The distribution of cut for commercial thinnings assumes that there is adequate volume of both sawtimber and pulpwood, to make a sale involving both products feasible. In cases where sawtimber volumes are limited and the sale is to include only pulpwood, a redistribution of cut should be made. The density of good quality (AGS) sawtimber that would have been removed should be taken instead from the poletimber-size class.

The stand diameter to be used in the distribution of cut depends upon the prescription. In combined TSI-Commercial Thinnings, sapling-size trees are to be cut, so the diameter of the entire stand (MD) is the appropriate one to distribute the cut around. In commercial thinnings, and shelterwood cuts, no saplings are cut, so the diameter of only the merchantable-size trees (MDM) is used.

The cut in Precommercial Thinnings and Thin-Harvests is not distributed as above, but is special. Since no commercial sale is involved in a Precommercial Thinning, cutting occurs strictly from the unacceptable growing stock, the noncommercial species, and the smallest trees in the stand. No merchantable trees of good quality are cut, since this might reduce total stand yield over the long term.

In Thin-Harvests, the cutting is very heavy in the large sawtimber and poletimber size classes. Such stands are within 15 years of maturity; the poles will not grow into valuable sawtimber size before final harvest so there is little reason to save them. The large sawtimber trees are already mature and might as well be harvested. This preserves for the final harvest the maximum number of small and medium sawtimber trees that are increasing in value most rapidly.

In all partial cuttings, unacceptable growing stock trees are removed first, even if this means that the structure goals cannot be met. Within this limit, the cutting is done so as to come as close to the desired structure as possible. Mechanics of distributing the cut follow.

Instructions for Distribution of Cut

The overstory data and guidelines on partial cutting can be used to calculate how much of each size and quality class should be cut to achieve the prescribed effect. This distribution of cut provides the information that timber markers need to achieve the desired structure in the residual stand. The calculations can be done by computer or by hand, using the Distribution of Cut Worksheet (Figure 10). Calculations for intermediate cuttings under even-aged silvicultural systems and those for selection system cuts are made using the same worksheet. The steps described below are easiest to follow if Figure 10 and Appendices A through F are consulted as examples.

The distribution of cut occurs in four major phases. The first is selection of stand density and structure parameters based on the prescription selected. Next, structure parameters are adjusted to fit the actual size distribution in the particular stand. This step is slightly different for even-age and all-age prescriptions. The third phase adjusts the structure once again to remove the maximum proportion of UGS possible within the relative density constraints already established. The final phase translates the result into marking guides (ratios), and into basal area for cut and residual stands. We recommend carrying these calculations to one decimal place.

In Phases I, II and III there are several alternate paths, depending on the prescription and conditions in the particular stand. In the explanations below, these alternate paths are written in smaller type; be certain to select the appropriate path from the several alternatives listed. The several choices are identified by statements that begin: ***"If this is a . . ."*** or ***"If the total of Column 6 is . . ."***.

Phase I. Prepare worksheet and determine density and structure parameters.

1. *Transfer the original relative density* from the Manual Overstory Summary form (totals block in the lower right corner) to Column 1, Distribution of Cut Form, for each size class and for the total. Include saplings, even if none are to be cut.

2. *Transfer UGS relative density* from the Manual Overstory Summary form (summary block of the UGS section, near the center right) to Column 7, Distribution of Cut Form.

If there will be no cutting in the sapling class, . . .
. . . record no saplings.

If this is the seed cut of a shelterwood sequence, and the stand contains 5 or more square feet of basal area per acre in noncommercial saplings and poles, . . .

. . . include these noncommercial sapling UGS in Column 7.

If there will be cutting in the sapling class, . . .
. . . record sapling UGS.

3. *Total the UGS recorded.*

4. *Transfer the original basal area per acre* from Manual Overstory Summary form (total block in the lower right hand corner) to Column 12, Distribution of Cut Form, for each size class and for the total.

5. *Determine the residual density for this treatment.*

If this is a thinning or selection cut . . .
. . . multiply the original relative density (Total, Column 1) by 0.65. If this number is 60 percent or more, record it in the total row of Column 5. If it is less than 60 percent, record 60 percent.

If this is a shelterwood seed cut in an area with moderate to high deer pressure, . . .
. . . record 60 percent.

If this is a shelterwood seed cut in an area with low deer pressure, . . .
. . . record 50 percent.

If this is the second cut (first removal cut) of a three-cut shelterwood sequence, . . .
. . . record 35 percent.

Record the desired residual density in the Total row, Column 5.

6. *Determine the density to be removed in this treatment.* Subtract the desired residual density (Total, Column 5) from the original relative density (Total, Column 1). Record this value in the Total row, Column 6.

7. *Determine the size class distribution for this treatment.* Copy the goal percents for each size class from Table 6 (Cut relative density to come from and relative density to be retained in various size classes, in percent, page 80) to Column 2, Distribution of Cut Form, by size classes. Use the line on Table 6 for the appropriate prescription and stand diameter. Record the percents as proportions; that is, divide each by 100 and record.

Phase II. Adjust the structure to fit the size class distribution of the actual stand.

If this is an even-aged treatment . .

1. Multiply the proportions in Column 2 by the Cut Density in the Total Row of Column 6. Record these values in Column 3.

2. Total Column 3 to be certain that the total cut goal is the same as the Total of Column 6.

3. For each size class, subtract the values in Column 3 (density to be cut) from the values in Column 1 (original density). Record only negative answers in Column 4.

If there are no negatives, . . .
. . . copy the numbers from Column 3 to Column 6 and proceed to Phase III.

If there are negatives, . . .
. . . an adjustment is required. Negatives occur in Column 4 when the original stand has less density in a particular size class than the planned cut. Increase the cut in other classes by writing positive numbers in those rows where the cut is to be increased. Make these increases in the smaller size classes to the extent possible. Do not increase the cut in any size class to more than is available (the value in Column 1).

Check to be sure that the adjustments balance; that is that the sum of the positive and negative numbers in Column 4 is zero.

Calculate the adjusted cut for each size class by summing Column 3 and Column 4. Record the answers in Column 6. Check to be certain that the total of the values in Column 6 equals the total already written there. Proceed to Phase III.

If this is an all-aged treatment . . .

1. Since no saplings will be cut in these treatments, transfer the original relative density of the sapling class from Column 1 to Column 3.

2. Determine the residual density of the merchantable size classes by subtracting the sapling density from the total Residual Density (Total, Column 5). Record the answer in the space above Column 3.

3. Determine the distribution of this merchantable residual among the size classes. Multiply the proportions already written in Column 2 by the merchantable residual above Column 3. Record each answer in the appropriate size class in Column 3.

4. Total Column 3 and be certain that the total residual goal is the same as the total of Column 5.

5. For each size class, compare the planned residual structure with the existing structure by subtracting the values in Column 3 from the values in Column 1. Record negatives only in Column 4.

If there are no negatives,. . .
. . . the cut can be implementedas planned. Copy the values for each size class in Column 3 to Column 5, Residual Goal. Calculate the Cut Goal by subtracting Column 5 from Column 1 for each size class. Record the answers in Column 6. Proceed to Phase III.

