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Department of
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Forest Service

**Northeastern Forest
Experiment Station**

General Technical Report NE-183

Quantitative Silviculture for Hardwood Forests of the Alleghenies

Dedication

This publication is dedicated to the memory of Roe S. (Sandy) Cochran, former Forest Resource Specialist with the Extension Service, The Pennsylvania State University. Sandy was a guiding light in the Allegheny Hardwood Silviculture Training Sessions on which this publication is based. He was instrumental in initiating, promoting, and conducting every session, from their inception in 1978 until his death in 1991. Sandy contributed to the technical and administrative aspects of the Training Sessions in many, many ways, but may best be remembered for his famous Wednesday night steak fry. It is to his untiring efforts to provide educational opportunities leading to good forestry practices in the Allegheny Region, his commitment to the forestry profession, and his exceptional drive and character that this publication is dedicated.

Cover Photo

The cover photograph was taken during one of the first Allegheny hardwood silviculture training sessions at the Kane Experimental Forest, sometime during 1976 or 1977. The individuals in the photograph represent the wide range of participants in the sessions, including University professors, consulting and industrial foresters, and foresters from public land management agencies. Among those in this photograph are several of the individuals who intiated the course, including Dave Marquis, at the left of the front row; Sandy Cochran, in the center in a light jacket; Ben Roach, on the right of the front row; and Rich Ernst, second from the left in the back row.

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Quantitative Silviculture for Hardwood Forests of the Alleghenies

David A. Marquis
Editor

A collection of lectures from the annual
Silviculture Training Sessions
conducted by the

USDA Forest Service
Northeastern Forest Experiment Station
Warren, Pennsylvania

and

The Pennsylvania State University
Cooperative Extension Service
University Park, Pennsylvania

Contents

Preface

Forest Service research on hardwood silviculture has been under way in northern Pennsylvania since the Kane Experimental Forest was established in 1929. Throughout the 1930's the Civilian Conservation Corp provided the manpower to initiate many long-term studies of ecology and forest growth. The experimental forest was closed during World War II, and after the war, a small silviculture research program was maintained at both the Kane Experimental Forest and the Pocono Experimental Forest. The Pocono forest was privately owned, but research was conducted there by Forest Service personnel. Many studies were maintained and remeasured by Ashbel Hough and others throughout the long period of reduced activity until the late 1960's.

In the 1960's, the program was revitalized by combining the minimal staffs of the Kane and Pocono Experimental Forests and establishing a new laboratory in Warren, Pennsylvania. The silviculture research staff at Warren was expanded in 1970, which led to a comprehensive research program on the forest management problems of the region.

The new program, combined with the reopening of the 1930 studies at Kane, provided for rapid accumulation of scientific knowledge on the ecology and management of Allegheny hardwoods. Special efforts were made to organize that knowledge into a coordinated set of management guidelines. Initial guidelines included procedures to obtain satisfactory regeneration after harvest cutting, and to control stand density and structure during thinning. These guidelines have since been expanded into a complete system of stand evaluation and silvicultural prescriptions that cover the full range of forest conditions and management alternatives in the region.

Much other research is also applicable to the Allegheny region. Oak silviculture research at the Central States Forest Experiment Station (later divided between the Northeastern and North Central Forest Experiment Stations) in Ohio, Kentucky, and other Central States has been used extensively, as has research of The Pennsylvania State University; West Virginia University; and the College of Environmental Science and Forestry, State University of New York at Syracuse. Research conducted or sponsored by the Hammermill Paper Company, Tg Forest Products (formerly Armstrong Forests), and Glatfelter Pulp Wood Company has been important also.

In 1976, the Northeastern Forest Experiment Station and the Cooperative Extension Service of The Pennsylvania State University organized several training sessions to explain and demonstrate the silvicultural prescription system to practicing foresters. Since then, two to four sessions have been held each year, with 20 to 30 participants at each session. The sessions are updated periodically as new research information becomes available. In 1985, a new classroom facility was built at Kane and in 1987 the sessions were lengthened from 3 to 4 days each. In addition, some supplementary 1-day sessions were added to provide in-depth coverage of techniques outlined in the basic sessions.

The sessions have been attended by representatives from nearly every forest management organization in the region: Allegheny National Forest, Monongahela National Forest, other Eastern Region national forests and headquarters offices, State and Private Forestry, Northeastern Forest Experiment Station, Pennsylvania Bureau of Forestry, Pennsylvania Game Commission, New York Department of Environmental Conservation, forestry faculty of eight or nine eastern universities, Hammermill Paper Co., International Paper Co., Tg Forest Products Inc., Kane Hardwoods Division of Collins Pine Co., National Fuel Gas, Westvaco, Charmin Paper Division of Proctor and Gamble, Glatfelter Pulp Wood Co., 15 to 20 forestry consulting firms and others. Ontario Ministry of Natural Resources has participated and others have come from as far away as Chile, Italy, Holland, and New Zealand.

The sessions provide excellent feedback on research needs. Some 60 to 80 participants each year provide candid evaluations on the applicability of the research, and help to identify areas needing further study or refinement. The result is an improved research product as well as an effective technology transfer process.

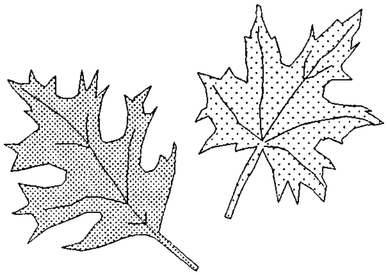
About half of the time in each training session is devoted to classroom lectures in which results of research and basic principles of silvicultural technique are presented. The remaining time is devoted to practical field exercises in which participants have an opportunity to apply the techniques under the guidance of course instructors. The sessions represent an exceptional collection of practical information on the systematic and scientific application of silviculture to a particular forest region.

Acknowledgments

Lectures presented here were prepared by scientists at the U. S. Department of Agriculture, Forest Service, Forestry Sciences Laboratory, Warren, Pennsylvania. A number of other scientists have contributed immeasurably to these lectures, or to the research leading to the silvicultural knowledge on which the guidelines are based. Some of these include: Ashbel F. Hough, Carl E. Ostrom, Thomas W. Church, Ted J. Grisez, Harold J. Huntzinger, Benjamin A. Roach, John C. Bjorkbom, Kurt W. Gottschalk, John A. Stanturf, David S. deCalesta, Coleman Holt, and Nancy G. Tilghman. For their contributions, we are especially grateful.

Ash Hough deserves special mention as a pioneer researcher who initiated -- and kept alive during nearly 30 years of official neglect -- the many long-term studies that have since helped tremendously to verify responses of forest stands to treatment. Likewise, Ben Roach deserves special mention for his early efforts in formulating systematic silvicultural prescription procedures in the Central States. His guide served as a model for the Allegheny system.

Special thanks also to the dedicated group of forest technicians of the Forestry Sciences Laboratory in Warren. Without these skilled assistants, the research leading to these guidelines could not have been completed: Virgil L. Flick, Vonley D. Brown, John A. Crossley, David L. Saf, and Harry S. Steele.



Pesticide Precautionary Statement

This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife--if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

The computer program described in this publication is available on request with the understanding that the U.S. Department of Agriculture cannot assure its accuracy, completeness, reliability, or suitability for any other purpose than that reported. The recipient may not assert any proprietary rights thereto nor represent it to anyone as other than a Government-produced computer program.

Introduction

David A. Marquis, Roe S. Cochran

Silviculture always has been a combination of art and science. Silvicultural systems and cutting methods are based upon scientific principles, but recognizing which technique will provide best results in any particular circumstance requires a great deal of experience and judgment -- the art side.

The person prescribing silvicultural treatments in any forest stand needs a thorough knowledge of present stand conditions, must be aware of the possible treatments and their many effects, and must juggle biological considerations with management objectives and costs. When management goals include the integration of several major resources, such as timber, wildlife, or aesthetics, the decisionmaking process can be very complex. Forest types that include variability in species composition and structure, such as the eastern mixed hardwoods, add further to that complexity.

In the past, we have depended upon the judgment of experienced silviculturists to weigh these many factors and determine the most appropriate treatment or course of action. And we have depended upon the skill of these same people to apply the prescribed treatments to the highly variable situations they encounter in each stand.

However, as our scientific knowledge grows and the range of disciplines needed to deal with multiple resources increases, we must have more objective ways to measure and evaluate forest stand conditions and to arrive at recommended treatments.

Much of our research in the hardwood forests of the Allegheny Region has been aimed at the development of a systematic and quantitative procedure for stand analysis and prescription. The articles that follow describe the continually evolving system that we have developed for hardwood forests of the Alleghenies.

Quantitative Silviculture for the Alleghenies

The stand analysis and prescription procedures described here are based on extensive research. Without such a foundation, no collection of guidelines can be very meaningful. This research included studies of important biological factors and investigations of the ways in which these factors regulate tree regeneration, tree and stand growth, or wildlife habitat. Guidelines based on research results provide a basis to decide how much is enough or too much in particular circumstances. For example, successful tree regeneration following harvest cutting is highly dependent upon the amount of advance reproduction, and that finding was used to develop specific guides on how many advance seedlings are needed, and how those numbers vary with species, seedling size, site, deer browsing pressure, cutting treatment, and other factors.

A complete series of guidelines of this type was developed and integrated into a stand analysis and prescription procedure. This system involves an inventory of basic overstory, understory, and site factors that are then summarized and analyzed in specific ways to evaluate the stand's potential for growth and regeneration. Then, a series of decision tables or charts is used to determine an appropriate prescription based upon critical levels of the various site and vegetation variables, in combination with specific landowner objectives.

All steps of this process are based upon stand and site variables that have been quantified. As a result, the entire process can be programmed, and the data analysis, report generation, and even the decisionmaking can be automated to a considerable degree. Our computer program has been named SILVAH, which stands for SILViculture of Allegheny Hardwoods. As a result, the system of stand inventory, analysis, and prescription is often referred to as the SILVAH stand analysis and prescription system.

Whether or not the SILVAH computer program is used to automate the process, the stand analysis and prescription technique provides a systematic and quantitative way to make silvicultural decisions in forest stands. It reduces the amount of subjectivity and judgment required, and ensures consistency across all stands and individual prescribers.

Assumptions and Applicability

The guidelines presented here were developed for and are applicable to the cherry-maple (Allegheny hardwoods), beech-birch-maple (northern hardwoods), oak-hickory, and oak-northern hardwood transition forest types growing on the Allegheny Plateau and Allegheny Mountain sections of Pennsylvania, New York, West Virginia, and Maryland. The guides to even-age intermediate culture are widely applicable, even outside the Allegheny Region. However, the guides to regeneration are more restricted to the region of applicability because of such local influences as deer populations, site characteristics, climate, and insect pests.

The basic procedures and framework of the decisionmaking process are universally applicable. If local silvical knowledge is sufficient to permit the needed modification in decision criteria, this system of stand inventory, analysis, and prescription can be adapted to most northeastern forests.

Management Goals

The silvicultural prescriptions currently incorporated into the SILVAH system assume that forest lands are being held and managed for multiple resource use, with timber production as one of the primary goals. Timber prescriptions may be modified to accommodate selected wildlife and aesthetic goals as well.

The SILVAH system further assumes that:

1. all resources are being managed on a sustained-yield basis;

2. emphasis in timber management is on sawlog and veneer production of black cherry, sugar maple, red maple, white ash, northern red oak, white oak, and other valuable species where they occur;

3. both even-age and uneven-age silvicultural systems will be used, each where it is most appropriate for the management objectives;

4. even-age silviculture will be applied to grow a full yield of high-value products as quickly as is economically feasible without losing total wood production in the meantime, and then reproduce the stand when it is mature by a means that will provide full stocking of mixed species composition in the next stand, including a substantial proportion of valuable intolerants such as black cherry, white ash, northern red oak, and red maple; and

5. uneven-age silviculture will be applied to obtain a substantial yield of timber products while maintaining a continuous forest cover at all times, for areas where aesthetics, recreation, and late-successional wildlife species are of special importance.

A Word of Caution

You must realize that our research is not completed. What we describe must not be considered the final, ultimate, everlasting, universal answer. Instead, this research represents the best information that we currently have. The guides have been tested extensively, and the system works consistently well in most common situations. But undoubtedly there will be modifications as we learn more from research still under way. Furthermore, guidelines cannot account for all the many variations that one encounters in the natural world.

Therefore, apply the guidelines critically. You cannot abdicate your responsibility to exercise professional judgment. The guides must be used as an aid to professional judgment, not as a substitute.

Always watch for situations in which the answer you get from the guidelines does not jibe with your professional experience. For example, if you inventory a stand and work up the data to find that the stocking guide indicates the stand to be fully stocked, you must not accept that as gospel and forget everything else you have ever learned. You should look at the stand and ask yourself some questions. The guide says this stand is fully stocked. Is it? Does it look fully stocked? If it is, there must be a lot of small dead trees in the stand. Are they there? The stand should look crowded. Does it? There should be relatively little understory except in open places, and reproduction should be scarce and small. Is that so?

If your answers to such questions conform to what the guides imply, you can feel reasonably confident that both you and the guides are on safe ground. If your answers do not fit, then something is wrong, and you need to find out what is wrong before you proceed. Maybe your inventory was sloppy or you did not take enough plots to get accurate data. Maybe you made some mistakes in arithmetic, or gave the computer improper processing instructions. Maybe the composition of the stand is outside the range of the guides. Or maybe the guides are wrong. So, the answer the guides provide must not be accepted on blind faith.

The guides <u>are</u> intended to assign some mathematical quantities to things we guessed at in the past. They are intended to reduce the amount of subjectivity and seat-of-the-pants forestry that was used in the past in stand prescription and marking. They are intended to provide an objective, measurable, and remeasurable basis for judgment. But that does not mean that the numbers generated are invariably right, and everything else is wrong.

If that limitation is recognized, and the guideliness are used in combination with a full measure of professional judgment, they provide a powerful tool to make stand analysis and prescription more accurate and consistent. This quantitative approach to silviculture combines more science than before, but does not obviate the need for the continuation of art.

The articles that follow illustrate how the art and science of quantitative silviculture is being applied in the Allegheny forest region.

History & Origin of Allegheny Hardwoods

David A. Marquis

ALLEGHENY HARDWOOD

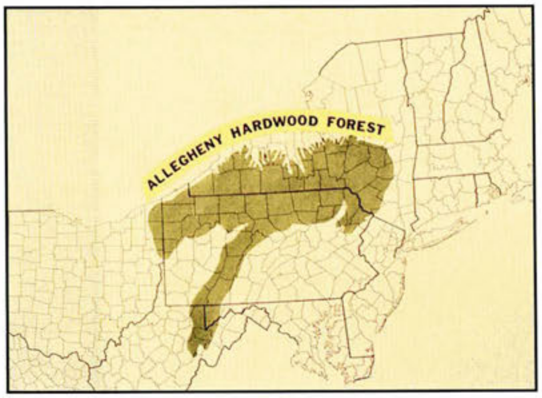
FORESTS

of

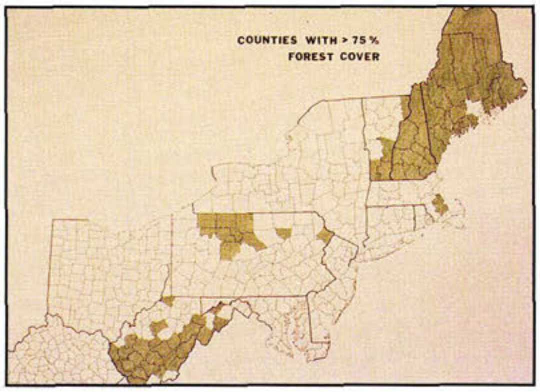
Northwestern Pennsylvania

1. The Allegheny hardwood--or cherry-maple--forest

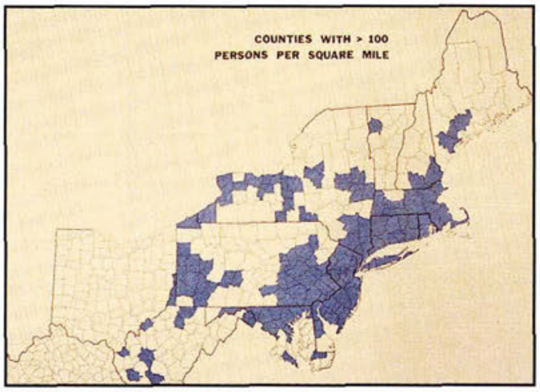
2. is a subtype of the northern hardwood or beech-birch-maple forest that spans the northern portion of the Eastern United States from New England to the Lake States.



3. Allegheny hardwoods occur on approximately 16 million acres of the Allegheny Plateau and Allegheny Mountain sections of Pennsylvania, New York, Maryland, West Virginia, and Ohio.



4. The area occupied by Allegheny hardwoods is a heavily forested region. It is one of the major contiguous blocks of commercial forest land in the Northeast, and wood-using industries play an important role in the rural economy of the region.



5. Yet these forests are surrounded on all sides by the eastern megalopolis; nearly one-third of the U.S. population lives within a day's drive of the region, providing a large and nearby market for forest products and a demand for many other uses of the forest land.

6. Allegheny hardwood or cherry-maple forests are unique in that they produce nearly all of the world's supply of commercial black cherry timber.

7. Cherry is a wood of exceptional beauty used in the production of fine furniture and veneer for cabinets and panelling.

8. No less important are the other hardwood species that grow in Allegheny forests--such as white ash--the long-time favorite wood for tool handles and baseball bats

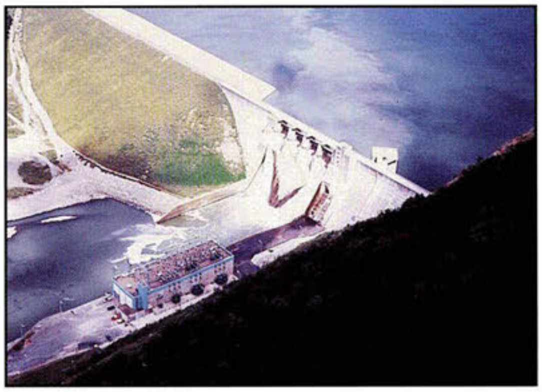
9. and the maples, well-known as sources of lumber for furniture and specialty products, for maple syrup,

10. and for their spectacular orange-red fall foliage.

11. Allegheny forests yield many social and economic benefits other than timber products. Hunting is one major example. Pennsylvania ranks first in the nation in the sale of hunting licenses, with big-game animals such as deer a leading attraction.

12. More than 400,000 deer are harvested annually in Plateau forests along with bear, turkey, and many kinds of small game.

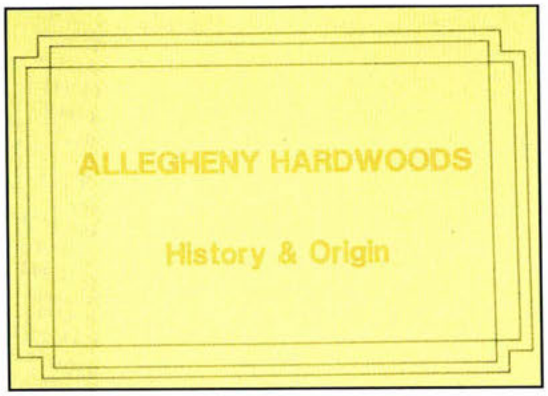
13. Fishing, hiking, camping, birdwatching, water sports, snowmobiling and other forms of outdoor recreation,



14. water resources for home and industry,

15. and scenic beauty must be added to the list of benefits derived from Allegheny hardwood forests.