If there are negatives, . . .
. . . an adjustment is required. Negatives in Column 4 reflect deficiencies in the current stand compared to the desired residual. Increase the residual in other classes to ensure that the correct residual density is left. Do not increase the residual in any class above the density in the original stand, or the value in Column 1. Record increases as positive numbers in Column 4. In general, increase the residual in smaller classes. The best trees in these classes will grow faster and smooth out the deficiencies prior to the next cut.

Be certain that the adjustments balance; that is, that the sum of the positive and negative numbers in Column 4 is zero.

Determine the actual residual goal by summingthe initial goal in Column 3 and the adjustments in Column 4 for each size class. Record the answers in Column 5. Be certain that the sum of the values in Column 5 is equal to the total already written there.

Determine the cut goal for each size class by subtracting Column 5 from Column 1 and recording the answers in Column 6. Proceed to Phase III.

Phase III. Adjust the planned cut to remove the maximum proportion of UGS from the stand within established density constraints.

1. *Determine the quality effects of the planned cut.* Subtract the original relative density of UGS (Column 7) from the planned cut (Column 6). Record the answers in Column 8. Positive values in Column 8 represent AGS being cut, and negative values represent UGS being left in the stand.

2. *Determine whether an adjustment is required and possible.*

If all the answers have the same sign (positive or negative), . . .
. . . adjustment is either not required or not possible. Copy all values from Column 6 to Column 9 and proceed to Phase IV.

If some of the differences are positive and some negative, . . .
. . . an adjustment to increase the UGS removed is required. The nature of the adjustment depends on the totals of Column 6 and Column 7.

3. *Make the adjustment, if required.*

If the total of Column 6 is greater than the total of Column 7 (that is, the planned cut exceeds the UGS) . . .

1. Erase or strike out the positive numbers in Column 8.

2. Change the negative numbers to positives. Because the relative density of the planned cut exceeds the relative density of UGS in Column 7, all the UGS in Column 7 can be removed in this treatment. The numbers just made positive represent increased cuts in those classes where UGS were to be left.
3. Decrease the cut in the remaining classes to balance the increases recorded in Step 2. Record the decreases as negative numbers in Column 8. Be sure not to decrease the cut so far as to leave UGS in these classes--that is, be certain that Column 6 minus your adjustment in Column 8 is greater than or equal to the value in Column 7.

4. Be certain that the adjustment is balanced; that is, that the sum of the positive and negative numbers in Column 8 is zero.

5. Determine the adjusted cut by summing the values in Column 6 and the values in Column 8 for each size class. Record the answers in Column 9. Be certain that the sum of Column 9 equals the Total, Column 6. Proceed to Phase IV.

If the total of Column 6 is less than the total of Column 7 (that is, the UGS exceed the planned cut) . . .

1. Erase or strike out the negative numbers in Column 8.

2. Change the positive numbers to negatives. Because the relative density of the UGS exceeds the planned cut, the entire cut should be UGS. The numbers just made negative represent decreased cuts in those classes where AGS were to be cut.

3. Increase the cut in the remaining classes to balance the decreases recorded in Step 2. Record the increases as positive numbers in Column 8. Be sure not to increase the cut in any size class so far as to cut AGS in that class; that is, be certain that the sum of Column 6 plus these adjustments in Column 8 is less than or equal to the value in Column 7 for each size class.

Table 6. - Cut relative density to come from and relative density to be retained in various size classes, in percent.

DIAMETER	SAPS	POLES	SSAW	MSAW	LSAW[1]
	EVEN-AGE SILVICULTURE CUT RELATIVE DENSITY TO COME FROM VARIOUS SIZE CLASSES				
MDM	Commercial Thinning and Shelterwood Cutting[2]				
8	--	100	0	0	0
9	--	96	4	0	0
10	--	88	12	0	0
11	--	81	19	0	0
12	--	74	24	2	0
13	--	68	26	6	0
14	--	63	27	10	0
15	--	58	28	13	1
16	--	54	28	14	4
17	--	51	27	15	7
MD	Combined TSI - Commercial Thinning				
4	91	9	0	0	0
5	82	18	0	0	0
6	74	26	0	0	0
7	67	29	4	0	0
8	61	30	9	0	0
9	55	31	14	0	0
10	51	31	15	3	0
	Precommercial Thinning				
--	100	0	0	0	0
	Thin-Harvest				
--	--	50	5	15	30[3]
	ALL-AGE SILVICULTURE RELATIVE DENSITY TO BE RETAINED IN VARIOUS SIZE CLASSES				
	Standard Selection Cutting (Mgmt Goal 3)				
	--[4]	41	37	22	0
	Single-tree Selection Cutting with Maximum Large Trees (Mgmt Goal 4)				
	--[4]	22	30	27	21

[1] For commercial thinning only, take up to 50 percent of original density in large saws and adjust other sizes proportionally.
[2] Note that shelterwood cuts being made in stands that contain 5 or more square feet of basal area per acre in noncommercial (UGS) saplings and poles should include removal of all noncommercial stems (usually by injection with an herbicide) even though no other cutting will occur in the sapling class.
[3] For thin-harvest only, take up to 75 percent of original density in large saws and adjust other sizes proportionally.
[4] In all-age cuts, all existing sapling density is retained.

Figure 10.

SILVAH - Distribution of Cut Worksheet

Stand ID

USDA, Forest Service, NEFES, Warren, PA 1/91

	Relative Density											Basal Area		
Size Class	Original Stand 1	Goal % 2	Initial Goal 3	Adjust 4	Residual Goal 5	Cut Goal 6	Original UGS 7	Adjust 8	Total Cut 9	% Cut 10	Cut Ratio 11	Original Stand 12	Cut 13	Residual 14
Saplings														
Poles														
Small Sawtimber														
Medium Sawtimber														
Large Sawtimber														
Total														
	From Tally Sheet	% from Table 6	All- or Even-aged ?	Record shortages / BALANCE	EA: N/A / AA: 3+4	EA: 3+4 / AA: 1-5	From Tally Sheet	Record excess UGS / BALANCE	6+8	9/1		From Tally Sheet	$\frac{10*12}{100}$	12-13

4. Be certain that the adjustment is balanced; that is, that the sum of the positive and negative numbers in Column 8 is zero.

5. Determine the adjusted cut by summing the values in Column 6 and the values in Column 8. Record the answers in Column 9. Be certain that the sum of Column 9 equals the total of Column 6. Proceed to **Phase IV.**

Phase IV. Translate the planned cut to a marking guide and to basal area.

1. *Calculate the percent cut* in each size class: Divide Column 9 by Column 1 and multiply by 100. Record the answers in Column 10.

2. *Determine the cut ratio* by translating the percents in Column 10 to proportions and reducing these to simple fractions. For example, if 52 percent of the poles are to be cut, this is the same as 52/100, which can be reduced to approximately 1/2 of the poles. Avoid fractions finer than 5ths. Record the ratios in Column 11.

3. *Determine the cut basal area* for each size class by multiplying the percents in Column 10 times the basal areas in Column 12 and dividing by 100. Record these values in Column 13. The sum of these values is the total basal area cut. These values can be converted to crude volumes using the basal area factors from the Overstory Tally - Manual Summary form.

4. *Determine the residual basal areas* for each size class by subtracting the cut values in Column 13 from the original stand values in Column 12. Record the answers in Column 14.

The distribution of cut ratios described above are all calculated automatically by the computer program, and they are printed in the narrative section of the computer printout as marking instructions. Data on the residual and cut stands are also included.

Timber Marking Procedures

The final step in the SILVAH system is to apply the prescription just prepared by marking the forest stand in accordance with the marking instructions. This will ensure that all the research results incorporated in the guidelines are applied on the ground, and that the residual stand after treatment will have the density, structure, species composition, and quality that have been so carefully planned. If this task is not performed properly, all of the time and effort expended in the previous steps will have been wasted.

Most markers are accustomed to marking stands to a specific residual basal area and to selecting trees for removal so as to improve tree spacing, total stand quality, and to regulate species composition. The SILVAH system incorporates control of stand structure as well. Now markers must make an effort to remove the desired density in *specific* tree sizes.

During the calculations for the SILVAH system, figures were carried to tenths of square feet of basal area. Then those precise calculations were reduced to broad ratios, like 1:5 large sawtimber or 2:3 poles for marking. If calculations are rounded off too soon, the ratios arrived at will be very different, due to the accumulation of errors. But with precise calculations rounded at the end, the ratios developed are adequately precise for marking, based on sound figures, and easy to apply with a little practice.

To use these ratios in the forest, stop at regular intervals through the stand and consider the circle of trees around you. Decide which trees are best to leave for the final crop and decide which of the trees in the circle must be removed to achieve the residual density goal and improve the growing conditions for these trees. The ratios are intended to help you achieve this. If the medium sawtimber ratio developed in the calculations is 1:5 and there are five medium sawtimber trees, choose the best four and mark the remaining one. If the pole ratio is 2:3, and there are six pole-size trees in the circle, choose the best two trees that do not interfere with the sawtimber. Leave these and mark the other four. Do the same in the other size classes, using the appropriate ratios. If you let your marking be guided by the ratios, you will achieve both the desired structure and the desired density.

The ratios automatically help you adjust your marking as conditions within the stand vary. Whatever your ratios, you will automatically mark more heavily in areas where the stand is dense, and more lightly in areas that are sparse. Do not allow the ratio to override other basic principals or common sense, and do not try to compensate from one spot to the next.

Marking is a phase of the SILVAH system that calls for professional experience and judgment. The ratios developed by the computer or the manual calculations provide guidelines that enable the marker to meet the landowner objectives by setting stand structure, density, quality, and species composition. But these guidelines will best achieve those objectives if implemented with full professional concern for tree quality, spacing, risk factors, and the variability encountered on the ground.

APPENDICES

Appendix A. Sample Manual Overstory Tally Form.

SILVAH - Manual Overstory Tally Form

Stand ID

USDA, Forest Service, NEFES, Warren, PA 1/91

AGS Size class		Black cherry	White ash	Yellow poplar	Red maple	N. Red oak	Eastern hemlock	All others	Sugar maple	Amer. beech	Striped maple	Other oaks, hickory
Saplings 1.0 – 5.5"	Dot				1			1	3	3		
	BA				.5			.5	1.6	1.6		
Poles 5.5 – 11.5"	Dot	5	1		14			3	19	3		
	BA	2.6	.5		7.4			1.6	10.0	1.6		
Small Saws 11.5 – 17.5"	Dot	47	10		34			3	9	2		
	BA	24.7	5.3		17.9			1.6	4.7	1.1		
Medium Saws 17.5 – 23.5"	Dot	47	2		4							
	BA	24.7	1.1		2.1							
Large Saws 23.5" +	Dot	1										
	BA	.5										
Total Basal area Poles & larger		52.5	6.9		27.4			3.2	14.7	2.7		

UGS Size class		Black cherry	White ash	Yellow poplar	Red maple	N. Red oak	Eastern hemlock	All others	Sugar maple	Amer. beech	Striped maple	Other oaks, hickory
Saplings 1.0 – 5.5"	Dot				2				4	7		
	BA				1.1				2.1	3.7		
Poles 5.5 – 11.5"	Dot	1			5			2	15	3		
	BA	.5			2.6			1.1	7.9	1.6		
Small Saws 11.5 – 17.5"	Dot	13			12			1	7	1		
	BA	6.8			6.3			.5	3.7	.5		
Medium Saws 17.5 – 23.5"	Dot	9			6							
	BA	4.7			3.2							
Large Saws 23.5" +	Dot											
	BA											
Total Basal area Poles & larger		12.0			12.1			1.6	11.6	2.1		
AGS + UGS BA Poles & larger		64.5	6.9		39.5			4.8	26.3	4.8		

Plot	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Conversion factor
Count	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		BAF/# plots 10/19 = .526

BA = Dots * Conversion factor

Appendix B. Sample Manual ID & Regen Tally Form.

SILVAH - ID & Regen Tally Form

Identification Data

USDA, Forest Service, NEFES, Warren, PA 1/91

Sheet 1 of 3

Owner/Agency	USFS					
Forest/Property	KANE EXP FOREST					
County/District	ELK					
Compartment/Unit	171	Stand No.	23			
Remarks						
Species Codes	1	dbh classes	2	Tally month	04	Year 1989
Overstory Cruise	Type 7	# plots	19	BAF/plot size	10.00	
Regen Cruise	Type 2	# plots	38	Plot size	1	
Acreage in stand	100.0	Stand age	0			
Cover Type		Habitat type		Soil type		Site class
Site species		Site Index		Height adjustment		
Elevation		Aspect		Slope %		Topo. position
Operability		Access		Water code		Water code
Acres W/I 1 mi.	Clearcuts		Cultivation		Open	Water code
Management goal	1	Mgmt. value	1	Deer impact index	4	Gypsy moth · Stress

Notes

Regeneration Data

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	#	%
1 Black cherry	30	40	15	25		40	75	50	20	15	25	10	30		25	10	15		30	5	18	47
2 Small oak																						
3 Other desirables	5	10	25	20		50	20	20	75	100	50		5	5		25	50	75	75	50		
4 All desirables 1+2+3	35	50	40	45		90	95	70	95	115	75	10	35	5	25	35	65	75	105	55	2	5
5 Large oak																						
6 Any small regen 1,2,4, or 5	✓	✓		✓		✓	✓	✓		✓	✓		✓		✓				✓		19	50
7 Residuals				SM					SM													
8 Any regen or Res. 6 or 7	✓	✓		✓		✓	✓	✓	✓	✓	✓		✓		✓				✓		20	53
9 Sapling regen																						
10 Woody interference	12		5							8	5	9	25								2	5
11 Laurel & Rhododendron																						
12 Ferns	5	5		25	30	15		5	10	15	20	30	40	50		10	5		15	20	4	11
13 Grasses																						
14 Any interfr. 10, 11, 12 or 13	✓				✓							✓	✓	✓							5	13
15 Grapevines																						
16 Site limitations																						

Appendix C. Sample Manual Overstory Summary form.