16. It is easy to expect these benefits will continue indefinitely, however, we must understand that these forests are changing. At present, they are largely second-growth, representing an intermediate stage in the ecological succession for this region. The capability exists to delay or hasten this natural process and to alter the level of benefits obtained from the various resources.

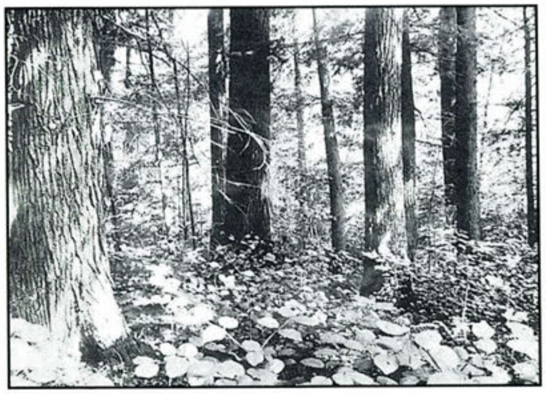


ALLEGHENY HARDWOODS

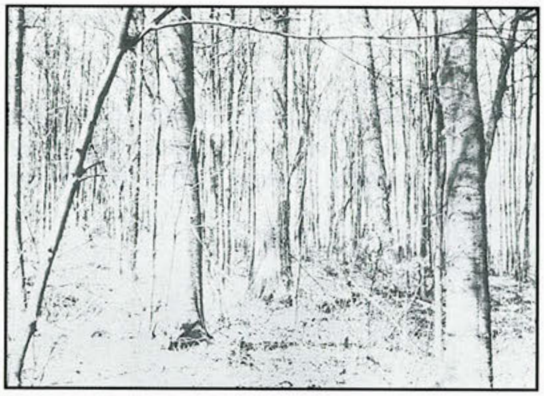
History & Origin

17. To fully understand the range of options available and the ecological basis for silvicultural treatments in Allegheny hardwoods, it is important to know something of the history and origin of present stands.

18. When white settlers first came to northern Pennsylvania, they found vast expanses of forest land stretching as far as the eye could see.



19. Many of these original forests were mature and overmature, and they contained very large trees of species like white pine, eastern hemlock, American beech, and sugar maple.

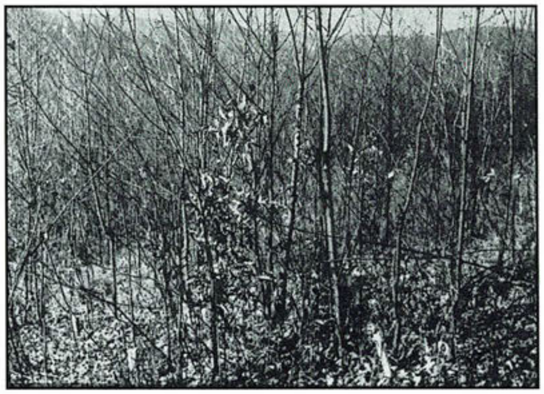


20. Beech-hemlock and beech-maple stands were by far the most prevalent. Beech, hemlock, and maple represented more than 70 percent of all trees observed during early land surveys on what is now the Allegheny National Forest.

21. Hemlock was most abundant on moist sites along stream valleys and poorly drained upland areas.

22. Beech, maple, and other hardwoods were more abundant on better drained sites.

23. White pine was also a common and extremely important species in the original forests. But stands containing large proportions of white pine were small, occurring primarily on river flats and lower slopes.



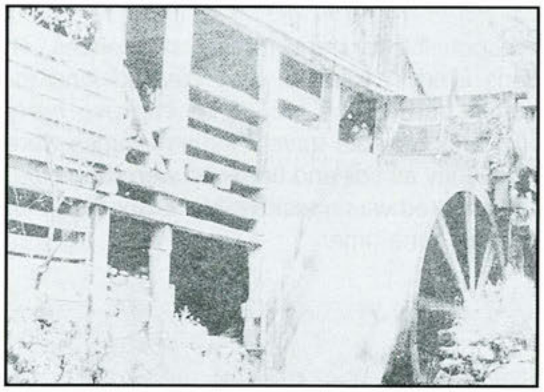
24. Not all stands were primeval in character. Disturbance such as wildfires and windthrow were common, resulting in the presence of stands of varying ages and sizes. These stands represent various stages of recovery from natural disturbances.

25. Indians were also responsible for many forest disturbances. All northeastern Indians lived in villages; they cleared land for agriculture, and often burned the woods to improve berry production, hunting, and facilitate travel. Indian villages were relocated rather frequently as soil and firewood were depleted, so the total acreage affected was considerably larger than that actually occupied at any one time.

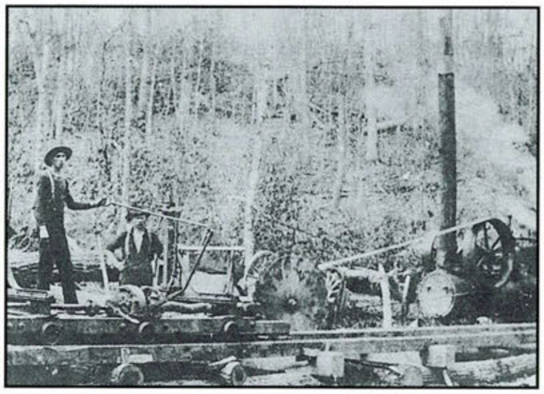
26. Many white pine stands are thought to have originated on the sites of abandoned Indian villages or on areas burned by Indians.

27. The presence of oak along the Allegheny River and its tributaries is probably also the result of fires started by Indians who lived, hunted, and travelled along the river. The oaks are more likely to resprout after repeated fires than most other species. Under current fire protection programs, these oak stands are gradually reverting to northern hardwoods.

28. Europeans began to settle northwestern Pennsylvania in the mid-1700's. Early settlers cleared some land for agriculture and cut some timber for their cabins and barns. But settlement proceeded slowly until the early 1800's. For example, in 1810 the population of Warren County was 26 and that of McKean County was 142.

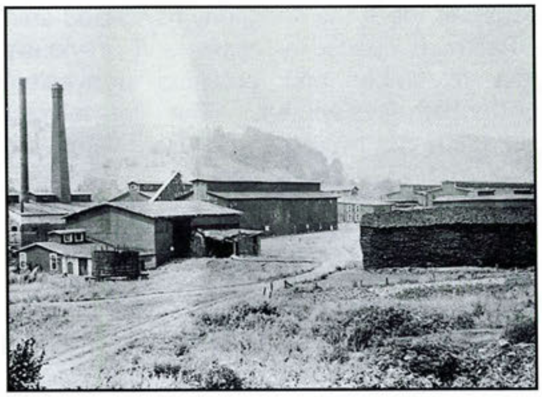


29. Even the earliest settlers did some timber cutting for market. The first sawmill in Warren County was a water-powered mill built in 1800; a raft of pine timbers from this mill was floated down the Allegheny River to Pittsburgh in 1801. Despite this early start, timber cutting remained limited during the early 1800's.



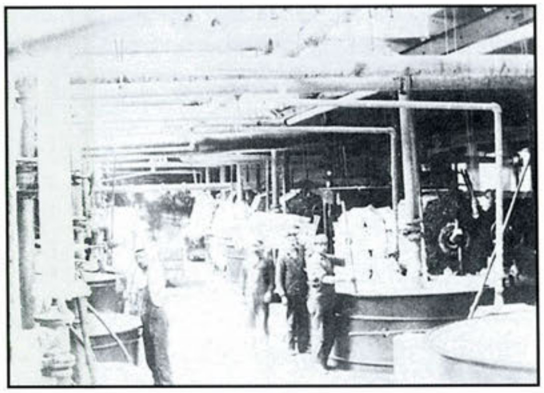
30. Cutting began to accelerate after 1840 when portable steam power plants became available, making circular sawmills practical.

31. Mills that could cut 10,000 board feet of lumber per day became common, and much larger circular mills were built toward the end of the century.



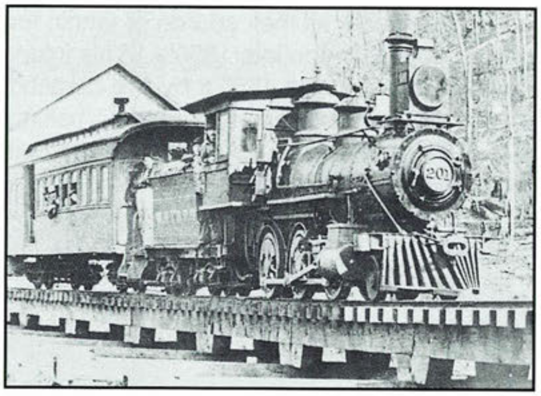
32. Tanneries that used hemlock bark as their source of tannin for curing leather began to appear in the late 1850's. This infant industry received a great boost in the 1860's by the demand for harness, military equipment, and industrial belting occasioned by the Civil War. Tanneries continued to increase in importance through the turn of the century.

33. An eighty-fold increase in coal production between 1850 and 1900, and an equivalent increase in the demand for mine props, timbers, planks, and railroad ties, contributed to expanded timber cutting

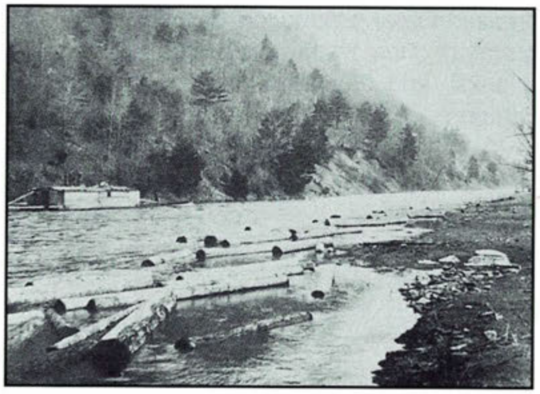


34. as did the demand for paper and other wood pulp products.

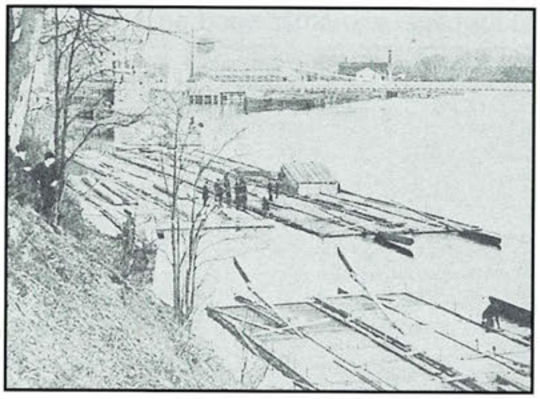
35. Settlement was proceeding more rapidly by 1850, and the demand for lumber to build houses, stores, and furniture increased markedly.



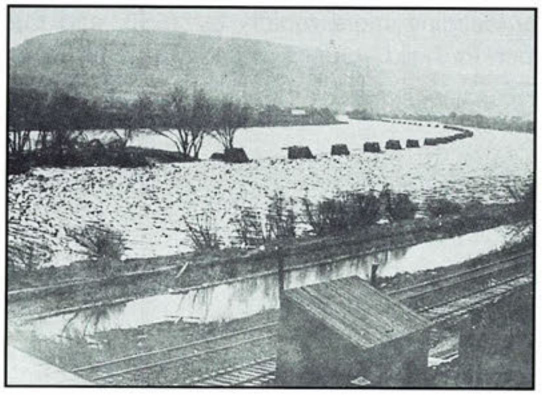
36. Major railroads began to reach the Allegheny hardwood area about this time. Railroads opened extensive and previously inaccessible areas of timber and provided convenient transportation for further development. The first railroad reached Warren in 1859, and two others followed within the next 10 years.



37. During early years of this period, white pine was the major species cut, mainly along the drainages. It was floated down secondary streams to mills, and floated,



38. rafted, or barged down the Susquehanna and Allegheny Rivers to major markets in Williamsport, Harrisburg, Philadelphia, Pittsburgh, and Cincinnati.

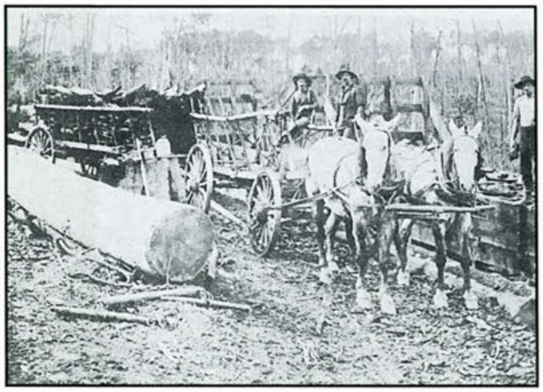


39. As late as 1875, pine was the predominant species passing through the big boom at Williamsport. But as limited supplies of pine were depleted and demands for construction lumber increased, more and more hemlock was cut.

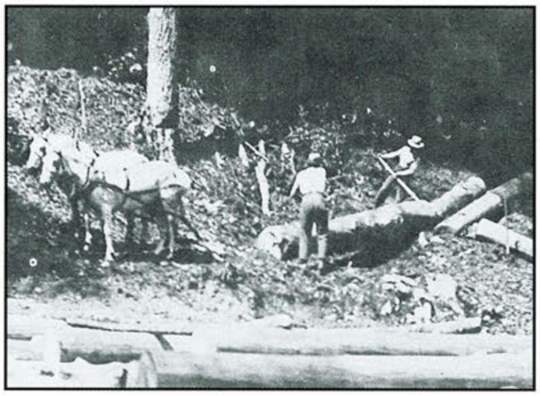
40. By 1890, nearly 8 times as much hemlock was passing through the Williamsport boom as pine--a complete reversal within 15 years.

41. Also, during this period, some large and especially valuable hardwoods were removed--for furniture, panelling and interior trim. Red oak and white ash were cut near the mills, whereas species such as yellow-poplar, cherry, chestnut, and basswood were cut elsewhere because they float well and could be transported by stream.

42. These early cuttings for white pine, hemlock, and selected hardwoods did not result in extensive clearcutting. Hardwoods and hemlock of the quality desired were scattered. And white pine rarely grew in pure stands over extensive areas; it typically grew as small groups of trees intermingled in stands of other species.

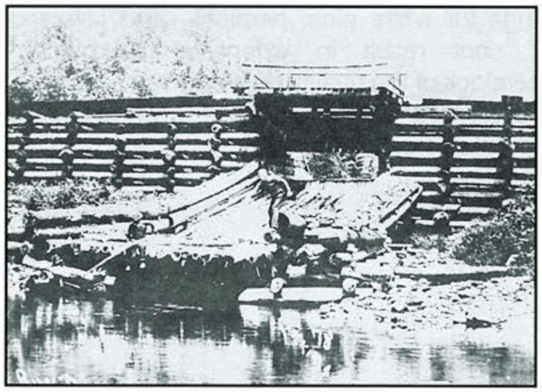


43. Furthermore, the technology required to move large volumes of logs was not well advanced enough to permit clearcutting of major portions of the virgin forest. Most of the cutting was still confined to areas where streams could be used to transport logs to the mill.



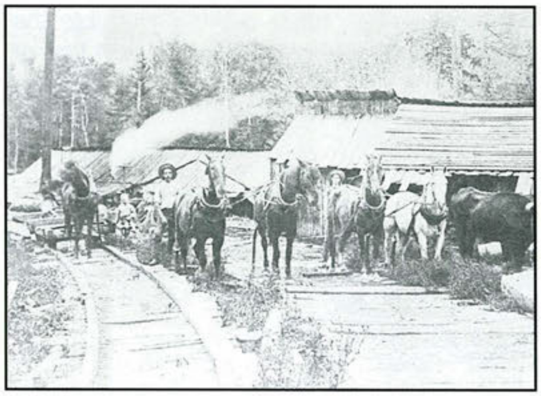
44. In typical operations of the day, trees were felled in the winter and skidded to streams with horses in preparation for the spring thaw.

45. Log slides were often built to extend the distance that logs could be moved.



46. Splash dams permitted logs to be driven down very small streams. With high water during the spring run-off, these dams filled up quickly. When the gates were opened, a rush of water carried the logs down otherwise shallow streambeds.

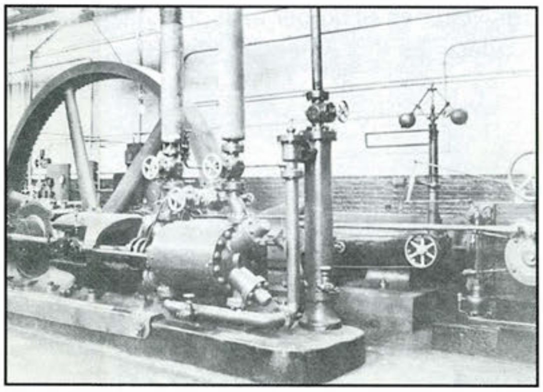
47. Many attempts were made to tap the timber resources more distant from streams. Horse-pulled wagons were used to haul both bark and logs over dirt or even plank roads. But road construction was difficult and expensive and hence little used.



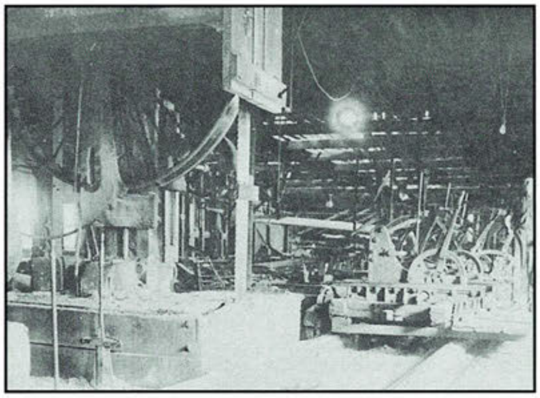
48. Some ambitious loggers built tram roads--the forerunners of logging railroads. Tracks were built of heavy timber on which wheeled log carts could be moved.

49. Because of the dependence on water transport, and markets limited to only the larger trees of selected species, the major portion of the virgin forest--lying on the uplands--remained fairly much intact through about 1880. The cuttings for pine, hemlock, and selected hardwoods were to be scattered and patchy partial ones that left considerable amounts of residual overstory in most places.

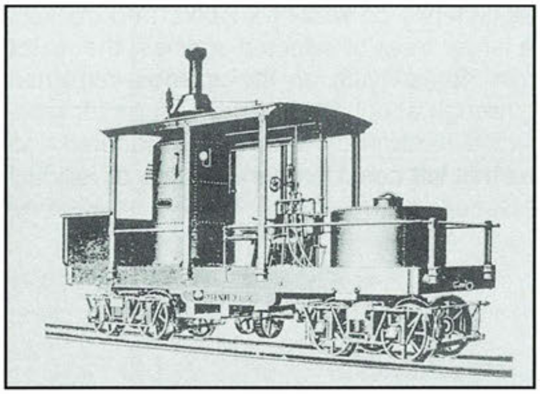
50. But these cuttings did create openings in the extensive forests and resulted in considerable amounts of advance hardwood reproduction.