SILVAH - Manual Overstory Summary

Stand ID

USDA, Forest Service, NEFES, Warren, PA 1/91

AGS		BC-WA-YP			RM-NRO-EH-Oth			SM-AB-StM-OO			All Species AGS		
Size class		BA	RD	BdFt	BA	RD	BdFt	BA	RD	BdFt	BA	RD	BdFt
Saplings	value				1.0	1.2		3.2	3.7		4.2	4.9	
	f		1.44			1.21			1.17				
Poles	value	3.1	1.9		9.0	6.8		11.6	11.5		23.7	20.2	
	f		0.60			0.75			0.99				
Small Saws	value	30.0	11.7	2520	19.5	11.1	1248	5.8	5.5	371	55.3	28.3	4139
	f		0.39	84		0.57	64		0.94	64			
Medium Saws	value	25.8	8.0	3302	2.1	1.0	223				27.9	9.0	3525
	f		0.31	128		0.49	106		0.92	106			
Large Saws	value	.5	0.1	74							0.5	0.1	74
	f		0.27	148		0.44	120		0.91	120			
All Sizes AGS	value	59.4	21.7	5896	31.6	20.1	1471	20.6	20.7	371	111.6	62.5	7738

UGS		BC-WA-YP			RM-NRO-EH-Oth			SM-AB-StM-OO			All Species UGS		
Size class		BA	RD	BdFt	BA	RD	BdFt	BA	RD	BdFt	BA	RD	BdFt
Saplings	value				1.1	1.3		5.8	6.8		6.9	8.1	
	f		1.44			1.21			1.17				
Poles	value	.5	0.3		3.7	2.8		9.5	9.4		13.7	12.5	
	f		0.60			0.76			0.99				
Small Saws	value	6.8	2.7	286	6.8	3.9	218	4.2	3.9	134	17.8	10.5	638
	f		0.39	42		0.57	32		0.94	32			
Medium Saws	value	4.7	1.5	301	3.2	1.6	170				7.9	3.1	471
	f		0.31	64		0.49	53		0.92	53			
Large Saws	value												
	f		0.27	74		0.44	60		0.91	60			
All Sizes UGS	value	12.0	4.5	587	14.8	9.6	388	19.5	20.1	134	46.3	34.2	1109

Multiply factor (f) by basal area (BA)

AGS + UGS		All Species							
Size class		MDM	MD	BA*f	BA*f	Cords	BA	RD	BdFt
Saplings	value				33.3		11.1	13.0	
	f				3.0				
Poles	value			317.9	317.9	6.7	37.4	32.7	
	f			8.5	8.5	0.18			
Small Saws	value			1060.0	1060.0	16.1	73.1	38.8	4777
	f			14.5	14.5	0.22			
Medium Saws	value			733.9	733.9	8.6	35.8	12.1	3996
	f			20.5	20.5	0.24			
Large Saws	value			13.3	13.3	0.1	0.5	0.1	74
	f			26.5	26.5	0.28			
All Sizes	value	14.5	13.7	2125.0	2158.3	31.5	157.9	96.7	8847

Appendix D. Sample Prescription Summary Worksheet.

SILVAH - Prescription Summary Worksheet

Stand ID

USDA, Forest Service, NEFES, Warren, PA 5/90

Years to Maturity

Species	BA	BA Sums	f	BA*f
Black cherry	64.5			
White ash	6.9			
Yellow poplar				
Red maple	41.1	117.8	.20	23.5
No. red oak				
Eastern hemlock				
All others	5.3			
Sugar maple	30.0			
American beech	10.1	40.1	.15	6.0
Striped Maple				
Other oaks, hick.				
Total		157.9	.19	29.5

Yrs. to Mat. = (18 − MDM)/growth factor (2)

$(18 - 14.5)/.19 = \frac{3.5}{.19} = 18$

Seed Source Index

Species	f	BA Poles +	M Seedlings BA*f
Black cherry	4.0	64.1	256.4
Sugar maple good	2.4		
Sugar maple poor	1.2	26.3	31.6
White ash	1.5	6.9	10.4
Red maple	1.5	39.5	59.3
Oaks	1.0		
Total			357.7

M Seedlings (4)	0 −32	33−83	83−134	135+
Seed Source Index	4	3	2	(1)

Shade Tolerant Composition

Species	Total basal area
Sugar maple	30.0
American beech	10.0
Eastern hemlock	
Total	40.1

Oak Stump Sprouting

Species	Size	BA	f	Sprouting stumps BA*f
N.Red Oak	Saps		20.4	
	Poles		1.7	
	SSaw		0.4	
	MSaw		0.1	
	LSaw		0.0	
Other oaks	Saps		18.6	
	Poles		2.1	
	SSaw		0.4	
	MSaw		0.1	
	LSaw		0.0	
Total				

Adv. Regen Adjustment	0	5	10	15	20
Stumps @ high deer (5)	0	46	97	147	198
Stumps @ low deer (5)	0	21	46	71	97

Prescription Variables

Site & Environmental Factors

Management Goal	1
Deer impact index	4
Seed source index	1
Site limitations	0

Understory Factors

Any small regen	50
Any regen or residuals	53
Any small regen − no deer	76
Any regen or residuals − no deer	76
Sapling regen	0
Any interference	13

Overstory Factors

Sapling basal area	11
Shade tolerant basal area	40
Relative stand density	97
Relative density AGS	63
Stand diameter (MD)	13.7
Merch. stand diameter (MDM)	14.5
Years to maturity	18

Prescription:

COMMERCIAL THINNING

Appendix E. Sample Distribution of Cut - Commercial Thinning.

SILVAH - Distribution of Cut Worksheet

Stand ID COMP. 171, STAND 23 - COMMERCIAL THIN

USDA, Forest Service, NEFES, Warren, PA 1/91

	Relative Density											Basal Area		
Size Class	Original Stand 1	Goal % 2	Initial Goal 3	Adjust 4	Residual Goal 5	Cut Goal 6	Original UGS 7	Adjust 8	Total Cut 9	% Cut 10	Cut Ratio 11	Original Stand 12	Cut 13	Residual 14
Saplings	13.0	–	–				–					11.1	–	11.1
Poles	32.7	63	21.3	✓		21.3	12.5	-1.1	20.2	62	3/5	37.4	23.2	14.2
Small Sawtimber	38.8	27	9.1	✓		9.1	10.5	+1.4	10.5	27	1/4	73.1	19.7	53.4
Medium Sawtimber	12.1	10	3.4	✓		3.4	3.1	-0.3	3.1	26	1/4	35.8	9.3	26.5
Large Sawtimber	0.1	0	0	✓								0.5	–	0.5
Total	96.7		33.8		62.9	33.8	26.1	0	33.8			157.9	52.2	105.7
	From Tally Sheet	% from Table 6	All- or Even-aged ?	Record shortages / BALANCE	EA: N/A / AA: 3+4	EA: 3+4 / AA: 1-5	From Tally Sheet	Record excess UGS / BALANCE	6+8	9/1		From Tally Sheet	10*12 / 100	12-13

Appendix F. Sample Distribution of Cut - Standard Selection Cut.