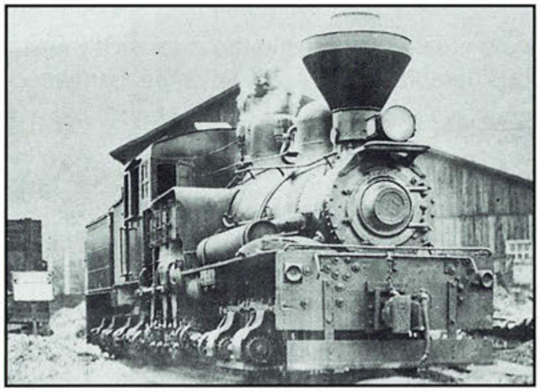
51. During the last half of the 19th century, the industrial revolution had begun to change the methods used to accomplish nearly everything, everywhere. By about 1880, major advances in logging, transportation, and milling methods combined to create dramatic changes in timber harvesting on the Allegheny Plateau.



52. Band saws came into use after 1880, making possible the construction of huge mills capable of sawing 100,000 feet or more of lumber per day.



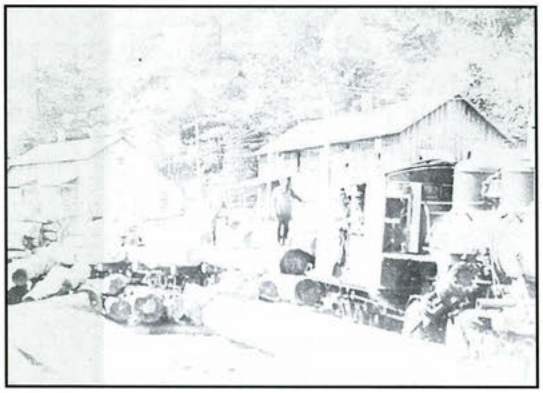
53. The most important change affecting timber production was the development of railroad locomotives designed especially for logging. Originally they were handmade and were little more than a boiler mounted on a flat car with a specially-designed means of transmitting power to the driving wheels.



54. Logging engines were powered by a crankshaft geared to each axle. This model of the Shay was first of several logging engine designs. These geared engines, although slow, were capable of traversing very steep grades and they could negotiate very uneven tracks and sharp curves.

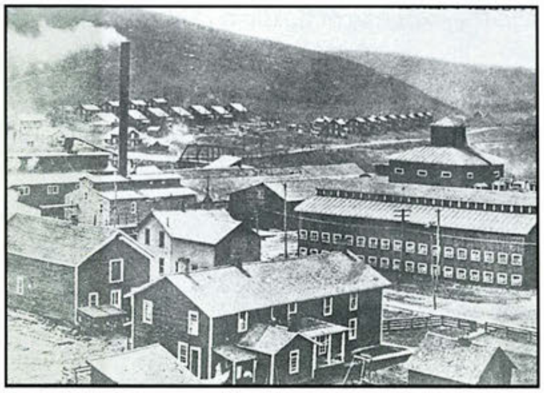
55. Other steam-powered equipment that added greatly to the ability to move large volumes of timber included steam tower skidders and log loaders like this American loader.

56. Before long, logging railroads had been built up nearly every valley to reach the timber on the high ground above,



57. and daily log trains delivered previously undreamed of quantities of logs to the mills on a year-round basis. It was not necessary to rely on access to streams; railroads could reach anywhere and they did.

58. By 1890 the stage was set for a dramatic change in forest cutting operations. Logging railroads had solved the problem of transporting logs from rugged mountain areas.

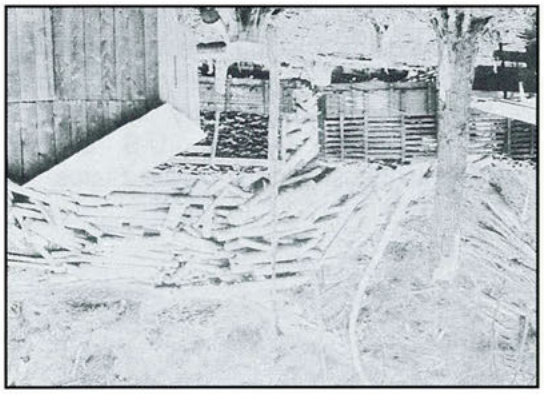


59. A major driving force behind the ensuing forest exploitation was the tanning industry, which by the early 1900's had become not only the major forest industry in northern Pennsylvania, but--as represented by the U.S. Leather Company--the largest single industry in the United States.

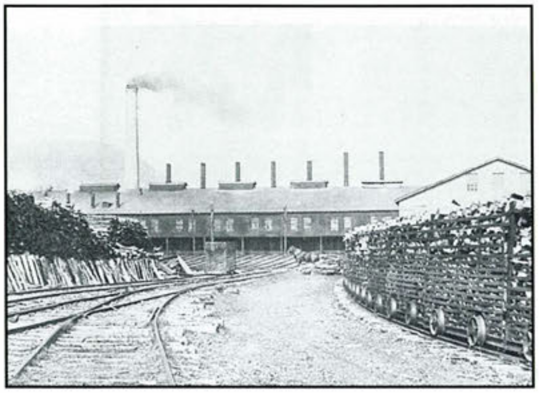
60. Tanneries used tremendous quantities of hemlock bark from which they extracted the tannin used to cure leather. These huge piles of hemlock bark were photographed at the Ludlow Tannery of the Curtis Leather Company.

61. Contrary to popular opinion, hemlock logs were seldom left in the woods to rot after the bark had been removed. This belief apparently was perpetuated because the logs were often left for several months during the bark peeling season while all available labor was used to peel the bark. Those logs were usually retrieved later and cut for construction lumber.

62. The ready and dependable supply of logs and markets and the development of the band saw led to a large sawmill industry, which was often associated with the tanning industry.



63. The combination of the two products, bark and sawlogs, made it possible to finance the expense of building railroads to reach the timber while providing good profits besides.



64. This same combination also led to a third major forest industry: wood chemical plants that produced charcoal, wood alcohol, acetic acid, acetate of lime, and similar products. Tanneries provided dependable markets for many of the chemicals produced, whereas the established logging railroads made transport economical enough to permit bulk recovery of these small wood products.

65. Chemical wood plants provided a market for virtually every size and species of tree growing on the Plateau.

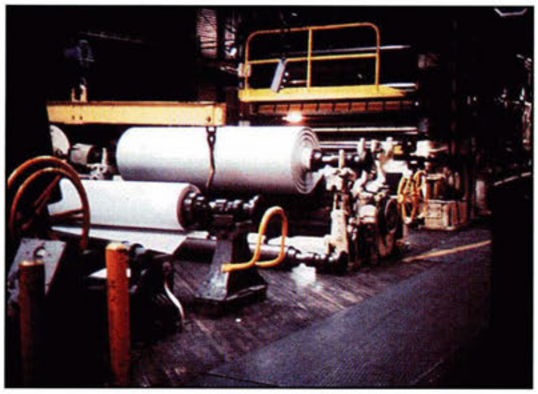
66. Nearly everything was useable. Bark was peeled from the hemlock to use for tanning leather, and the logs were cut for construction lumber.

67. Hardwood logs were also used for construction lumber and for railroad ties, barrel staves, lath,

68. and high quality furniture, like this black cherry dimension stock,

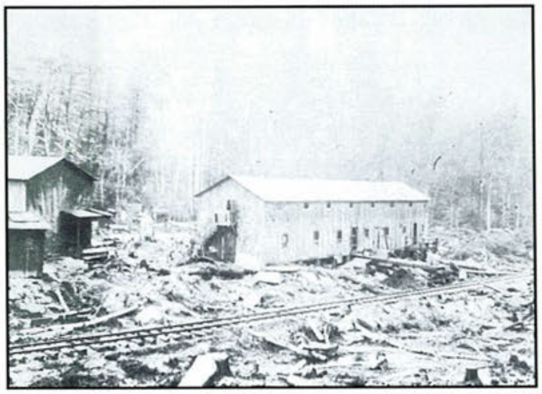
69. tool handles, baseball bats from these white ash rounds.

70. Boltwood was used for charcoal and wood chemicals



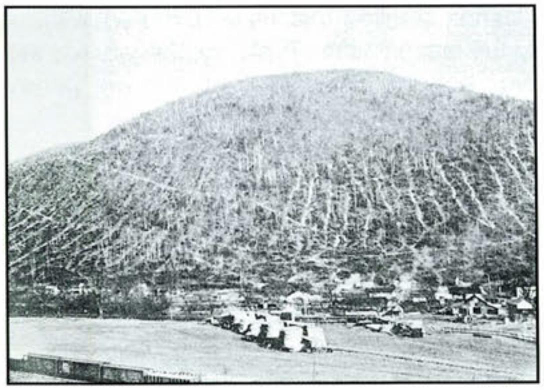
71. or for pulp and paper products.

72. Scrap pieces were made into clothes pins or other small products, or were cut and bundled for kindling wood for use in the many stoves of that era.

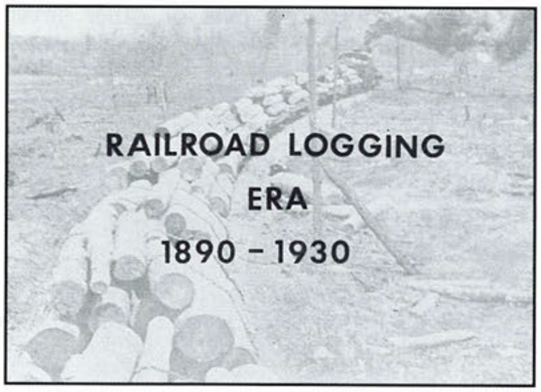


73. Logging camps sprang up everywhere to accommodate the multitude of loggers required to cut and skid the timber.

74. During this era, deer were hunted and sold on the open market to supply the camps with venison and hides. As a result of excessive deer harvests, the deer herd in Pennsylvania was nearly eliminated by the turn of the century.

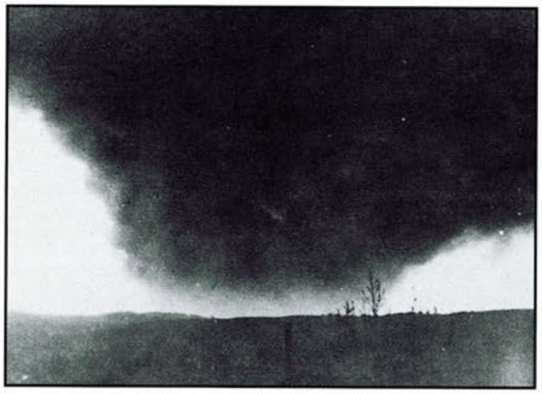


75. During the railroad era between 1890 and 1930, the virgin and partially cut forests of the Allegheny Plateau were almost completely removed.



76. The period of heavy cutting--the railroad logging era--began about 1890, reached a peak about 1910, and ended about 1930, at which time the forests of the Allegheny Plateau had been completely liquidated.

77. In a few areas, the heavy coniferous slash left after railroad logging

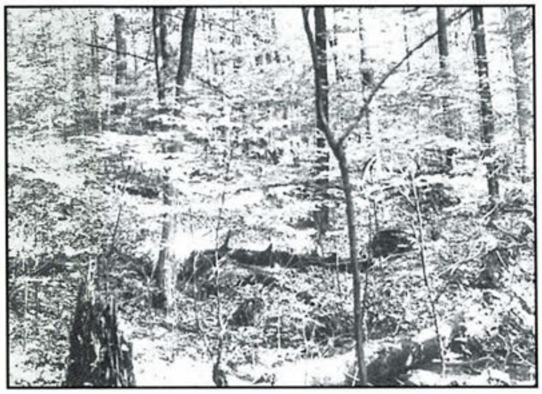


78. resulted in severe forest fires. When this occurred on poorly drained soils, especially in areas where deer browsing or frost damage was heavy,

79. orchard or open stands resulted that have persisted without much tree cover to the present time. Typically, these areas are located in the valley bottoms or occasionally on the poorly drained soils of the broad, flat plateau tops.

80. These areas are now dominated by such plants as aster, goldenrod, grass, and fern with only a few widely spaced trees of black cherry or red maple.

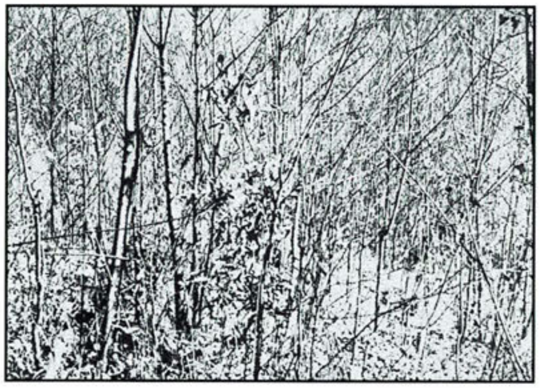
81. On most of the Allegheny Plateau on areas that were not burned severely, fine new second-growth stands containing valuable species such as black cherry, white ash, yellow-poplar, red maple, and sugar maple have developed.



82. This stand on Little Arnot Creek is typical. It had been partially cut in 1868 for hemlock. In 1927, the stand became part of the first commercial timber sale on the newly formed Allegheny National Forest.

83. All hemlock and hardwood sawlogs were removed during the winter of 1927-28

84. and the remaining trees were clearcut for chemical wood about a year later.



85. Ten years after clearcutting, a new forest of saplings was established.

86. Twenty years after cutting, the stand had grown into the small pole stage.

87. By age 30, several dominant black cherry stems in the foreground provide a reference that can be used to watch the stand develop

88. through age 40

89. to age 50

90. and up to age 60 in 1988. This stand exhibits all the characteristics of a typical Allegheny hardwood stand that resulted from the railroad era clearcuttings.

91. Within the general pattern of cutting described, great variation occurred from place to place. The number of partial cuts made in an individual stand during the 1850 to 1890 period ranged from none to several; the severity ranged from light to heavy. Each of these partial cuts was followed by a surge of advance reproduction that influenced the composition and character of the next stand after the railroad era clearcuttings removed the remainder of the overstory.

92. Although the chemical wood clearcuts were about as complete as a commercial clearcut can be, some residuals were left in most stands. The number, size, and distribution of the residuals had an important influence on the character of the next stand. Many stands never received a chemical wood clearcut, whereas others were clearcut several times. Some examples of the major stand types that originated from these different patterns of cutting follow.

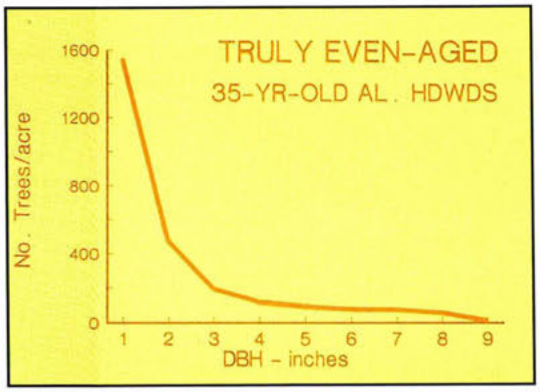
93. The first example is a stand of mature and overmature northern hardwoods that had been cut over lightly about 1900 for hemlock logs. In 1935, it contained about 106 square feet of basal area per acre almost entirely in beech and sugar maple. The canopy had been opened appreciably by the hemlock cutting and by natural mortality of the old-growth trees, many of which were overmature.

94. As a result, there was a dense understory of sugar maple and beech advance seedlings throughout the stand

95. and in areas where the hemlock cutting had been heavy, there were some pole-size trees of a new age class.

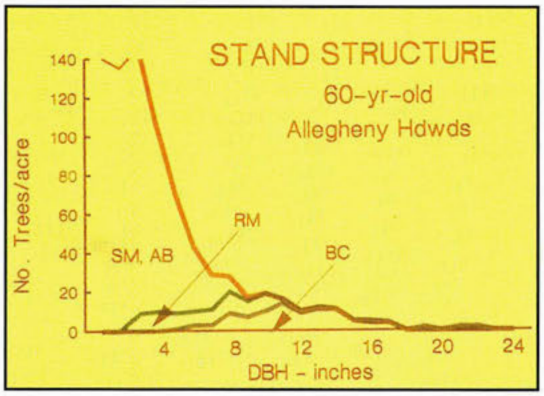
96. A cut to remove the balance of the sawtimber combined with a chemical wood clearcut, was completed in 1935. Tallies made after cutting revealed that about 180 stems per acre 1- to 8-inches in diameter were left standing after the chemical wood cut. The stems represented 10 square feet of basal area.

97. As part of an experiment, eight 1/4-acre plots were established in this stand to determine the influence of those small residual trees. All stems larger than 0.5-inch dbh were mowed down on two of these plots immediately after commercial logging was complete, thus creating a truly even-aged stand. However, 5,000 to 6,000 stems of sugar maple and beech advance reproduction less than 0.5-inch d.b.h. that were not mowed. There were no significant number of black cherry advance seedlings.

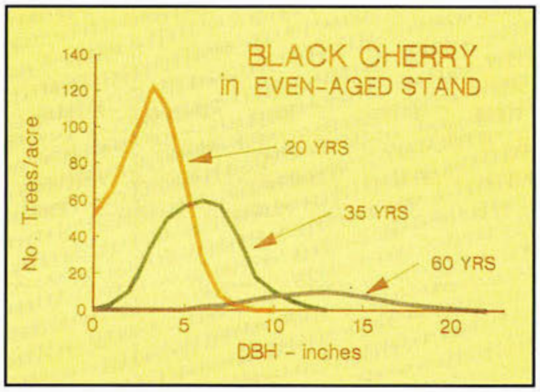


98. Data from the mowed plots 35 years after clearcutting illustrate the composition and structure of truly even-aged stands in the cherry-maple type. When the number of trees in this stand is plotted over diameter class, the diameter distribution for the stand forms an inverse J-shaped curve. This type of diameter distribution is traditionally associated with all-aged stands. Even-aged stands are assumed to follow a bell-shaped or normal curve. This apparent discrepancy in stand structure has led to many erroneous conclusions about the age arrangement and proper management of northern hardwood forests. Some have assumed that because a stand exhibits a typical all-age diameter distribution, it must be all-aged. But nothing is further from the truth, as illustrated by this truly even-aged stand.

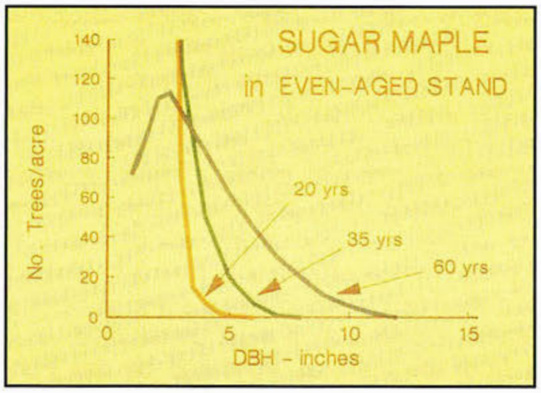
99. The inverse-J distribution occurs in even-aged stands because the tolerant species such as sugar maple and beech are capable of surviving for many years without growing much when they are crowded or overtopped. In dense young stands, a few individuals emerge into dominant crown positions and grow rapidly. The remaining tolerant stems are overtopped but survive leaving a large number of trees in the small diameter classes. This is the inverse-J curve.



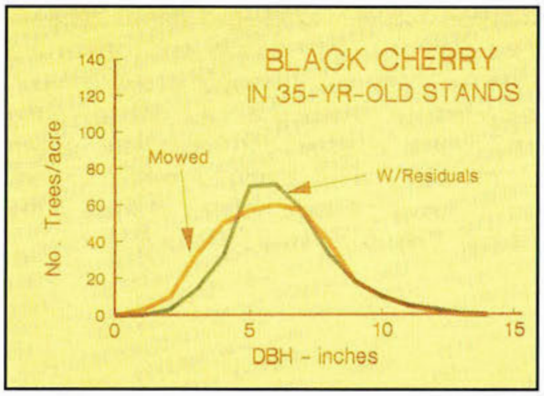
100. When such stands contain a mixture of species of widely different tolerances and growth rates, the diameter distribution and crown canopy is stratified by species groups. The intolerants grow better than other species and capture dominant crown positions and larger diameters. The intolerants that do not maintain dominance quickly die and are absent from the smaller size classes. But the tolerants survive in the lower crown layers and smaller sizes and create a highly stratified, even-aged mixture. Even-aged Allegheny hardwoods usually contain black cherry in the dominant position, sugar maple and beech in the suppressed position, and red maple in an intermediate strata between the two extremes.



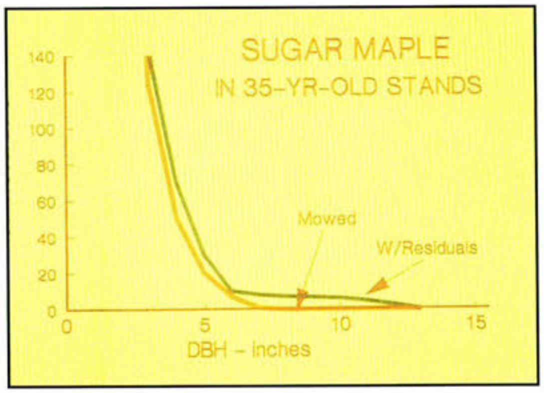
101. The diameter distribution of the intolerant cherry does form a bell-shaped curve even though that of the entire stand as a whole does not. The distribution for black cherry is a bell-shaped curve that moves to the right and becomes increasingly flatter as the stand matures. Note that the largest cherry in this stand are 13 inches d.b.h. at age 35.



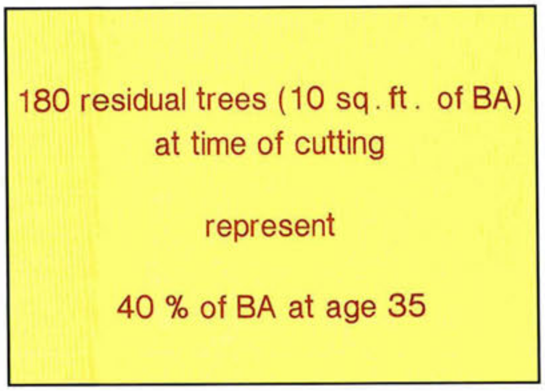
102. By contrast, the distribution for sugar maple is a very steep inverse-J curve with the largest sugar maple much smaller than the largest black cherry at the same age. In this stand, the largest sugar maple were only 7 inches d.b.h. at age 35.



103. Leaving a small number of residual trees during the final chemical wood clearcut resulted in slightly larger diameter distributions from the unmowed plots. The general form of the diameter distribution for black cherry remains the same--bell-shaped with little difference between mowed and unmowed plots.



104. The maples in both plots have steep inverse-J curves, but the unmowed plots contain a few maples of larger diameters that cause the tail of the inverse-J curve to extend much farther than would be expected in a truly even-aged stand. The trees in this extended tail are the residual stems of a distinctly older age class. These residuals have a place in the main crown canopy, and the diameters are approximately the same as those of the larger black cherry. Although the slight difference in the diameter distribution of sugar maple in the two stands may appear inconsequential, the residual trees have had a major impact on stand development.

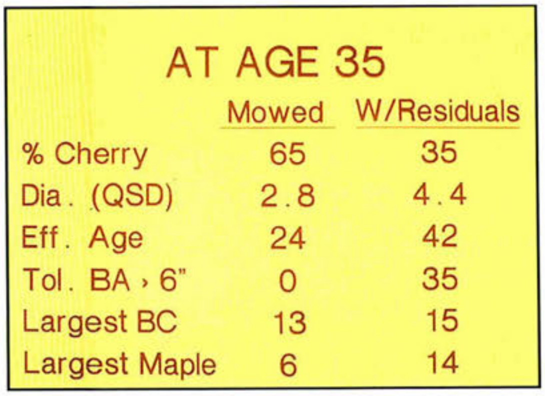


180 residual trees (10 sq. ft. of BA)
at time of cutting

represent

40 % of BA at age 35

105. The relatively small number of residuals left after chemical wood cutting (180 stems per acre representing 10 square feet of basal area) constitute about 47 square feet or 40 percent of the total stand basal area at age 35.



AT AGE 35

	Mowed	W/Residuals
% Cherry	65	35
Dia. (QSD)	2.8	4.4
Eff. Age	24	42
Tol. BA › 6"	0	35
Largest BC	13	15
Largest Maple	6	14

106. Leaving a few tolerant residual saplings and poles had these effects: A lower proportion of black cherry (35 versus 65 percent of the basal area) and correspondingly higher proportions of sugar maple and beech than that on the mowed plots; a larger quadratic stand diameter (4.4 versus 2.8 inches); faster stand development producing an effective age of 42 years versus 24 years; presence of tolerant species in the main crown canopy and merchantable size classes -- 35 square feet of sugar maple and beech versus none in the mowed plots. The largest sugar maple in the mowed stand was 6 inches, whereas in the unmowed plots they were as large as 14 inches. Even the cherry were slightly larger in the plots with residuals, suggesting that cherry grows faster when in mixture with maple than it does in pure stands.

107. Examination of numerous other stands that were clearcut for chemical wood and known to contain small residual trees has revealed the same pattern consistently. Where sugar maple and beech are present in the main crown canopy in diameters comparable to the largest black cherry, the sugar maple and beech are invariably residual stems of an older age. They are in the main crown layer because they received a head start on the faster growing intolerants.

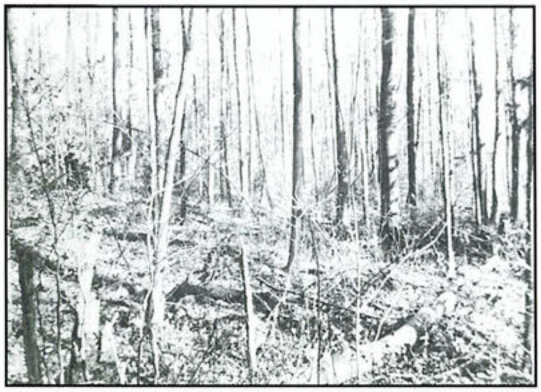
108. The second example is a stand that received two chemical wood cuts. The original stand on this site had been clearcut about 1895, resulting in a 42-year-old second-growth stand when this photo was taken in 1937. The second-growth contained a considerable number of black cherry stems that had originated after the first clearcut, along with the usual sugar maple and beech. There was little advance regeneration, such as found in the old-growth stands of that era. Because the stand was young, there were few sawlogs and the second clearcut in 1937 was for chemical wood only.

109. Strip-wise fashion was the usual practice when cutting for chemical wood only. This usualy was not feasible in a cutting where sawlogs were removed first (the usual practice) because of the slash and skid trails caused by the sawlog harvest. Two cutters were typically assigned to a strip about 60 feet wide. They felled the trees from the center of the strip and cut the center line very clean to facilitate skidding with horses. Slash was allowed to accumulate along the edges of the strip. Although trees as small as 2 or 3 inches d.b.h. were utilized for chemical wood, the cutters seldom bothered to cut such small stems when they were located in the windrows of slash along the strip edge.

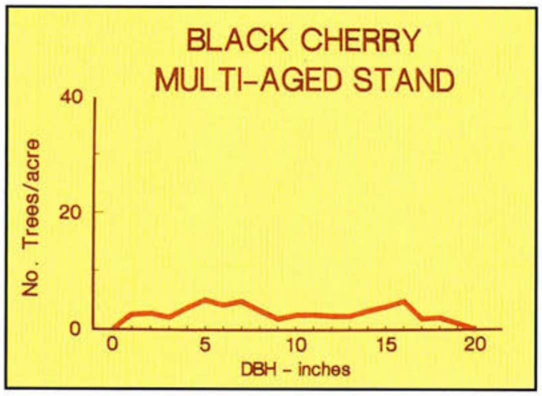
110. Evidence of this type of cutting is plainly visible today if you know what to look for. Such stands contain lines of shade-tolerant residuals in the main crown about 60 feet apart.

111. The shade tolerant species in areas between the lines have small diameters and suppressed crown positions. The large trees in the areas between the lines are fast-growing intolerants. Because stumps of young trees sprout vigorously, these third-growth stands that resulted from clearcutting of young second-growth typically have a very high percentage of sprout origin stems.

112. This aerial photograph shows clearly the strip-wise pattern of cutting and windrows of slash that were common in the chemical-wood-only cuts.

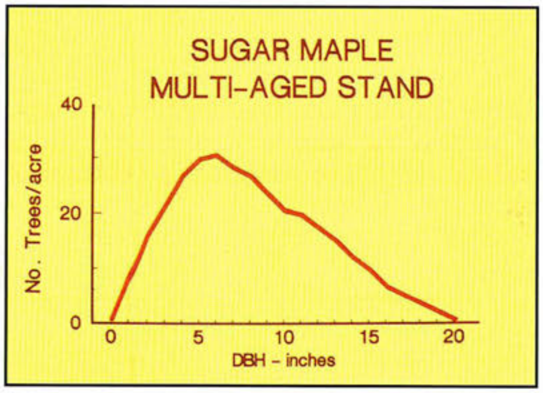


113. For our third and final example, here is a stand that never received a chemical wood clearcut. This stand was partially cut for hemlock sawlogs in 1888, and then cut again for the remaining hemlock and hardwood sawlogs in 1900. Because the stand was never cut for chemical wood it never received a complete clearcut, though the final sawlog cut was quite heavy. A surge of reproduction developed after each of the two partial cuts, and this reproduction, together with some residuals from the original stand, provides three distinct age classes in the present stand.



BLACK CHERRY MULTI-AGED STAND

114. Because basal area was not reduced below about 40 square feet per acre, the proportion of shade-intolerant species tends to be low in these multi-age stands that were never clearcut. The black cherry diameter distribution in this stand is broad and irregular. This is typical of older stands with a low percentage of cherry. Several closely spaced age classes of cherry cause the curve to show several slight peaks.



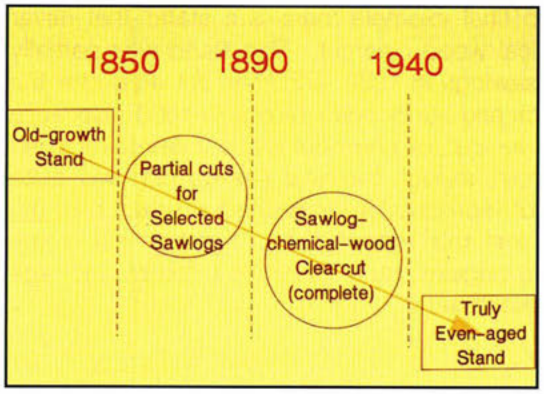
SUGAR MAPLE MULTI-AGED STAND

115. The sugar maple distribution in multi-aged stands may depart dramatically from the inverse-J form. The intermingling of several age classes, and death of the very small maples in this older stand produce a nearly bell-shaped curve. So, shade tolerant species often exhibit diameter distributions exactly opposite of what you would expect. If the sugar maple exhibits a steep J-shaped curve, it is probably an even-aged stand. If it exhibits a bell-shaped curve, it is often a multi-aged stand.

MAJOR TYPES OF ALLEGHENY HARDWOOD STANDS

Truly Even-aged
Even-aged Third growth
Even-aged Second growth
Multi-aged

116. Most Allegheny hardwood stands can be grouped into four major types on the basis of past cutting history: truly even-aged stands, third-growth even-aged stands with residuals, second-growth even-aged stands with residuals, and multi-aged stands.



1850 1890 1940

Old-growth Stand

Partial cuts for Selected Sawlogs

Sawlog-chemical-wood Clearcut (complete)

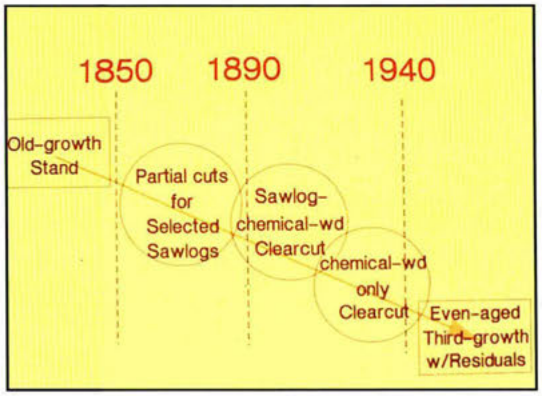
Truly Even-aged Stand

117. Truly even-aged stands are rare and limited to research plots and small portions of stands where the final cutting was usually complete. The previous hemlock-beech old-growth stands may or may not have had partial cuts during the 1850-1900 era. To be truly even-aged, the final cut must be complete leaving no residual stems larger than seedling size.

TRULY EVEN-AGED

60 to 90 years old
High % Cherry
Highly stratified
No Residuals

118. The crown canopy of truly even-aged stands is highly stratified by species. Black cherry is usually abundant and occupies the dominant crown positions and larger diameters. There are few, if any, tolerant species in the upper canopy or larger diameters because there were no residuals.



1850 1890 1940

Old-growth Stand

Partial cuts for Selected Sawlogs

Sawlog-chemical-wd Clearcut

chemical-wd only Clearcut

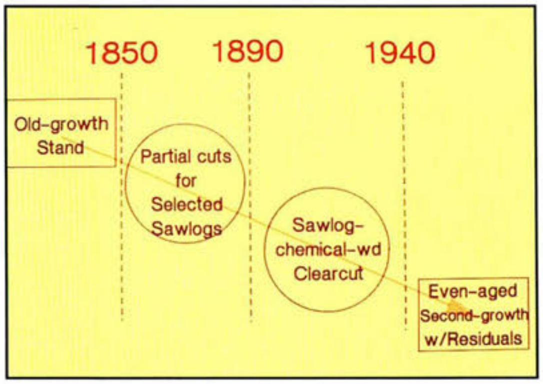
Even-aged Third-growth w/Residuals

119. Third-growth, even-aged stands resulted from two clearcuts over a short period of time. Usually, the first was a combined sawlog-chemical wood clearcut in the 1880-1920 era, followed by a second clearcut for chemical wood only in the 1920-40 era.

EVEN-AGED THIRD GROWTH (with Residuals)

50 to 70 years old
High % Cherry
Stratified Canopy
Residual Tolerants in Lines
High % Sprouts

120. These third-growth stands typically have a high percentage of cherry usually regenerated after the first clearcut, providing a source of cherry sprouts in addition to new seedlings following the second clearcut. Third-growth stands usually have a very high percentage of sprout-origin stems because young trees tend to sprout prolifically when cut. The canopy is stratified with tolerant residuals in the main canopy arranged in parallel lines as a result of the strip-wise pattern of cutting. These stands tend to be our youngest because this type of cutting occurred toward the end of the railroad logging era, after the old-growth stands were gone. Quality of third-growth often seems poor, because of the young age and the high proportion of sprouts.



1850 1890 1940

Old-growth Stand

Partial cuts for Selected Sawlogs

Sawlog-chemical-wd Clearcut

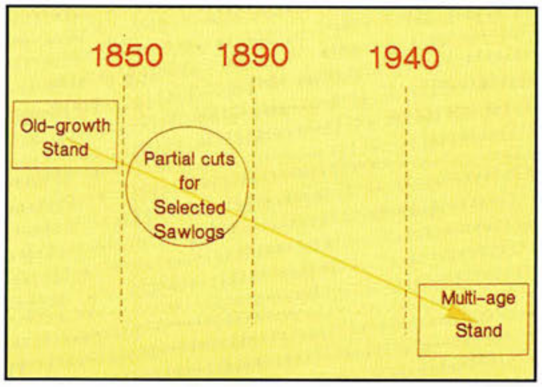
Even-aged Second-growth w/Residuals

121. Second-growth, even-aged stands are perhaps our most common type. They originated from the most typical pattern of cutting--one or two partial cuts in the 1850-1910 era, followed by a clearcut for sawlogs and chemical wood in the 1900-30 era.

EVEN-AGED SECOND-GROWTH
(with Residuals)

60 to 90 years old
Moderate % Cherry
Stratified Canopy
Residual at Random

122. Most of the original old-growth stands on these sites had one or more partial cuts before the final clearcut, and this encouraged in large amounts of tolerant advance regeneration. Much of this tolerant advance growth was too small to harvest at the time of the final clearcut, and some of these stems were left as residuals. So these second-growth, even-age stands often have a fair proportion of tolerant residuals in the main crown canopy, distributed at random through the stand. Most second-growth stands are slightly older than the third-growth discussed previously because final harvests of this type occurred earlier, while some old growth was in existence.



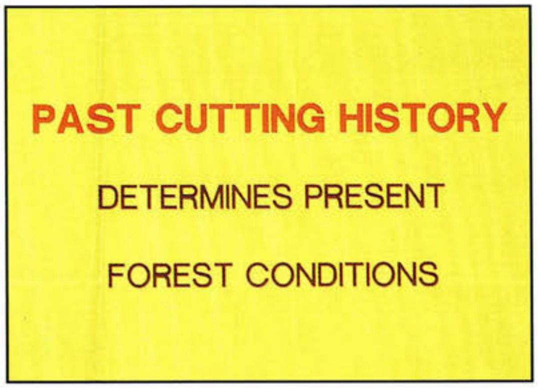
123. Multi-age stands never had a complete clearcut. The final partial cut usually was confined to sawlog trees. This partial cut may have been heavy and was often called a commercial clearcut. But considerable quantities of pole- and sapling-size trees were left as residuals. Often, this type of cutting occurred in areas where there was no chemical wood markets, or where the final cut occurred before the chemical wood plants were built.

MULTI-AGED

90 plus years old
Low % Cherry
Crown not Stratified
Residual Tolerants in all Sizes

124. Multi-age stands are our oldest stands because they originate from the cutting that occurred in the 1880-1910 era before chemical wood plants were widely distributed. Shade-tolerant species are usually well represented in the main crown canopy, so the distinct stratification evident in even-aged stands is absent. The tolerant residuals often dominate the stand, and it is common for some of them to exceed several hundred years of age. Cherry percentages are usually low, because of the incomplete cutting and high density of residuals.