SILVAH - Distribution of Cut Worksheet

Stand ID COMP. 171, STAND 23 - STANDARD SELECTION

USDA, Forest Service, NEFES, Warren, PA 1/91

Size Class	Relative Density: Original Stand	Goal %	Initial Goal	Adjust	Residual Goal	Cut Goal	Original UGS	Adjust	Total Cut	% Cut	Cut Ratio	Basal Area: Original Stand	Cut	Residual
	1	2	3 49.9	4	5	6	7	8	9	10	11	12	13	14
Saplings	13.0		13.0		13.0							11.1	—	11.1
Poles	32.7	41	20.5	✓	20.5	12.2	12.5	+0.3	12.5	38	2/5	37.4	14.2	23.2
Small Sawtimber	38.8	37	18.5	✓	18.5	20.3	10.5	-2.3	18.0	46	1/2	73.1	33.6	39.5
Medium Sawtimber	12.1	22	11.0	✓	11.0	1.1	3.1	+2.0	3.1	26	1/4	35.8	9.3	26.5
Large Sawtimber	0.1			✓	0.0	0.1			0.1	100	ALL	0.5	0.5	—
Total	96.7		63.0		62.9	33.8	26.1		33.7			157.9	57.6	100.3
	From Tally Sheet	% from Table 6	All- or Even-aged ?	Record shortages / BALANCE	EA: N/A / AA: 3+4	EA: 3+4 / AA: 1-5	From Tally Sheet	Record excess UGS / BALANCE	6+8	9/1		From Tally Sheet	10*12 / 100	12-13

Appendix G. Sample Stand Analysis Tally Form.

SILVAH - Computer Overstory Tally Form

USDA, Forest Service, NEFES, Warren, PA 1/91

Overstory Data

Stand ID COMP 171, STAND 23 Sheet 1 of 3

Species	dbh	Quality	Ht. or Count	Grade	Defect	Crown	Wildlife	Species	dbh	Quality	Ht. or Count	Grade	Defect	Crown	Wildlife	Species	dbh	Quality	Ht. or Count	Grade	Defect	Crown	Wildlife
BC	18	1	2					RM	12	2		6				SM	12	1	1				
SM	2	2						SM	6	1						AB	14	2		8			
BC	16	1	4					SM	10	2						SM	8	2		6			
BC	12	1	1					RM	14	1	4					AB	6	2		6			
BC	18	1	4					RM	10	1						0							
RM	8	1						BC	22	1	5					SM	4	1					
RM	8	1						B	10	1						AB	6	2		6			
RM	10	1						AB	6	2						RM	14	1	2				
RM	14	1	1					BC	22	2	3					RM	12	1	1				
RM	16	1	1					RM	14	1	4					SM	6	1					
RM	18	2	1					RM	12	2		6				SM	10	2		6			
BC	12	1	2					0								BC	18	1	4				
RM	8	1						SM	8	1						BC	14	1	2				
RM	8	1						BC	16	1	4					BC	18	1	4				
RM	14	1	2					BC	14	1	4					BC	18	1	3				
0								BC	12	2	2					BC	18	1	3				
RM	12	1	2					BC	16	1	4					BC	18	1	4				
RM	20	2		8				BC	20	1	4					BC	16	1	3				
RM	18	2		8				SM	4	1						BC	16	1	3				
RM	12	1	2					WA	8	1						0							
RM	16	1	3					BC	16	1	3					BC	20	1	5				
BC	20	1	5					BC	16	1	3					SM	8	2		6			
RM	6	2						BC	18	1	3					BC	20	1	6				
RM	4	1						WA	14	1	3					SM	6	1					
BC	18	1	2					SM	2	2		6				SM	12	1	1				
BC	22	1	6					BC	12	2	1					RM	10	2		6			
RM	14	2	1					BC	22	1	4					SM	10	1					
RM	12	1	1					WA	20	1	4					SM	14	1					
BC	12	2		6				BC	18	1	3					0							
BC	20	1	3					0								RM	10	1					
0								SM	6	1						RM	12	2		6			
SM	10	1						AB	2	1						RM	10	1					
BC	18	2	3					BC	18	2	3					RM	18	1	4				
RM	16	1	3					BC	16	1	3					AB	8	2		8			
SM	10	2						SM	6	1						RM	8	1					
SM	10	1						SM	10	1						RM	12	1	1				
BC	18	1	3					SM	10	1						RM	16	1	4				
RM	16	1	2					BC	16	2	2					RM	8	2		6			

Appendix H. Sample printout from SILVAH stand inventory, analysis, and prescription program

SILVAH -- SILVICULTURE OF ALLEGHENY HARDWOODS - V4.50
STAND SUMMARY, PRESCRIPTION, AND MANAGEMENT SIMULATOR PROGRAM
DEVELOPED BY THE NORTHEASTERN FOREST EXPERIMENT STATION, WARREN, PA.

OWNER/AGENCY	-- USFS	DATE TALLIED:	APR/1982
FOREST/PROPERTY	-- KANE EXP. FOREST	DATE PRINTED:	8/NOV/1991
COUNTY/DISTRICT	-- ELK	FILE:	c:\silvah\sample.SIL
COMPT - STAND	-- 171 23	DEFAULT:	SILVAH.DEF
ACRES	-- 100.00	TYPE:	ALLEGHENY HARDWOOD
STAND AGE	-- UNKNOWN	SIZE:	SMALL SAW
SITE	-- 70 FOR BC	DENSITY:	GT 95 %

COMPUTER SAMPLE AS PROVIDED IN TRAINING SESSION HANDBOOK

OVERSTORY CRUISE INFORMATION

Overstory data is from an individual tree tally prism cruise,
using a 10 factor prism, and with trees tallied by
2 inch dbh classes, heights, and pulp & cull grades only.

Overstory data based on 19. plots;
0. additional plots needed to reach 15 % of the mean;
0. additional plots needed to reach 10 % of the mean.

Mean basal area is 158. plus or minus 15. square feet per acre
at 90 % confidence (9. % of mean).

UNDERSTORY CRUISE INFORMATION

Data on advance regeneration, site limitations, and understory
is from a standard regeneration cruise using 6-ft radius plots.

Understory data is based on 38. plots.

SILVAH -- SILVICULTURE OF ALLEGHENY HARDWOODS - V4.50
STAND SUMMARY, PRESCRIPTION, AND MANAGEMENT SIMULATOR PROGRAM
DEVELOPED BY THE NORTHEASTERN FOREST EXPERIMENT STATION, WARREN, PA.

OWNER/AGENCY -- USFS
FOREST/PROPERTY -- KANE EXP. FOREST
COUNTY/DISTRICT -- ELK

DATE TALLIED: APR/1982
DATE PRINTED: 8/NOV/1991
FILE: c:\silvah\sample.SIL

COMPT - STAND -- 171 23

DEFAULT: SILVAH.DEF

ACRES -- 100.00
STAND AGE -- UNKNOWN
SITE -- 70 FOR BC

TYPE: ALLEGHENY HARDWOOD
SIZE: SMALL SAW
DENSITY: GT 95 %

COMPUTER SAMPLE AS PROVIDED IN TRAINING SESSION HANDBOOK

SPECIES OR CATEGORY	% OF PLOTS STOCKED	AVERAGE VALUE
DESIRABLE TREE REGENERATION		
BLACK CHERRY	47.	
SMALL OAK	0.	
OTHER DESIRABLES	0.	
** ALL DESIRABLES	5.	
LARGE OAK	0.	
** ANY SMALL REGEN	50.	
RESIDUALS	5.	
** ANY REGEN OR RESIDS	53.	
SAPLING REGEN	0.	
OAK SPROUT POTENTIAL	0.	0. Stumps/ac to sprout
** ANY REGEN OR SPROUTS	50.	
** ANY REGEN,RESIDS,SPROUTS	53.	
FACTORS AFFECTING REGENERATION DIFFICULTY		
DEER IMPACT		4 High
SEED SUPPLY		1 Abundant seeds
INTERFERING UNDERSTORY		
WOODY INTERFERENCE	5.	
LAUREL & RHODO	0.	
% FERNS	11.	
% GRASSES	0.	
** ANY INTERFERENCE	13.	
GRAPEVINES	0.	
SITE LIMITATIONS FOR REGENERATION		
SITE LIMITATIONS	0.	