These stands are often classified as northern hardwoods rather than Allegheny hardwoods. These type differences, of course, are simply the opposite ends of a continuum that forms the northern hardwood ecosystem. Many of the differences we observe in present day stands on the Allegheny Plateau are the result of differences in their past cutting history. This is true of such characteristics as species composition, age, amount of sprouting, and crown stratification.



PAST CUTTING HISTORY

DETERMINES PRESENT

FOREST CONDITIONS

125. Understanding how the present forests originated and developed, should enable you to determine proper forest management and provide insight into cutting techniques that will produce desired regeneration today.

Several lessons can be learned from our examination of past history. Although we tend to think of our present second-growth stands as even-aged stands resulting from complete clearcutting at the turn of the century, this is an oversimplification. The present stands are not completely even-aged. They were created by a sequence of cuts that resembled shelterwood or diameter-limit cuttings more than clearcutting. A close look at these stands reveals that their age arrangement is complex and that regeneration did not always originate in one fell swoop.

Cherry seedlings (and red maple) can start at the time of clearcutting and outgrow already established seedling-sapling advance reproduction of sugar maple and beech. Because present stands lack tolerant advance reproduction and may contain small cherry advance seedlings, it is no wonder that clearcutting today tends to create nearly pure cherry third-growth. Deer browsing, of course, may limit any kind of reproduction today.

If stands with a mixture of tolerants and intolerants are desired, it probably will be necessary to retain sapling- and pole-size stems of the tolerant species at the final harvest so that a new stand containing both species groups in the main canopy will result. In other words, creation of stands that can be managed by even-age techniques sometimes requires creating several age classes on purpose.

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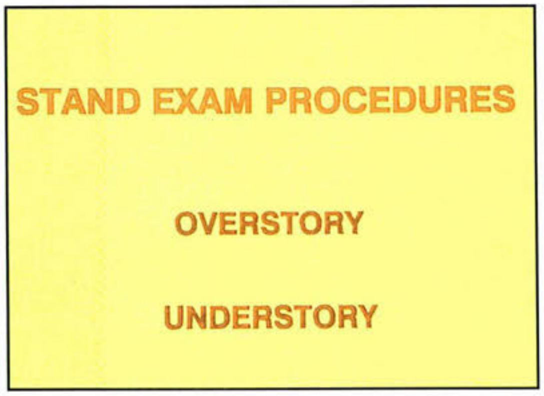
Stand Examination Procedures

James C. Redding

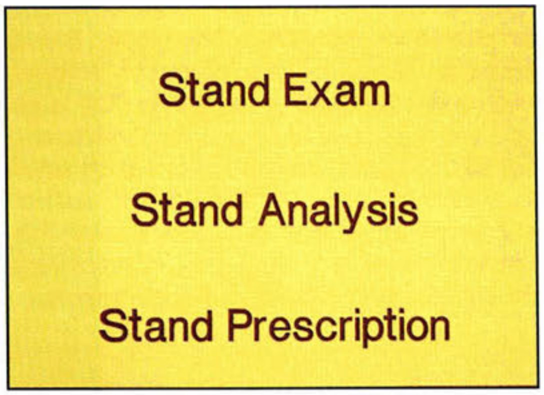


STAND EXAM PROCEDURES

OVERSTORY

UNDERSTORY

1. The SILVAH (SILViculture of Allegheny Hardwoods) stand analysis and prescription procedure provides a systematic way to evaluate forest stands and make silvicultural decisions,

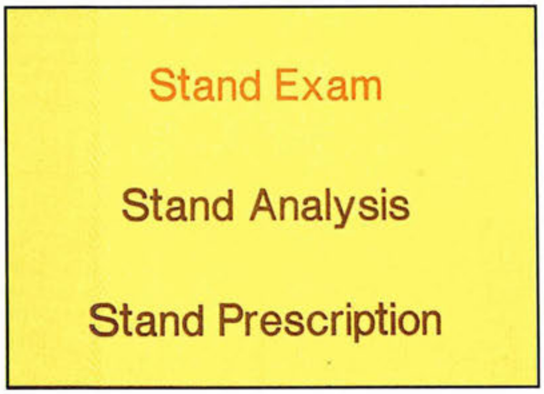


Stand Exam

Stand Analysis

Stand Prescription

2. and consists of three steps: (a) stand examination, (b) stand analysis, and (c) stand prescription.

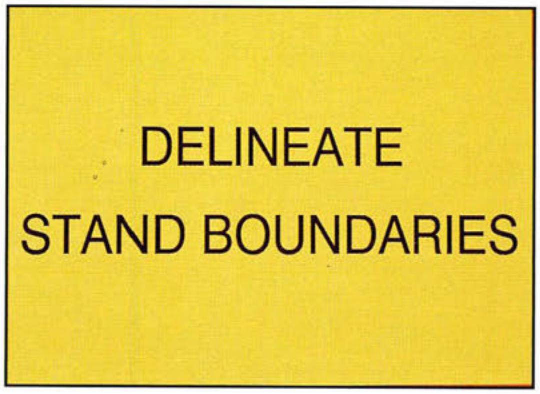


Stand Exam

Stand Analysis

Stand Prescription

3. The stand examination or inventory described here provides the basic data needed to determine the stand's density, species composition, structure, stage of maturity, and potential for future growth or regeneration. Silvicultural treatments can be based on these measured facts rather than subjective judgments. Inventory data collected in this manner tells you not only how much you can cut, but also precisely where the cut is located.



DELINEATE
STAND BOUNDARIES

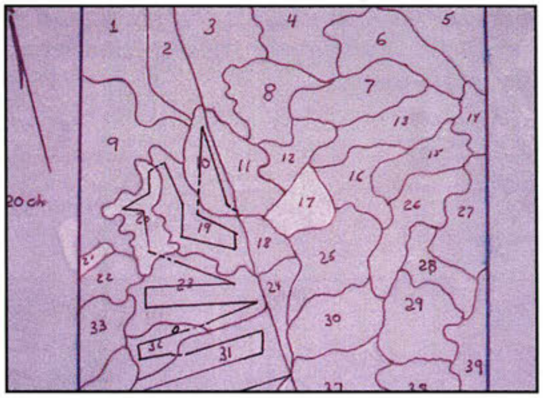
4. The first step in examining a stand is to determine the stand boundaries.

5. Stand units usually are identified from aerial photographs first and later checked and adjusted on the ground as needed.

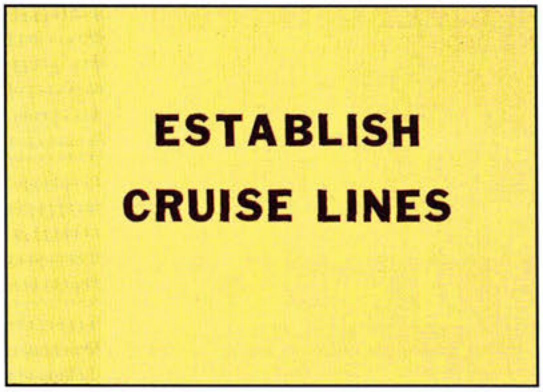
Stand boundaries should be set to keep the stand as uniform as possible in composition, age, structure, and site quality. However, consideration also should be given to the ease of management. Boundaries that coincide with easily recognized features of the terrain such as roads or streams allow for more efficient field work and stands that can be reidentified readily.

6. Stand area is dictated largely by stand conditions--the amount of uniform conditions available in one block. Stand area should be large enough to provide a reasonably efficient field operation which varies with size of ownership. 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. Areas of uniform stand condition usually do not cover 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.

7. In areas of heavy deer browsing, avoid very small stands and long narrow ones such as those indicated by arrows.



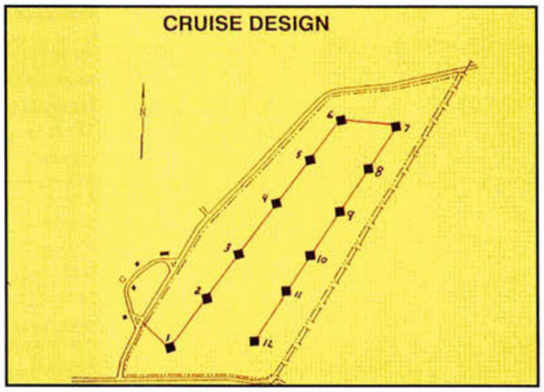
8. An acetate overlay on the aerial photo with each stand numbered provides a useful method of keeping track of stands, cruise lines, and plot locations as well as a place to record field notes on changes in stand condition.



ESTABLISH

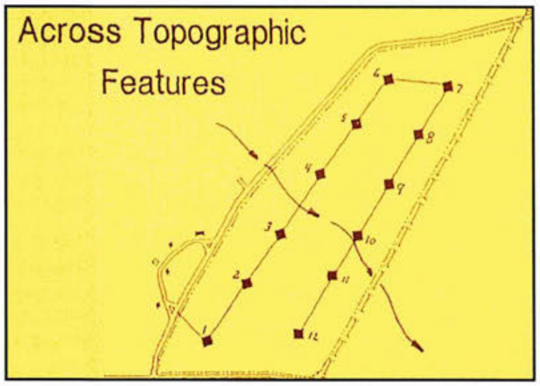
CRUISE LINES

9. The next step is to devise a sampling scheme that ensures the plots are well distributed throughout the stand and that plot locations are set without bias.



CRUISE DESIGN

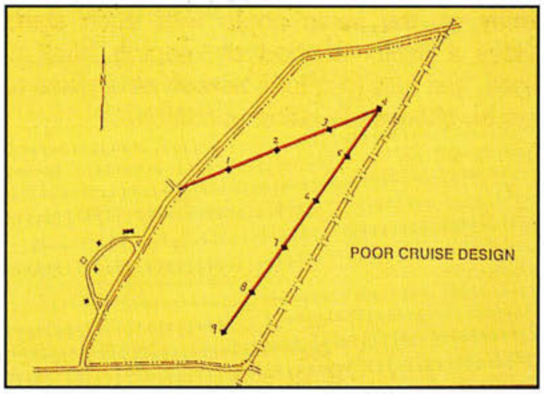
10. A systematic sample using predetermined cruise lines with sample plots at fixed intervals along the lines is usually easiest.



Across Topographic Features

11. Cruise lines should be laid out across topographic features rather than 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 like roads and powerlines, 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 to obtain enough well-distributed sample points to provide accurate estimates for the stand. The number of plots required to keep standard error within any desired limits can be calculated if data on variances are available.



12. Avoid laying out cruise lines that miss significant portions of the stand. Even if the overstory is uniform, understory conditions can be quite variable.

HOW MANY PLOTS?

13. The number of plots needed to obtain an adequate sample depends on stand conditions.

Overstory Parameters

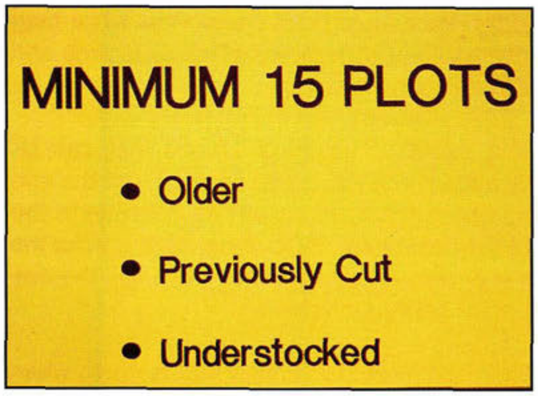
± 10%

14. Critical overstory parameters (total basal area, species composition, stand diameter, relative density) usually can be estimated plus or minus 10 percent (at a 95% confidence level) with a sample of 10 to 25 plots, depending on variability in the stand and stand size.

10 PLOT MINIMUM

- Young
- Uncut
- Fully Stocked

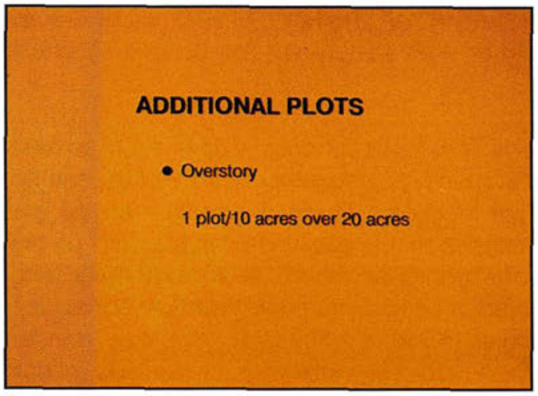
15. As a rule of thumb, we suggest a minimum of 10 overstory plots in stands that have relatively uniform conditions (such as young, previously uncut, and fully stocked stands),



MINIMUM 15 PLOTS

- Older
- Previously Cut
- Understocked

16. and a minimum of 15 overstory plots in stands that have less uniform conditions (such as previously cut, older, or understocked stands).

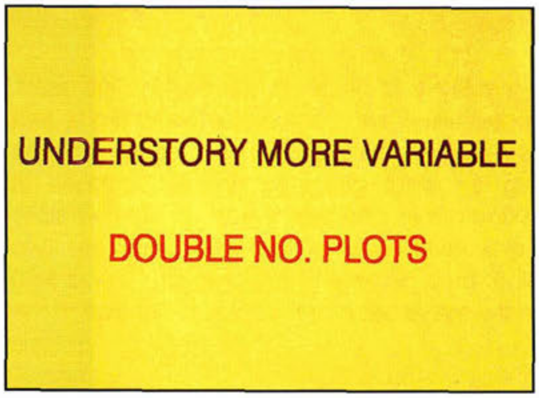


ADDITIONAL PLOTS

- Overstory

  1 plot/10 acres over 20 acres

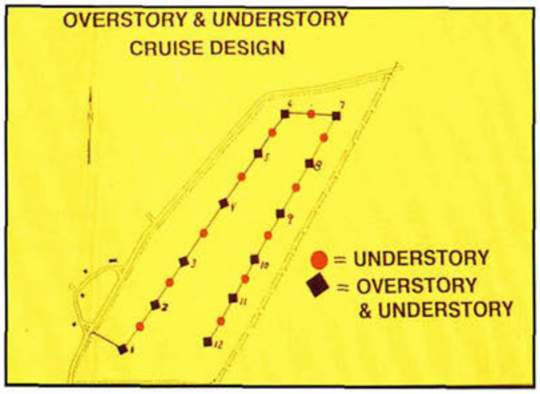
17. For stands greater than 20 acres in size, take an additional overstory plot for every 8 to 10 acres over 20 acres.



UNDERSTORY MORE VARIABLE

DOUBLE NO. PLOTS

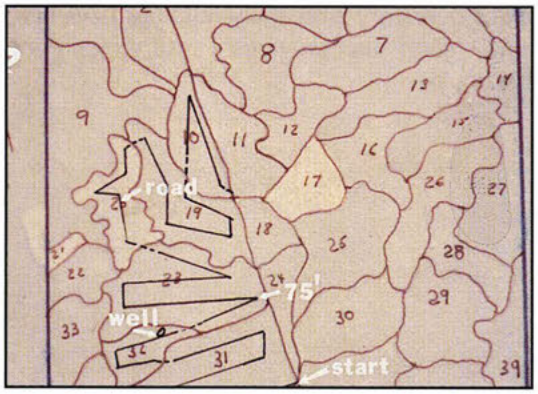
18. Because of the variability in numbers of desirable advance seedlings and amount of undesirable herbaceous cover, more regeneration plots than overstory plots are required for an adequate assessment. We recommend two regeneration plots for every overstory plot.



OVERSTORY & UNDERSTORY
CRUISE DESIGN

● = UNDERSTORY
◆ = OVERSTORY & UNDERSTORY

19. To obtain the desired number of understory plots, locate the cruise lines and overstory plot centers first. Each overstory plot center also will be an understory plot center. In addition, take an extra understory plot halfway between each of the combined overstory-understory plot locations.

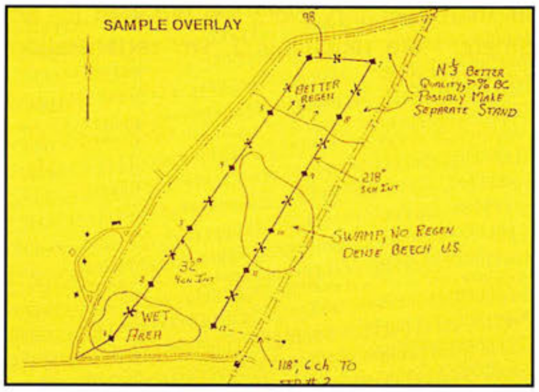


20. An hour spent in the office laying out cruise lines on a map or aerial photograph of the property will often save time and many miles of unproductive walking.

Attempt to select a stand or group of stands that can be examined in a day and lay out the cruise lines so that the end point of one stand corresponds as closely as possible to the beginning point of the next stand. Also, if possible lay out the entire day's work in a circular route so that you finish the day near the starting point and your vehicle.

Do not assume that the top of the aerial photo is north when determining the bearings of your cruise lines. Some photos are as much as 15° to 18° off. Use a U. S. Geological Survey sheet or a known straight feature on the ground to orient your photo.

In laying out cruise lines, look for checkpoints such as road intersections, well openings, 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). You may wander far off course if you do not plan your cruise and check yourself carefully.



21. Use the acetate overlay you made as a working field map. Record bearings of cruise lines, intervals between plots, and connecting lines between stands on the overlay. These overlays are also a useful place to record changes in understory conditions, such as wet areas, or in overstory conditions that may lead to breaking the stand into two stands or changing the typed stand boundaries. Good field notes on the overlay make data summarization easier.

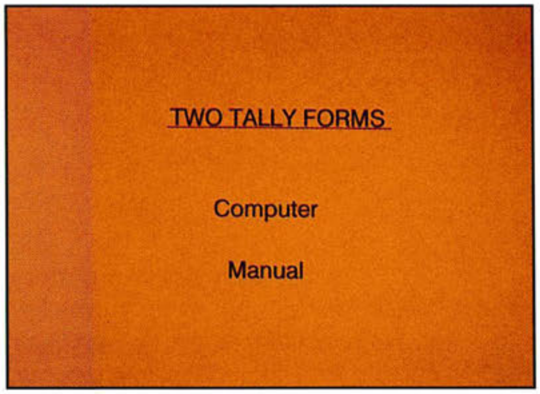
22. After the cruise lines and plots have been drawn on a map or photo of the stand, the field work can begin. A hand compass and pacing are all that are needed to locate the actual on-the-ground plots. Be sure to take the plot wherever it falls--do not move plot locations to avoid thick patches of beech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

DATA COLLECTION

- Overstory
- Understory

23. Data on overstory and understory conditions plus information on site limitations are collected and recorded during the course of the stand inventory. First we discuss overstory data collection.

24. The recommended sampling procedure for the overstory is a variable radius plot using a ten-factor prism 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 accurate sawlog volume estimates are desired and if data are being summarized by computer, you may also record merchantable sawlog height, grade, and defect for sawtimber-size trees. Other prism factors, or fixed-area plots, also may be used if desired.

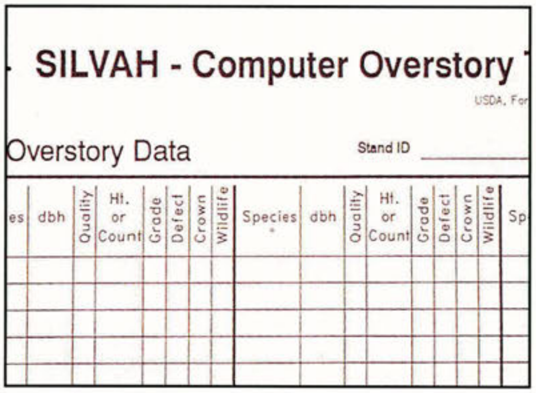


TWO TALLY FORMS

Computer

Manual

25. We have designed two overstory tally forms for entering all overstory data collected during stand inventory (Appendix 2 and 3).



SILVAH - Computer Overstory

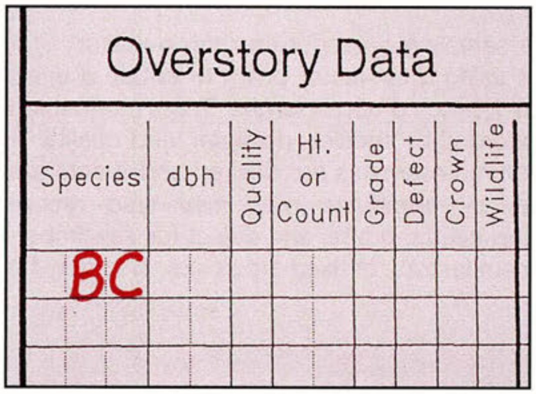
USDA, For

Overstory Data

Stand ID ______

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

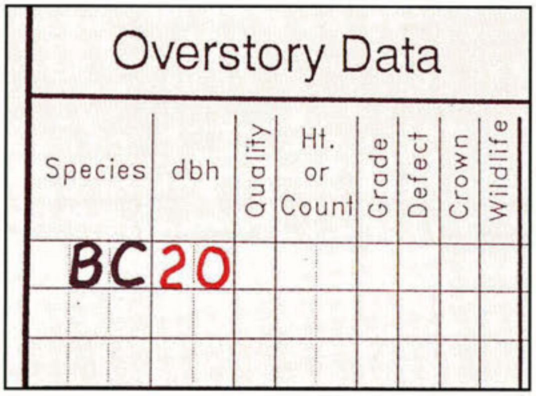
26. The Computer Overstory Tally form (Appendix 2) is used when the data analysis will be performed by computer. Each tree sampled in the overstory is recorded on a separate line.



Overstory Data

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

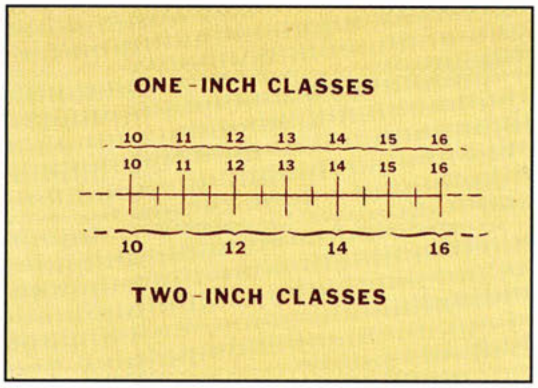
27. For example, suppose we intercepted a 20-inch black cherry with the prism. From the mnemonic species code list (Appendix 1), we find the species code for black cherry (BC) and record it on the tally form in the first column. The SILVAH program recognizes three different types of species code (Appendix 1): forest survey, mnemonic, or user defined.



Overstory Data

Species	dbh	Quality	Ht. or Count	Grade	Defect	Crown	Wildlife
BC	20						

28. Diameter breast high (d.b.h) should be estimated and recorded to the nearest 1- or 2-inch class. Estimating d.b.h requires practice--inexperienced workers often find it necessary to measure diameters for a day or two. Thereafter, occasional checks should suffice except for large trees, which are difficult to estimate accurately. In this example, we record the tree as 20 inches d.b.h.



29. Caution--breaking points for trees recorded by 1-inch size classes fall on the half inch, and breaking points for trees recorded by 2-inch size classes fall on the whole inch. For example, when using 2-inch diameter classes, the 14-inch class extends from 13.01 to 15.00; and for 1-inch classes, it extends from 13.51 to 14.50. Be consistent when recording trees, and use either 1-inch classes or 2-inch classes but not both.

QUALITY CLASSES

Code	Class
1	AGS
2	UGS
3	Dead

30. Three quality classes are recognized and are recorded as coded values.

AGS (Code 1)

- Sawlog Now
- Sawlog Potential
- Acceptable Species
- Will Survive 15 Years

31. Acceptable growing stock trees (AGS, code 1) are trees that either now contain sawlog material or have the potential in the future to contain sawlog material anywhere in the tree, are of an acceptable commercial species and will survive until your next entry. Do not discriminate because of size; assume that every tree will grow to sawtimber size and judge quality on that basis.

UGS (Code 2)

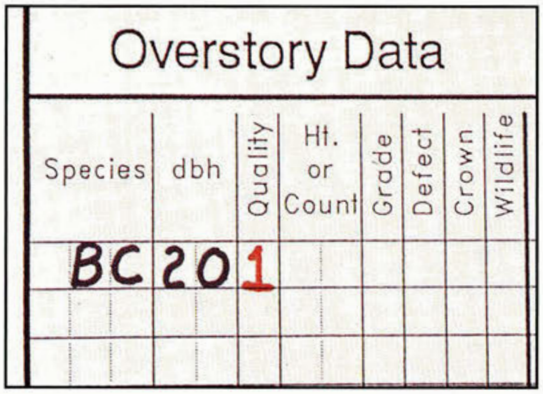
- Will Never Contain Sawlog
- Will Not Survive 15 Years
- Unacceptable Species

32. Unacceptable growing stock trees (UGS, code 2) are trees that do not presently contain sawlog material or do not have the potential for sawlog material, are of an unacceptable species or in your judgment will not survive until your next entry. All noncommercial species are considered unacceptable growing stock.

DEAD (Code 3)

- Salvage sales
- Optional (wildlife)

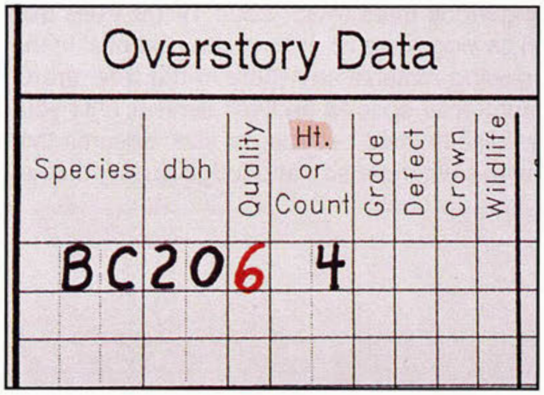
33. The third quality code is for recording dead trees (code 3). This coding is designed to give volume estimates from dead trees if a salvage cut is prescribed. Tallying dead trees is optional. This quality class also can be used to tally non-salvageable material that has benefit for wildlife.



Overstory Data

Species	dbh	Quality	Ht. or Count	Grade	Defect	Crown	Wildlife
BC	20	1					

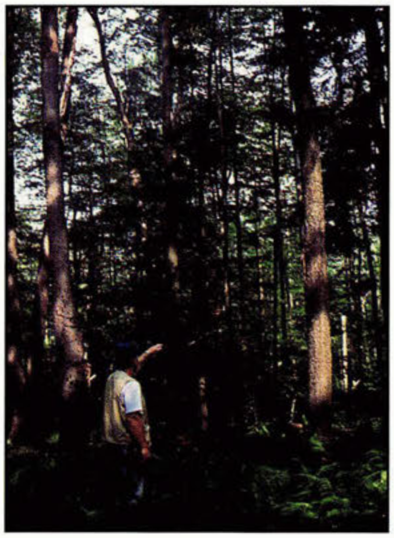
34. In our example, the tree is acceptable growing stock or quality Code 1.



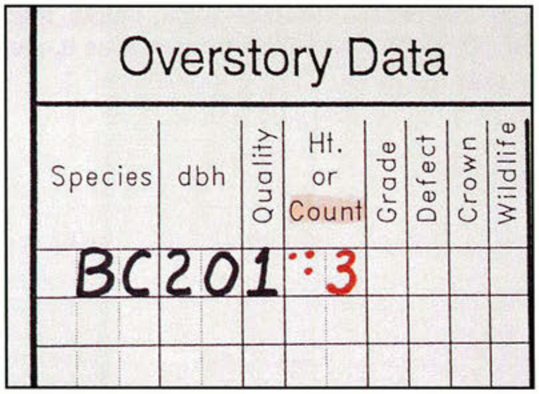
Overstory Data

Species	dbh	Quality	Ht. or Count	Grade	Defect	Crown	Wildlife
BC	20	6	4				

35. 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 contains a sawlog. These merchantable heights will be used in sawlog volume calculations. If no heights are recorded for sawlog trees, SILVAH will estimate merchantable heights from equations of average heights encountered in stands in northwestern Pennsylvania. In the example, there are four 8-foot bolts or 32 feet of clear bole.



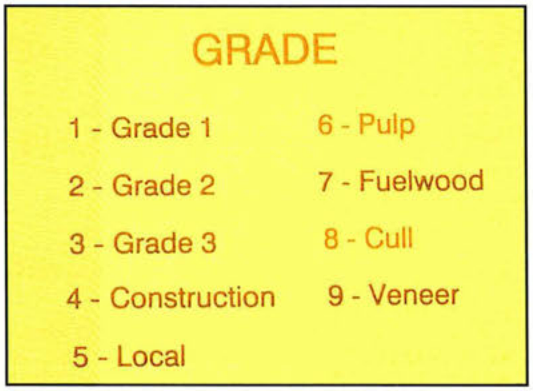
36. Estimates of merchantable sawlog height should be to a point where diameter drops below the minimum inside bark diameter for sawtimber or the height at which the bole breaks up. We recommend a minimum diameter inside bark (d.i.b) of 10.5 inches for hardwoods.



Overstory Data

Species	dbh	Quality	Ht. or Count	Grade	Defect	Crown	Wildlife
BC	20	1	3				

37. If heights are not recorded on the form, the height column may be used to record tree count. The number of trees with the same species, diameter, quality, and other attributes is entered into the column--the example shows three. You must record the proper code in the overstory cruise type field as described later.

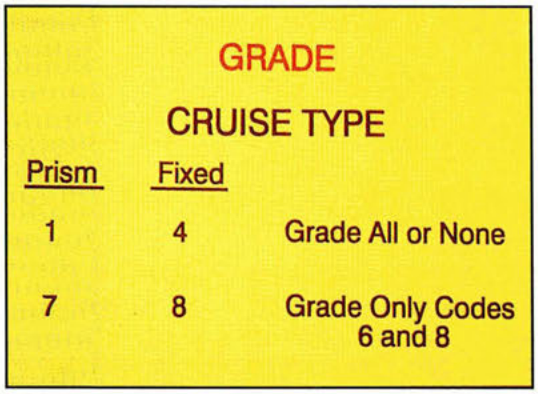


GRADE

1 - Grade 1
2 - Grade 2
3 - Grade 3
4 - Construction
5 - Local
6 - Pulp
7 - Fuelwood
8 - Cull
9 - Veneer

38. SILVAH gives you several options for recording tree grade depending on the accuracy you desire and the time and money you are willing to spend on an inventory. These options are coded values entered on the header sheet and are clearly defined in Appendix A of the User's Guide to SILVAH. If you choose not to grade trees, SILVAH will estimate grade based upon equations of average grade recovery by species and d.b.h., including a percentage for culls and sawtimber-size trees containing only pulpwood. If either all trees or no trees are graded (with prism cruise), the appropriate cruise type (in the stand ID data block) is 1. If you use a fixed area cruise, the code is 4.

One option that adds very little time to an inventory but increases accuracy is to code in the grade column only those trees that are culls or sawtimber size trees containing only pulpwood volume. If you choose this option, use a cruise type 7 for prism cruise or 8 for fixed area cruise in the stand ID data block.

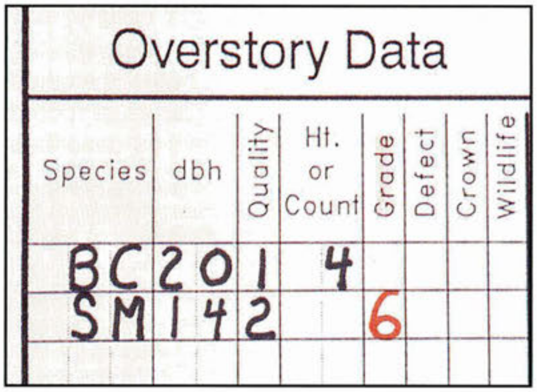


GRADE

CRUISE TYPE

Prism	Fixed	
1	4	Grade All or None
7	8	Grade Only Codes 6 and 8

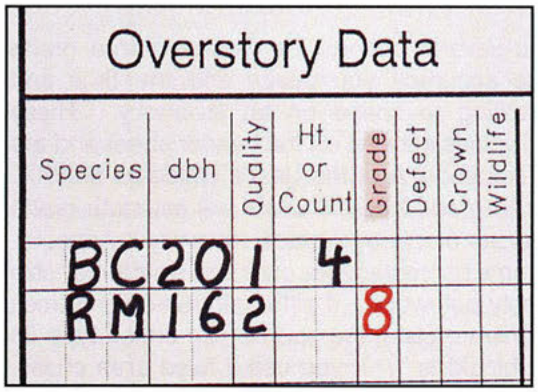
39. It is very important to enter the proper code for cruise type on the header sheet to allow SILVAH to properly analyze your cruise data.



Overstory Data

Species	dbh	Quality	Ht. or Count	Grade	Defect	Crown	Wildlife
BC	20	1	4				
SM	14	2		6			

40. For example, if you intercept a 14-inch sugar maple that contains only pulpwood material and code the grade as 6, the program will assign only pulpwood volume to this tree.

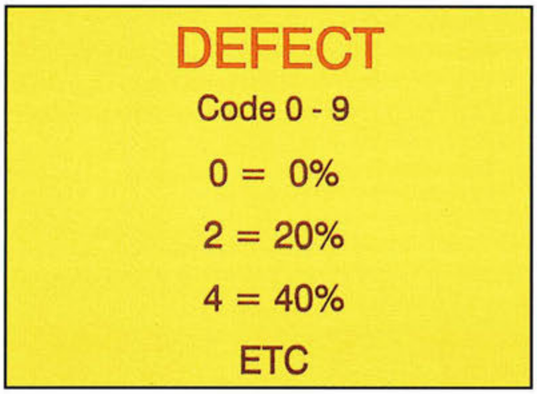


Overstory Data

Species	dbh	Quality	Ht. or Count	Grade	Defect	Crown	Wildlife
BC	20	1	4				
RM	16	2		8			

41. Likewise, if you intercept a 16-inch cull red maple, you would code it 8 in the grade column. The program will not include this tree in volume estimates.

    Crown condition if oaks is the single most important factor in predicting mortality due to gypsy moth defoliation-induced stress. Three classes are recognized. Crowns in good condition (code 1) have less than 25 percent dead branches, little or no epicormics, and healthy foliage. Crowns in poor condition (code 3) have one or more of the following conditions: 50 percent or more of the branches are dead; foliage density size and coloration are abnormal; or epicormic sprouting is heavy. Trees whose crowns fall between these extremes are rates as fair (code 3).



DEFECT

Code 0 - 9

0 = 0%

2 = 20%

4 = 40%

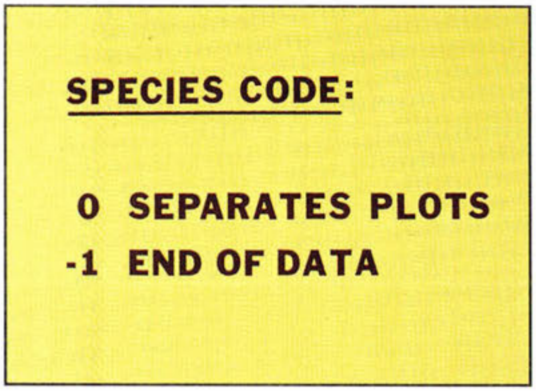
ETC

42. If accurate timber values and net volumes are to be calculated from the inventory data, percent defect also may be recorded. Enter a value from 0 to 9 representing the percentage (to the nearest 10 percent) of the merchantable tree volume that is unmerchantable due to decay, sweep, crook, or other defect. Thus, a 1 equals 10 percent, 9 equals 90 percent and so on. If you choose not to collect and record defect, deductions will be made based on averages of defect by species and diameter from a sample of trees in northwestern Pennsylvania.

WILDLIFE

1 Den - Potential
2 Den - Existing
3 Snag - Potential
4 Snag - Existing

43. If information is desired on wildlife habitat, overstory trees with value as den trees or snags may be recorded. Care should be taken to mark dead trees using a code 3 in the quality column. Both potential and actual den trees and snags are recorded using the codes shown here.

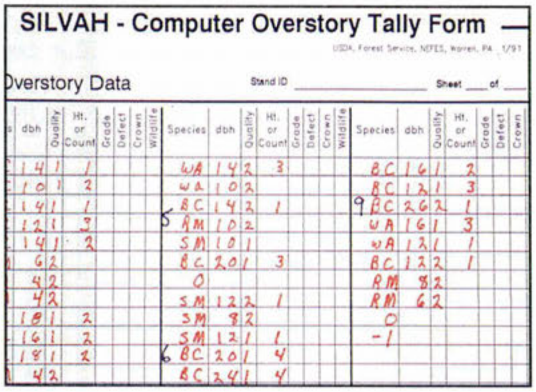


SPECIES CODE:

0 SEPARATES PLOTS

-1 END OF DATA

44. A zero entered in the species column of the tally form separates one plot from the next; a -1 in the species column after the zero indicates the last plot in the stand.



SILVAH - Computer Overstory Tally Form

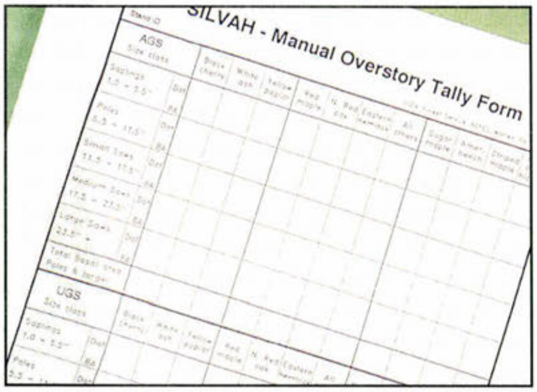
USDA, Forest Service, NEFES, Warren, PA 1/91

Dverstory Data

Stand ID ____________ Sheet ___ of ___

s	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
	14	1	1					WA	14	2	3					BC	16	1	2			
	10	1	2					WA	10	2						BC	12	1	3			
	14	1	1					BC	14	2	1					9 BC	26	2	1			
	12	1	3					5 RM	10	2						WA	16	1	3			
	14	1	2					SM	10	1						WA	12	1	1			
	6	2						BC	20	1	3					BC	12	2	1			
	4	2						0								RM	8	2				
	4	2						SM	12	2	1					RM	6	2				
	18	1	2					SM	8	2						0						
	16	1	2					SM	12	1	1					-1						
	18	1	2					6 BC	20	1	4											
	4	2						BC	24	1	4											

45. The completed overstory tally form should look like this. By maintaining each plot separately in this way, it is possible to calculate plot to plot variances and estimate sampling accuracy.