SILVAH -- SILVICULTURE OF ALLEGHENY HARDWOODS - V4.50
STAND SUMMARY, PRESCRIPTION, AND MANAGEMENT SIMULATOR PROGRAM
DEVELOPED BY THE NORTHEASTERN FOREST EXPERIMENT STATION, WARREN, PA.

OWNER/AGENCY -- USFS
FOREST/PROPERTY -- KANE EXP. FOREST
COUNTY/DISTRICT -- ELK

DATE TALLIED: APR/1982
DATE PRINTED: 8/NOV/1991
FILE: c:\silvah\sample.SIL

COMPT - STAND -- 171 23

DEFAULT: SILVAH.DEF

ACRES -- 100.00
STAND AGE -- UNKNOWN
SITE -- 70 FOR BC

TYPE: ALLEGHENY HARDWOOD
SIZE: SMALL SAW
DENSITY: GT 95 %

COMPUTER SAMPLE AS PROVIDED IN TRAINING SESSION HANDBOOK

SPECIES OR CATEGORY	% OF PLOTS STOCKED	VALUE	
SITE INFORMATION			
COVER TYPE		1	Forest
HABITAT TYPE		9	Unknown
SOIL TYPE		9	Unknown
SITE CLASS		9	Unknown
SITE SPECIES		BC	
SITE INDEX		70	
REL MERCH HT		1.00	
ELEVATION		0	
ASPECT		0	
SLOPE %		0	
TOPO POSITION		9	Unknown
OPERABILITY		9	Unknown
ACCESSABILITY		9	Unknown
STRESS FACTORS			
DEER IMPACT		4	High
GYPSY MOTH		4	Unknown
OTHER STRESS		4	Unknown

SILVAH -- SILVICULTURE OF ALLEGHENY HARDWOODS - V4.50
STAND SUMMARY, PRESCRIPTION, AND MANAGEMENT SIMULATOR PROGRAM
DEVELOPED BY THE NORTHEASTERN FOREST EXPERIMENT STATION, WARREN, PA.

```
OWNER/AGENCY     -- USFS                      DATE TALLIED:      APR/1982
FOREST/PROPERTY  -- KANE EXP. FOREST          DATE PRINTED:    8/NOV/1991
COUNTY/DISTRICT  -- ELK                       FILE: c:\silvah\sample.SIL

COMPT - STAND    --  171     23               DEFAULT: SILVAH.DEF

ACRES            --   100.00                     TYPE: ALLEGHENY HARDWOOD
STAND AGE        -- UNKNOWN                      SIZE: SMALL SAW
SITE             --    70 FOR  BC             DENSITY: GT 95 %
COMPUTER SAMPLE AS PROVIDED IN TRAINING SESSION HANDBOOK
```

MANAGEMENT GOALS

No restrictions on mgmt for either visual or wildlife goals.
For this goal, stand value is Medium

WILDLIFE TREES	NO./ACRE
POTENTIAL DEN TREES	.0
EXISTING DEN TREES	.0
SNAGS WITH POTENTIAL CAVITIES	.0
SNAGS WITH EXISTING CAVITIES	.0
OTHER STANDING DEAD TREES (Not Snags)	.0

WATER HABITATS WITHIN THIS STAND INCLUDE:

Unknown
Unknown

HABITAT CONDITIONS SURROUNDING THIS STAND

CLEARCUT ACRES W/I 1 MILE	.00
CULTIVATED ACRES W/I 1 MILE	.00
OPEN ACRES W/I 1 MILE	.00
WATER HABITATS INCLUDE:	Unknown

SILVAH -- SILVICULTURE OF ALLEGHENY HARDWOODS - V4.50
STAND SUMMARY, PRESCRIPTION, AND MANAGEMENT SIMULATOR PROGRAM
DEVELOPED BY THE NORTHEASTERN FOREST EXPERIMENT STATION, WARREN, PA.

OWNER/AGENCY -- USFS | DATE TALLIED: APR/1982
FOREST/PROPERTY -- KANE EXP. FOREST | DATE PRINTED: 8/NOV/1991
COUNTY/DISTRICT -- ELK | FILE: c:\silvah\sample.SIL

COMPT - STAND -- 171 23 | DEFAULT: SILVAH.DEF

ACRES -- 100.00 | TYPE: ALLEGHENY HARDWOOD
STAND AGE -- UNKNOWN | SIZE: SMALL SAW
SITE -- 70 FOR BC | DENSITY: GT 95 %
COMPUTER SAMPLE AS PROVIDED IN TRAINING SESSION HANDBOOK

ORIGINAL STAND

PRODUCT LISTING (total stand)

SPECIES >	ALL SP	BC	RM	SM	AB	WA	B
	NET LOG VOLUME (INT 1/4" LOG RULE) - MBF / 10						
VENEER	7.8	6.7	.8	.1	.0	.3	.0
GRADE 1	44.4	37.7	4.8	.4	.0	1.5	.0
GRADE 2	33.8	15.1	11.4	1.9	.3	5.1	.0
GRADE 3	23.0	9.9	7.2	3.6	.1	1.1	1.1
PALLET	.0	.0	.0	.0	.0	.0	.0
TOTAL	109.1	69.4	24.2	6.0	.4	8.0	1.1
	NET BULK VOLUME - CORDS / 10						
BOLTWOOD	.0	.0	.0	.0	.0	.0	.0
PULPWOOD	185.4	75.9	52.9	40.8	3.9	5.5	6.4
FIREWOOD	.0	.0	.0	.0	.0	.0	.0
TOTAL	185.4	75.9	52.9	40.8	3.9	5.5	6.4
	VALUE - DOLLARS / 1000						
VENEER	37.2	35.5	.7	.1	.0	.9	.0
GRADE 1	210.6	201.2	4.1	.4	.0	4.9	.0
GRADE 2	81.3	59.5	7.3	1.1	.0	13.4	.0
GRADE 3	36.6	31.2	2.9	.8	.0	1.5	.1
PALLET	.0	.0	.0	.0	.0	.0	.0
TOTAL	365.6	327.4	15.1	2.3	.1	20.7	.1
$/MBF	335.	472.	62.	39.	14.	260.	5.
BOLTWOOD	.0	.0	.0	.0	.0	.0	.0
PULPWOOD	3.7	1.5	1.1	.8	.1	.1	.1
FIREWOOD	.0	.0	.0	.0	.0	.0	.0
TOTAL	3.7	1.5	1.1	.8	.1	.1	.1
$/CORD	2.	2.	2.	2.	2.	2.	2.
GR.TOTAL	369.3	328.9	16.2	3.1	.1	20.8	.2

SILVAH -- SILVICULTURE OF ALLEGHENY HARDWOODS - V4.50
STAND SUMMARY, PRESCRIPTION, AND MANAGEMENT SIMULATOR PROGRAM
DEVELOPED BY THE NORTHEASTERN FOREST EXPERIMENT STATION, WARREN, PA.