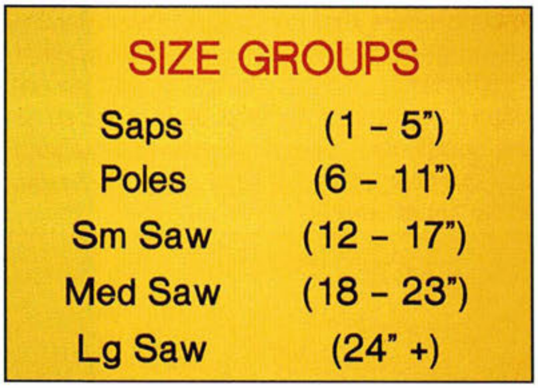


SILVAH - Manual Overstory Tally Form

AGS

UGS

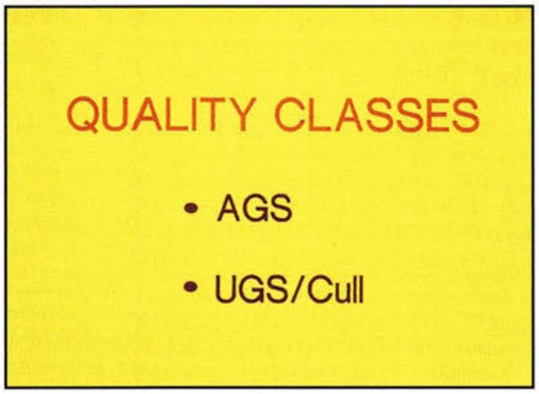
46. If you intend to calculate the stand summary and prescription by hand, the alternate manual tally form may be used (Appendix 3). Instead of recording each tree, a dot tally of the entire stand is made. Trees intercepted by the prism are dot tallied by species, size class, and quality class.



SIZE GROUPS

Saps	(1 - 5")
Poles	(6 - 11")
Sm Saw	(12 - 17")
Med Saw	(18 - 23")
Lg Saw	(24" +)

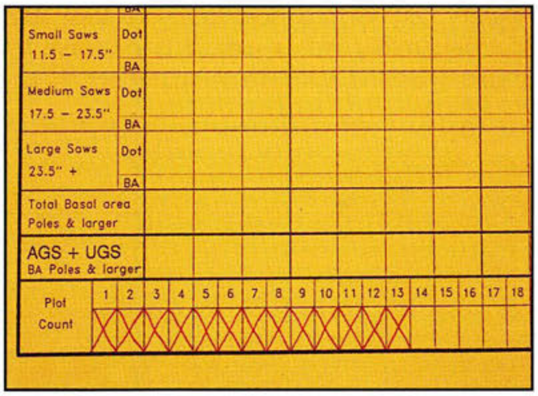
47. Five size classes are recognized on the manual tally form. When using this form, we recommend using size class breaking points that correspond to 1-inch diameter classes. Thus, saplings are 1.0 inch to 5.5 inches d.b.h. (1- through 5-inch classes). Poles are 5.6 to 11.5 inches d.b.h. (6- through 11-inch classes). Small sawtimber is 11.6 to 17.5 inches d.b.h. (12- through 17-inch classes). Medium sawtimber is 17.6 to 23.5 inches d.b.h. (18- through 23-inch classes). Large sawtimber is 23.5 inches d.b.h. and larger (24-inch class and larger). When these size classes are entered into the computer, use the following diameter midpoints: 3", 8", 14", 20", 26", respectively.



QUALITY CLASSES

- AGS
- UGS/Cull

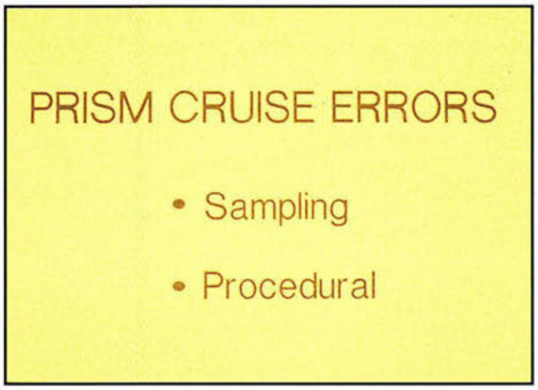
48. Two quality classes are recognized on the manual tally sheet: acceptable growing-stock (AGS) trees are unacceptable growing-stock trees (UGS). Dead trees are not tallied but could be tallied on a separate sheet if merchantable volume of dead material is wanted as described before.



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
Count	X	X	X	X	X	X	X	X	X	X	X	X	X					

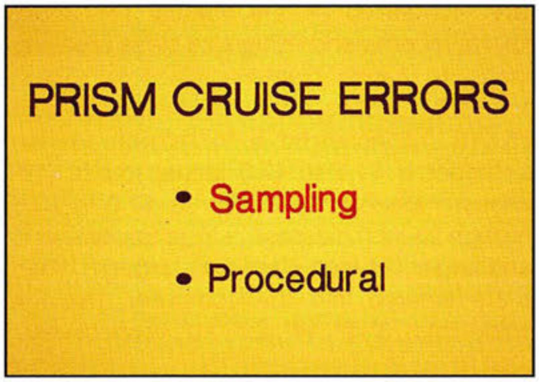
49. No provision is made for separating plots on the manual tally form--data from all plots are combined in the dot tally. But the number of plots sampled must be recorded. Make an "X" (or record total number of trees intercepted by the prism) in the boxes provided for this purpose. If numbers of trees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



PRISM CRUISE ERRORS

- Sampling
- Procedural

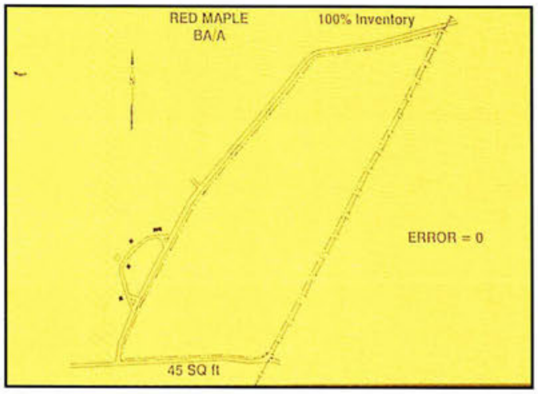
50. That completes the review of the tally forms; next we discuss inventory procedures. As with any prism cruise, two sources of error should be avoided: sampling and procedural.



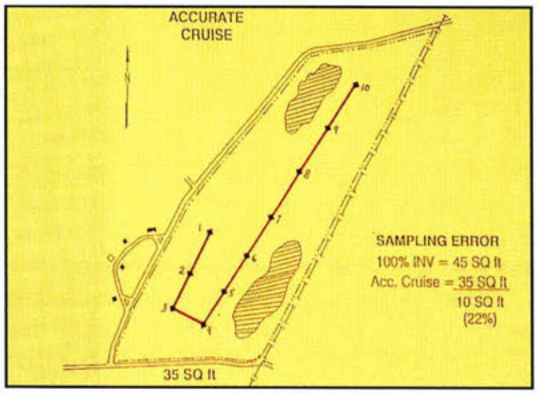
PRISM CRUISE ERRORS

- Sampling
- Procedural

51. First we look at sampling errors that are caused by variability within a stand. Some portions of a stand may differ from other portions in species composition, density, tree size, and so on. To get an accurate stand average, plots must be located so as to sample the various conditions. Sampling error can be kept to acceptable limits by sampling enough evenly distributed plots to adequately cover the entire stand.



52. By analyzing the cruise of a stand used in a field exercise, I will illustrate what a poorly laid out cruise can do to sampling error. It is a 32-acre stand on which we have a 100 percent inventory of all trees 1.0 inch and larger, so we know exactly what is there. For red maple, we know there are 45 square feet of basal area per acre.



53. For an exercise, we laid out 10 variable radius prism plots that were not evenly distributed throughout the stand. These plots were carefully measured to eliminate any error in procedure producing what we call an "accurate cruise." As you can see, the poorly distributed plots missed the areas with a higher basal area of red maple (the shaded areas) resulting in a 22 percent error due to an inadequate sample. We can minimize, but not eliminate, sampling error by sampling enough well-distributed plots to thoroughly cover the stand.

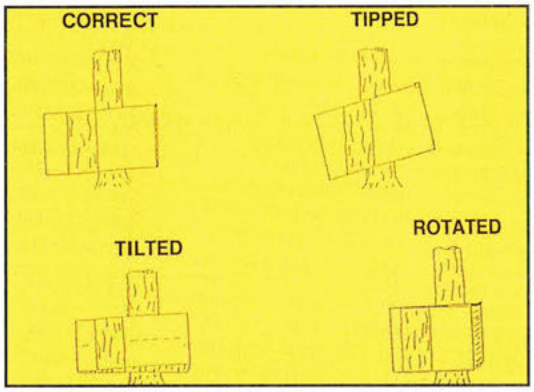
PRISM CRUISE ERRORS

- Sampling
- Procedural

54. The second type of error found in prism cruising is error in procedure. With care, this source of error can be eliminated.

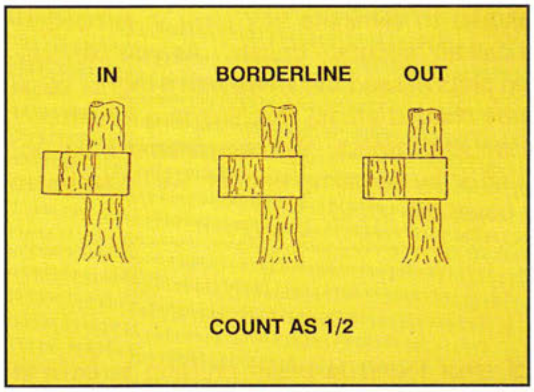
IMPROPERLY
CALIBRATED
PRISM

55. Inaccurate prisms are one source of procedural error. 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 has not been 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.

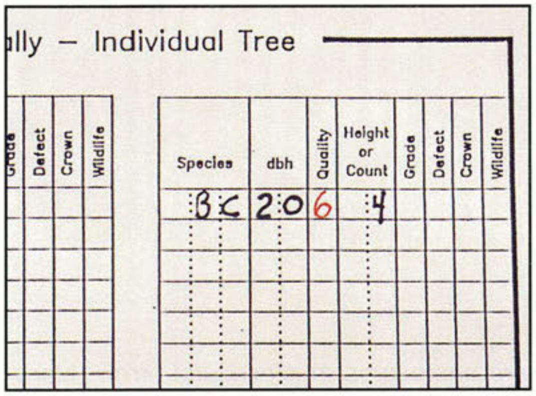


56. Another error is sloppy procedure. The prism and not the observer must be kept over the center of the plot. It usually helps to rest the prism on a plot center pole and rotate around it. The prism must also be held level and vertical (except where tilted purposely to compensate for slope or leaning 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 also can cause problems. Experienced foresters sometimes go through the motions of making a prism count without ever actually looking through the prism. Avoid subconsciously deciding whether the tree is in or out until you have checked it with the prism.



57. Borderline trees present another problem. Improper classification of borderline trees (trees that you can not positively identify as in or out through the prism) has been a source of error in past tallies. If pressures to get the job done preclude checking borderline trees, we recommend counting each one as a 1/2 tree as opposed to counting every other one. Total basal area will be no different, but composition and distribution will be. For example, counting the first borderline tree, which may be a pole sugar maple, while ignoring the second, which may be a black cherry small saw, would affect both composition and distribution.

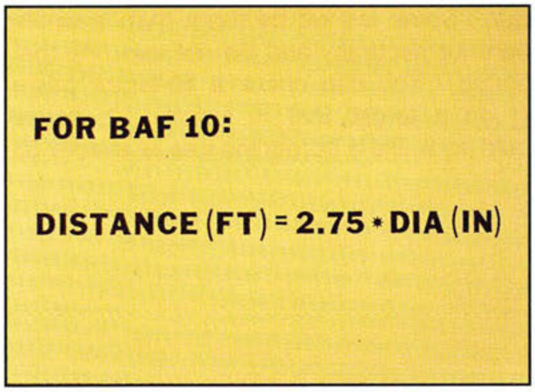


lly – Individual Tree

Grade	Defect	Crown	Wildlife

Species	dbh	Quality	Height or Count	Grade	Defect	Crown	Wildlife
BC	20	6	4				

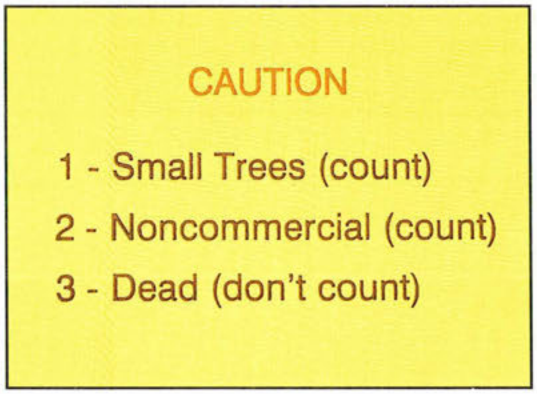
58. Half-trees may be recorded on the computer tally form by adding a 5 to the quality class. Thus, an acceptable growing stock borderline tree is tallied as 6 (1 + 5) in the quality column. The computer summarization program will interpret this as a half-tree. If you are recording data on the manual form, use an "X" rather than a dot, or keep them separate.



FOR BAF 10:

DISTANCE (FT) = 2.75 * DIA (IN)

59. The most accurate procedure is to measure the distance to the tree centerline and its d.b.h. If the distance in feet is more than 2.75 times the diameter in inches, the tree is out of range for a 10-factor prism. Otherwise it is in. A 75-foot, automatic return tape that can be clipped to the belt will facilitate such checks.



CAUTION

1 - Small Trees (count)

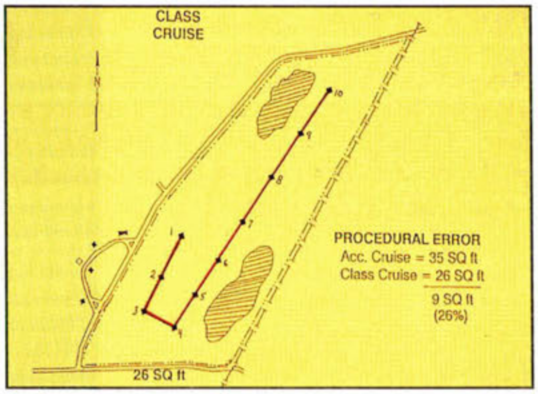
2 - Noncommercial (count)

3 - Dead (don't count)

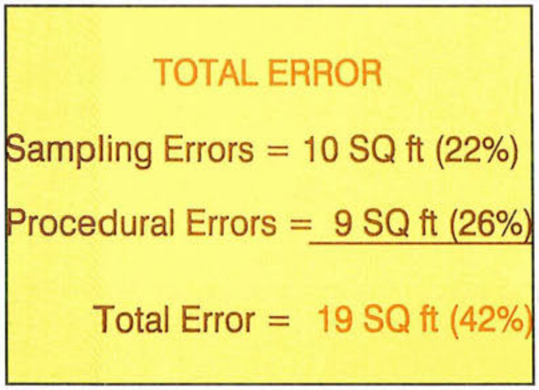
60. Small trees present another problem. In tallying the basal area, one precaution is especially important: do not overlook the small trees. The overstory density guide is based on all trees 1.0 inch d.b.h. or larger. Decisions on appropriate thinning procedures and evaluations of selection cutting 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 the wrong answer.

Including these small trees does not add appreciably to the time required for the overstory tally, because relatively few of these trees are picked up in the 10-factor prism cruise in older stands. At the other sampling extreme, many of the small trees and even some larger trees will be dead when stands are very dense; be sure not to include these in the tally unless they are coded as dead trees. Dead trees should not be counted unless you plan to salvage merchantable volume from these stems or want to record them for wildlife purposes.

Be sure to include all live noncommercial species in your tally as they are taking up growing space and are part of the growing stock.



61. With data from the field exercise we also were able to demonstrate procedural error. On those 10 plots for which we had an "accurate" prism cruise, we had students from previous training sessions take those plots using the exact same plot center. The results of 10 years of data from student inventories show that their average estimate of red maple basal area was 26 percent too low due to improper procedure in using the prism.



TOTAL ERROR

Sampling Errors = 10 SQ ft (22%)

Procedural Errors = 9 SQ ft (26%)

Total Error = 19 SQ ft (42%)

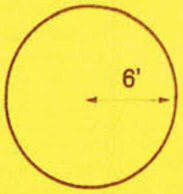
62. Combining the sampling error caused by poor cruise design with improper procedure in using the prism gives us a total cruise error of 42 percent. If you are going to invest time and money to conduct an inventory, it is imperative that you control these important but often overlooked sources of error.

DATA COLLECTION

- Overstory
- Understory

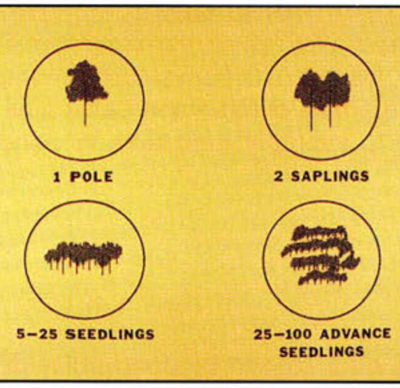
63. At the same time the overstory data are collected, regeneration (understory) data also are collected using the same plot centers as those for the overstory survey. Additional plots located between the overstory plots will also be needed to obtain an adequate sample. At locations where both overstory and understory data are collected, tally the understory data first to avoid estimating errors due to trampled vegetation.

UNDERSTORY PLOT FOR ITEMS 1 THRU 11

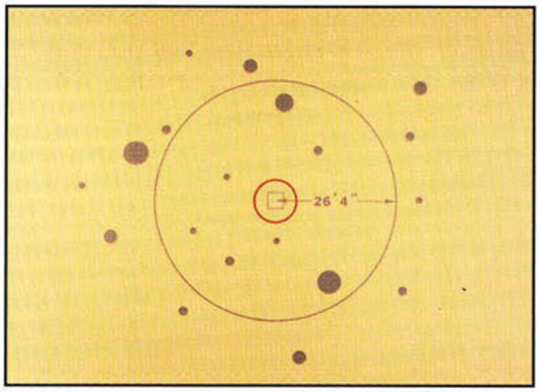


= 1/385 OR -0026 Acres

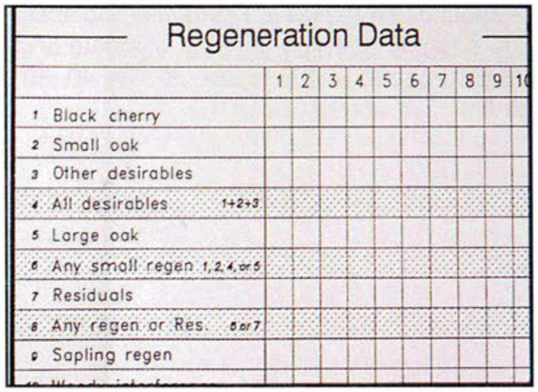
64. Most of the understory data will be collected on a 6-foot radius plot. This size was selected because it approximates the ground area occupied by a single tree when the tree first reaches merchantable (pulpwood) size.