OWNER/AGENCY -- USFS   DATE TALLIED: APR/1982
FOREST/PROPERTY -- KANE EXP. FOREST   DATE PRINTED: 8/NOV/1991
COUNTY/DISTRICT -- ELK   FILE: c:\silvah\sample.SIL
COMPT - STAND -- 171 23   DEFAULT: SILVAH.DEF
ACRES -- 100.00   TYPE: ALLEGHENY HARDWOOD
STAND AGE -- UNKNOWN   SIZE: SMALL SAW
SITE -- 70 FOR BC   DENSITY: GT 95 %
COMPUTER SAMPLE AS PROVIDED IN TRAINING SESSION HANDBOOK

ORIGINAL STAND

SPECIES >	ALL SP	BC	RM	SM	AB	WA	B
		COMPOSITION -- BA, % OF BA, TREES					
TOT BA	157.9	64.7	41.1	30.0	10.0	6.8	5.3
SPECIES%	100.	41.	26.	19.	6.	4.	3.
# TREES	505.	51.	89.	159.	182.	7.	16.
		QUALITY -- % IN AGS					
SAPS	33.	0.	67.	43.	20.	0.	0.
POLES	63.	83.	68.	65.	0.	100.	80.
SM SAW	76.	83.	76.	62.	33.	70.	50.
MED SAW	78.	84.	40.	0.	0.	100.	0.
LG SAW	100.	100.	0.	0.	0.	0.	0.
ALL SIZE	70.	84.	69.	61.	16.	77.	60.
		DIAMETERS AND AGES -- INCHES, YEARS					
DIAM	13.1	16.4	12.9	9.1	6.0	14.6	9.4
DIAM MER	13.9	16.4	13.3	9.9	9.6	14.6	10.0
QUAD DIA	7.6	15.3	9.2	5.9	3.2	13.5	7.7
YRS MAT	22.	8.	24.	54.	56.	17.	53.
EFCT AGE	75.	82.	66.	66.	64.	73.	67.
		STRUCTURE					
Q FACTOR	1.41	1.05	1.24	1.73	2.04	1.01	1.05
WEIB C	.00	.00	.00	.00	.00	.00	.00
		RELATIVE DENSITY -- %					
REL DEN	97.	24.	26.	30.	11.	3.	4.
AGS RDEN	62.	20.	18.	18.	2.	2.	2.
		VOLUMES AND VALUES - INT 1/4" LOG RULE					
GTOT CDS	50.2	24.7	14.1	7.2	.6	2.5	1.1
NTOT CDS	40.1	19.8	11.3	5.8	.5	2.0	.9
PULP CDS	18.5	7.6	5.3	4.1	.4	.6	.6
GRS BDFT	14047.	8033.	3617.	1015.	101.	919.	362.
NET BDFT	10909.	6938.	2422.	601.	42.	796.	109.
DOLLARS	3693.	3289.	162.	31.	1.	208.	2.

SILVAH -- SILVICULTURE OF ALLEGHENY HARDWOODS - V4.50
STAND SUMMARY, PRESCRIPTION, AND MANAGEMENT SIMULATOR PROGRAM
DEVELOPED BY THE NORTHEASTERN FOREST EXPERIMENT STATION, WARREN, PA.

OWNER/AGENCY -- USFS
FOREST/PROPERTY -- KANE EXP. FOREST
COUNTY/DISTRICT -- ELK

DATE TALLIED: APR/1982
DATE PRINTED: 8/NOV/1991
FILE: c:\silvah\sample.SIL

COMPT - STAND -- 171 23

DEFAULT: SILVAH.DEF

ACRES -- 100.00
STAND AGE -- UNKNOWN
SITE -- 70 FOR BC

TYPE: ALLEGHENY HARDWOOD
SIZE: SMALL SAW
DENSITY: GT 95 %

COMPUTER SAMPLE AS PROVIDED IN TRAINING SESSION HANDBOOK

ORIGINAL STAND

BASAL AREA - SQ. FT. PER ACRE

SPECIES > DIA.	ALL SP	BC	RM	SM	AB	WA	B
2	5.3	.0	.5	1.6	3.2	.0	.0
4	5.8	.0	1.1	2.1	2.1	.0	.5
6	8.4	.0	1.6	4.7	1.6	.0	.5
8	11.6	1.1	3.2	5.3	.5	.5	1.1
10	17.4	2.1	5.3	7.9	1.1	.0	1.1
12	22.6	6.8	7.4	4.7	.5	1.1	2.1
14	27.9	10.5	11.1	2.6	1.1	2.6	.0
16	22.6	14.2	5.8	1.1	.0	1.6	.0
18	20.5	17.4	3.2	.0	.0	.0	.0
20	9.5	7.4	1.1	.0	.0	1.1	.0
22	5.8	4.7	1.1	.0	.0	.0	.0
24	.5	.5	.0	.0	.0	.0	.0
SAPS	11.1	.0	1.6	3.7	5.3	.0	.5
POLES	37.4	3.2	10.0	17.9	3.2	.5	2.6
SM SAW	73.2	31.6	24.2	8.4	1.6	5.3	2.1
MED SAW	35.8	29.5	5.3	.0	.0	1.1	.0
LG SAW	.5	.5	.0	.0	.0	.0	.0
TOTAL	157.9	64.7	41.1	30.0	10.0	6.8	5.3
SPECIES%	100.	41.	26.	19.	6.	4.	3.

ACCEPTABLE GROWING STOCK ONLY

SAPS	3.7	.0	1.1	1.6	1.1	.0	.0
POLES	23.7	2.6	6.8	11.6	.0	.5	2.1
SM SAW	55.3	26.3	18.4	5.3	.5	3.7	1.1
MED SAW	27.9	24.7	2.1	.0	.0	1.1	.0
LG SAW	.5	.5	.0	.0	.0	.0	.0
TOTAL	111.1	54.2	28.4	18.4	1.6	5.3	3.2

SILVAH -- SILVICULTURE OF ALLEGHENY HARDWOODS - V4.50
STAND SUMMARY, PRESCRIPTION, AND MANAGEMENT SIMULATOR PROGRAM
DEVELOPED BY THE NORTHEASTERN FOREST EXPERIMENT STATION, WARREN, PA.

OWNER/AGENCY -- USFS
FOREST/PROPERTY -- KANE EXP. FOREST
COUNTY/DISTRICT -- ELK

DATE TALLIED: APR/1982
DATE PRINTED: 8/NOV/1991
FILE: c:\silvah\sample.SIL

COMPT - STAND -- 171 23

DEFAULT: SILVAH.DEF

ACRES -- 100.00
STAND AGE -- UNKNOWN
SITE -- 70 FOR BC

TYPE: ALLEGHENY HARDWOOD
SIZE: SMALL SAW
DENSITY: GT 95 %

COMPUTER SAMPLE AS PROVIDED IN TRAINING SESSION HANDBOOK

This Allegheny hardwood stand is dominated by Black Cherry, Red Maple, and Sugar Maple, which together comprise 86 % of the basal area.

This is a small sawtimber stand, with average diameter of 13.1 inches. Total growing stock amounts to 158. sq. ft. of basal area per acre. Gross total volume in all trees, to a 4-inch top, is 40. cords per acre; if divided into pulpwood and sawtimber the net merchantable volume is 19. cords of pulpwood and 10909. board feet of sawtimber (Int 1/4" log rule) per acre. The total stand value is estimated to be about 3693. dollars per acre.

Relative stand density is 97. % of the average maximum stocking expected in undisturbed stands of similar size and species composition. This density is well above the optimum for best individual tree growth. At this relative density, growth rate of the biggest trees is probably moderate, while growth rate of the medium and smaller-sized trees is probably poor and mortality due to crowding high. Partial cutting to provide more growing space for trees of better quality and species is highly desirable at this time.

If this stand is managed under an even-age silvicultural system, the several species groups will mature at markedly different times. The average number of years to maturity is 22. and effective stand age is about 75. years old.

If this stand is managed under an all-age silvicultural system, the distribution of diameters, proportion of sawtimber, and density of shade-tolerant species are adaptable to selection cutting.

Trees of acceptable quality for future growing stock provide a fully stocked stand by themselves and warrant further management. Sapling trees too small to be merchantable do not represent a significant proportion of stand stocking and need not be included in any partial cuttings.

Advance regeneration of all types is scarce; harvest cuttings at this time will not likely result in a satisfactory new stand.

Neither site limitations nor undesirable understory plants are likely to interfere with attempts to establish regeneration.

SILVAH -- SILVICULTURE OF ALLEGHENY HARDWOODS - V4.50
STAND SUMMARY, PRESCRIPTION, AND MANAGEMENT SIMULATOR PROGRAM
DEVELOPED BY THE NORTHEASTERN FOREST EXPERIMENT STATION, WARREN, PA.

```
OWNER/AGENCY     -- USFS                    DATE TALLIED:      APR/1982
FOREST/PROPERTY -- KANE EXP. FOREST         DATE PRINTED:    8/NOV/1991
COUNTY/DISTRICT -- ELK                      FILE: c:\silvah\sample.SIL

COMPT - STAND    --  171     23             DEFAULT: SILVAH.DEF

ACRES            --   100.00                    TYPE: ALLEGHENY HARDWOOD
STAND AGE        -- UNKNOWN                     SIZE: SMALL SAW
SITE             --   70 FOR  BC            DENSITY: GT 95 %
COMPUTER SAMPLE AS PROVIDED IN TRAINING SESSION HANDBOOK
```

******RECOMMENDED TREATMENT******

Commercial Thinning (integrated sale)

Perform a thinning to provide additional growing space for the better trees and provide some intermediate yield. Stand size and composition are such that the thinning can be performed on a commercial basis and will yield a product mix consisting of both sawlogs and pulpwood.

The volumes to be removed are: 2001. bd ft (Int 1/4" log rule) and 6.4 cords per acre.

******MARKING INSTRUCTIONS******

Reduce relative stand density to 63. % leaving 109. sq. ft. of basal area per acre. Remove trees in the size and quality classes shown below:

Cut 3. out of 5. trees from the polesize class.

Cut 1. out of 4. trees from the ssawsize class.

Cut 1. out of 4. trees from the msawsize class.

Cut 1. out of 2. trees from the lsawsize class.

About 80 % of the trees cut will be UGS. This will result in the removal of about 84 % of the UGS this stand and about 100 % of the merchantable-sized UGS.

Within the size and quality constraints above, favor the best trees whenever possible. Try to preserve seed sources of scarce species if they are desired in the regeneration, and strive for uniform spacing among residuals whenever possible.

SILVAH -- SILVICULTURE OF ALLEGHENY HARDWOODS - V4.50
STAND SUMMARY, PRESCRIPTION, AND MANAGEMENT SIMULATOR PROGRAM
DEVELOPED BY THE NORTHEASTERN FOREST EXPERIMENT STATION, WARREN, PA.

OWNER/AGENCY -- USFS
FOREST/PROPERTY -- KANE EXP. FOREST
COUNTY/DISTRICT -- ELK

DATE TALLIED: APR/1982
DATE PRINTED: 8/NOV/1991
FILE: c:\silvah\sample.SIL

COMPT - STAND -- 171 23

DEFAULT: SILVAH.DEF

ACRES -- 100.00
STAND AGE -- UNKNOWN
SITE -- 70 FOR BC
COMPUTER SAMPLE AS PROVIDED IN TRAINING SESSION HANDBOOK

TYPE: ALLEGHENY HARDWOOD
SIZE: SMALL SAW
DENSITY: GT 95 %

	ORIGINAL	CUT	RESIDUAL
BASAL AREA - SQ FT/A			
SAPS	11.1	.0	11.1
POLES	37.4	22.4	14.9
SM SAW	73.2	17.9	55.3
MED SAW	35.8	8.7	27.1
LG SAW	.5	.2	.3
TOTAL	157.9	49.3	108.6
NUMBER OF TREES - #/A			
# TREES	505.	89.	416.
DIAMETERS - IN.			
DIAM	13.1		13.6
DIAM MER	13.9		14.8
QUAD DIA	7.6		6.9
RELATIVE DENSITY - %			
REL DEN	97.		63.
AGS RDEN	62.		54.
BD FT INT 1/4", VALUE/A			
GR. BDFT	14047.	2636.	11411.
NET BDFT	10909.	2001.	8909.
DOLLARS	3693.	657.	3036.

	ORIGINAL	CUT	RESIDUAL
SPECIES COMPOSITION - %			
% BC	41.		48.
% WA	4.		5.
% SM	19.		15.
% RM	26.		24.
% AB	6.		5.
QUALITY -- % IN AGS			
% AGS	70.		93.
AGES - YRS.			
YRS MAT	22.		17.
EFCT AGE	75.		78.
STRUCTURE			
Q FACTOR	1.4		1.3
WEIB C	.0		.0
CORD VOLUME/A			
TOT CDS	50.2	12.9	37.3
NET CDS	40.1	10.3	29.9
PULP CDS	18.5	6.4	12.1

---------------------------- TOTAL STAND ----------------------------

BD FT INT 1/4", VALUE			
GR. MBF	1404.7	263.6	1141.1
NET MBF	1090.9	200.1	890.9
M DOLLAR	369.3	65.7	303.6

CORD VOLUME			
TOT CDS	5019.	1286.	3733.
NET CDS	4015.	1029.	2986.
PULP CDS	1854.	642.	1212.

Marquis, David A.; Ernst, Richard L.; Stout, Susan L. 1992. **Prescribing silvicultural treatments in hardwood stands of the Alleghenies (revised).** Gen. Tech. Rep. NE-96. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 101 p.

This publication brings together the results of 20 years of research and experience in the silviculture of hardwood forests in the Allegheny region. It provides a summary of silvicultural knowledge, and guidelines, decision tables, and step-by-step instructions for determining silvicultural prescriptions in individual stands.

23:24:614--176.1 (747) (748) (752) (754)

Keywords: Silvicultural prescriptions, management guides, regeneration, stand culture, Allegheny hardwoods, northern hardwoods, oak-hickory, decision support system

---

CAUTION

Pesticides used improperly can be injurious to man, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers under lock and key--out of the reach of children and animals--and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues. Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment if specified on the container.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the Environmental Protection Agency, consult your local forest pathologist, county agricultural agent, or State Extension specialist to be sure the intended use is still registered.