65. Guides to the numbers of seedlings required per 6-foot plot at various times in the regeneration process have been developed by Marquis and others. These guidelines assure that there is at least one stem per 6-foot plot when the stand first reaches merchantable size--thus assuring full stocking.



66. 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 recommended.



Regeneration Data

	1	2	3	4	5	6	7	8	9	1
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										

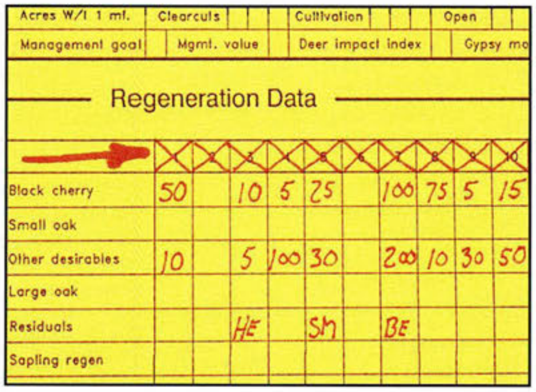
67. Understory data are recorded on a separate tally form (Appendix 4).

68. Although it may seem necessary at first to make a time-consuming count to determine whether a plot has the required number of appropriate-size seedlings, this is seldom necessary. With a little experience, the determination can be made on most plots without any counting.

69. Most plots will be abundantly stocked or

70. sparsely stocked, and seedlings that are large enough to count will be readily visible from a standing position.

71. Those that you must kneel down to find are generally too small to count anyway. 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+.



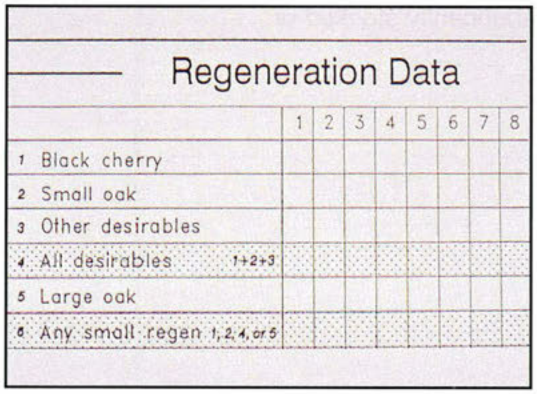
Acres W/I 1 mi. | Clearcuts | Cultivation | Open

Management goal | Mgmt. value | Deer impact index | Gypsy mo

Regeneration Data

	1	2	3	4	5	6	7	8	9	10
Black cherry	50		10	5	25		100	75	5	15
Small oak										
Other desirables	10		5	100	30		200	10	30	50
Large oak										
Residuals			HE		SM		BE			
Sapling regen										

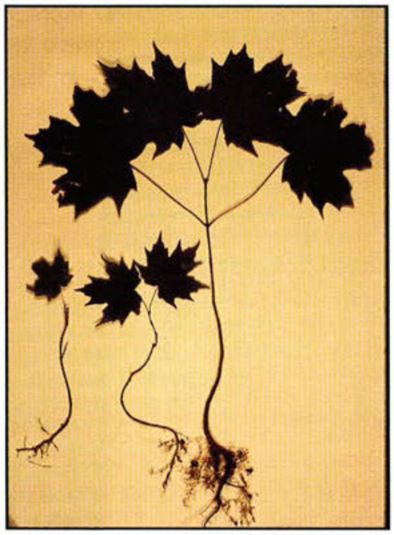
72. You must keep an accurate record of the number of understory plots examined. Some plots may have no data in any of the 16 factors, so, indicate each plot tallied by placing an "X" through the plot number at the top of the regeneration block on the tally form. After the cruise is completed, count the number of plots taken and enter this value in the box for # plots (regen).



Regeneration Data

	1	2	3	4	5	6	7	8
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								

73. In completing the Regeneration tally form (Appendix 4), the first step is to assess the amount of desirable advance regeneration on the 6-foot radius plot. Black cherry and oak are tallied separately from other desirable species. Desirable species may vary from location to location or ownership to ownership, but a list should be developed and applied consistently so results are comparable from stand to stand.



74. Advance seedlings are weighted by height and vigor. Seedlings such as the sugar maple on the right should not be counted. Any seedling that is less than 2 inches tall, has fewer that two normal-size leaves or still bears cotyledons has a poor chance of survival and should not be counted. Seedlings between 2 inches and 1 foot tall such as the one in the middle are counted as one seedling, and those of good vigor over 1 foot tall as on the left are counted as two seedlings.

DESIRABLE SPECIES

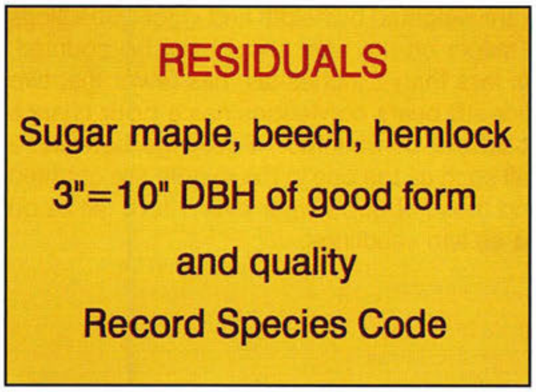
Black Cherry
Red Maple
Sugar Maple
White Ash
Red Oak
Yellow-Poplar
Cucumber
(Basswood)
(Hemlock)

75. Desirable timber species usually include black cherry, sugar maple, red maple, white ash, yellow-poplar, cucumbertree, red oak, white oak, and basswood. In some localities, beech, birch (yellow and sweet), oaks other than red or white, hickory, hemlock, and white pine also may be considered as desirable. Count these species as desirable only if they fully meet the management objectives for the property.

LARGE OAK REGEN

4.5 FEET TALL +

76. Large oak regeneration is based on guides from the Central States where only seedlings 4.5 feet tall or taller are counted as advance seedlings. Count each such stem as one seedling.



RESIDUALS

Sugar maple, beech, hemlock

3"=10" DBH of good form

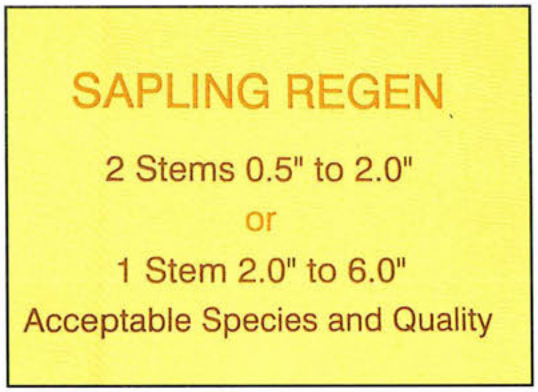
and quality

Record Species Code

77. If there is a sugar maple, beech, or hemlock 3 to 10 inches d.b.h. on the 6-foot radius plot of acceptable quality to leave as a residual tree, record the species code of that tree in the residual box.

78. Desirable residual trees have at least moderately good crowns and clear straight boles free of branches, epicormic branches, or other defects for at least the first 17 feet. Remember that residual trees are very large advance regeneration. They will be left after the final harvest cut to form a part of the new stand. Because they will be essentially open-grown for 30 to 40 years (until the fast-growing intolerant seedlings catch up to them), bole quality will not improve. Therefore, residuals must be free of branches or defects initially. If your organization does not retain residuals after harvest cutting, do not record in this row.

79. Particular attention should be given to epicormic branches. Stems with more than one or two epicormics on the butt log should not be considered acceptable residual trees.



SAPLING REGEN

2 Stems 0.5" to 2.0"

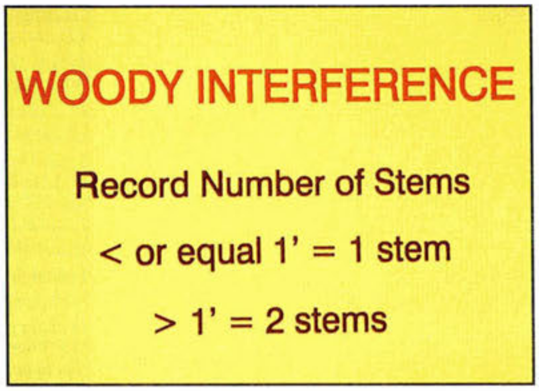
or

1 Stem 2.0" to 6.0"

Acceptable Species and Quality

80. For sapling regen, if there are at least two stems of commercial species 0.5 inch 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. Do not count stems of species that would be considered woody interference such as beech-root suckers.

81. Saplings should be 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. Sapling regen is an entire new age class that is already well established and growing vigorously, under the present canopy, and that needs only to be released to form the next stand.



WOODY INTERFERENCE

Record Number of Stems

< or equal 1' = 1 stem

> 1' = 2 stems

82. Stems of beech, striped maple, sourwood, blackgum, elm, hophornbeam, and blue beech on the 6-foot radius plot should be counted as woody interference. Count all stems less than 1 foot tall as one stem, and all stems over 1 foot tall as two stems.

83. Count clumps of beech root suckers that originate from the same spot as one stem.

LAUREL AND RHOD

Coded Value - 6' Plot

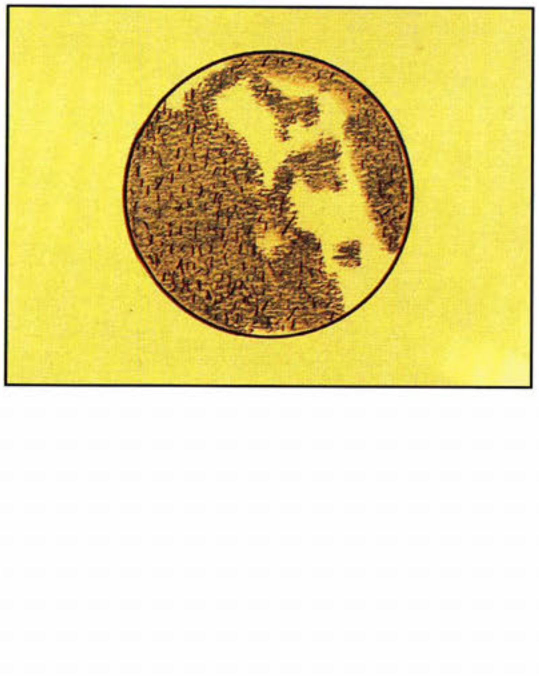
1 = <1' and <50% of plot

2 = >1' and <50% of plot

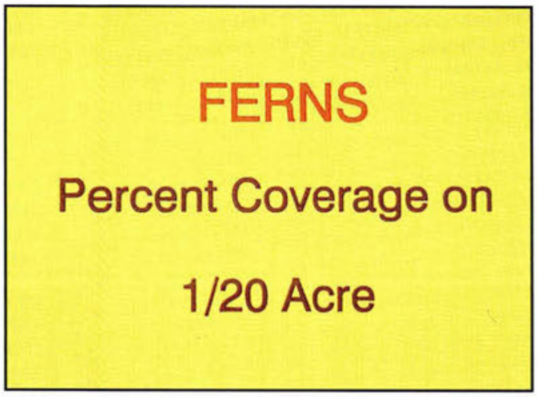
3 = <1' and >50% of plot

4 = >1' and >50% of plot

84. 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 that 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 of the plot and more than 1 foot tall.



85. Because the remaining undesirable understory attributes tend to be more variable, we will assess them on the larger 26-foot radius plot. Record an ocular estimate of the percentage of the larger plot surface area covered by fern or grass foliage, when viewed from directly above the plot.



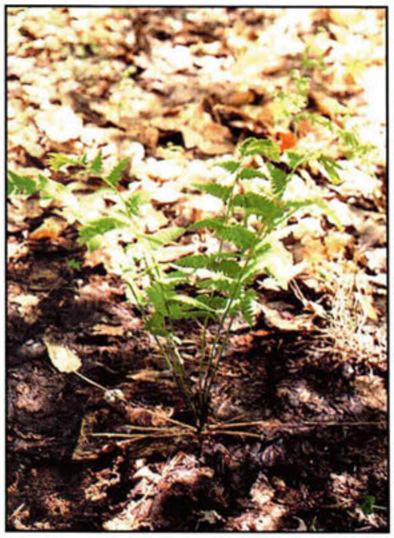
FERNS

Percent Coverage on

1/20 Acre

86. Count any fern that grows as individual fronds from the ground level. These ferns reproduce through underground rhizomes and spread very rapidly under light conditions created by partial cutting.

87. Ferns that grow in clumps, tend not to spread rapidly after thinning, so we estimate their percent coverage and record a number equal to one-half our estimate.



88. Record the weighted average percentages of the plot covered by fern foliage.

GRASSES

Percent Coverage on

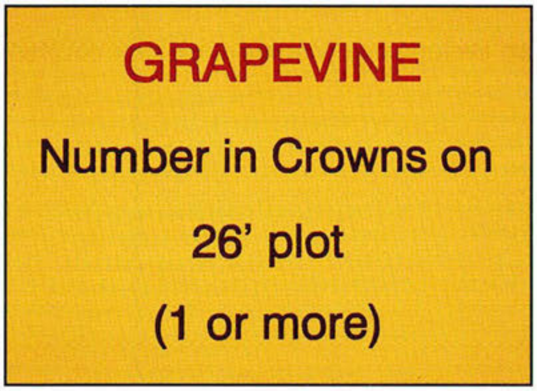
1/20 Acre

89. For grass and sedge, record an ocular estimate of the percentage of the plot surface covered by foliage of any grass or sedge.

FERN AND GRASS

ASSESS SEPARATELY

90. If grass and fern are found together on the same plot, do not add percentages together as the rate of spread of one species is independent of the amount of the other species.



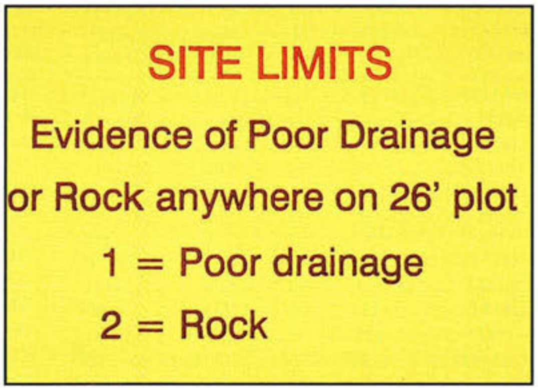
GRAPEVINE

Number in Crowns on

26' plot

(1 or more)

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



SITE LIMITS

Evidence of Poor Drainage

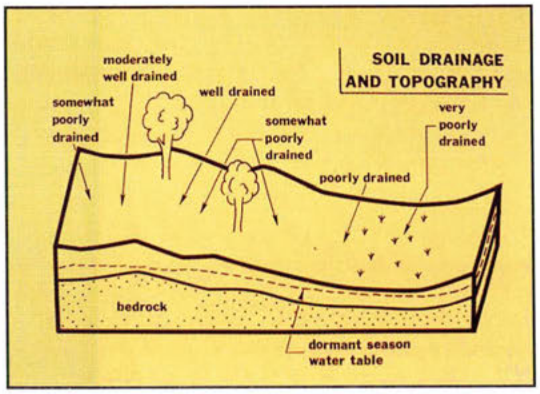
or Rock anywhere on 26' plot

1 = Poor drainage

2 = Rock

92. Record the coded 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 zero indicates that there are no site limits on that plot.

93. Taking soil samples or digging soil pits is neither feasible nor necessary to determine site limitation. They should be evaluated on the basis of surface conditions.

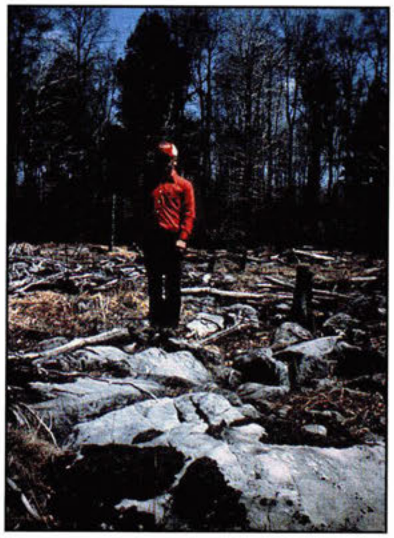


94. On the Allegheny Plateau, look for poor soil drainage in concave positions of broad flat ridge tops, in upland bottoms, and at the base of slopes. Low topography is more likely to be poorly drained than is high topography. Convex topographic configuration generally indicates well-drained or moderately well-drained soils. In valley bottoms, soil drainage becomes poorer from the stream channel toward 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.

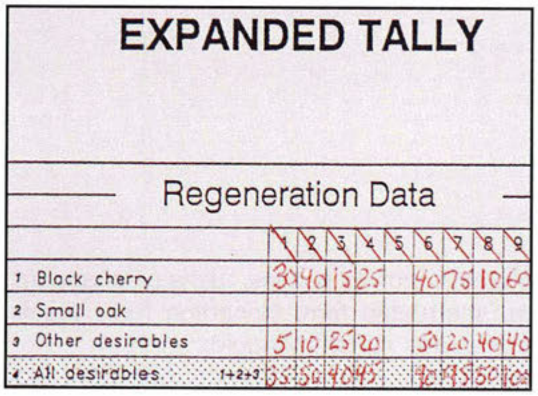
95. Other indicators of poor soil drainage include: standing water in depressions or wet surface soils that persist during the dormant season and during periods of normal rainfall in the summer and early fall;

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

97. and very deep spongy humus layers at the soil surface.



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

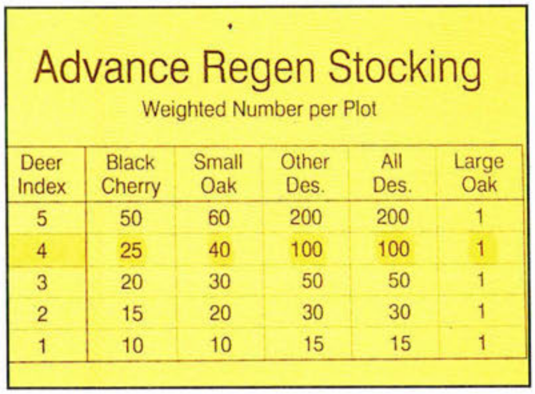


EXPANDED TALLY

Regeneration Data

	1	2	3	4	5	6	7	8	9
1 Black cherry	30	40	15	25		40	75	10	60
2 Small oak									
3 Other desirables	5	10	25	20		50	20	40	40
4 All desirables 1+2+3	35	50	40	45		90	95	50	10

99. When complete, the expanded regeneration tally sheet will look like this.

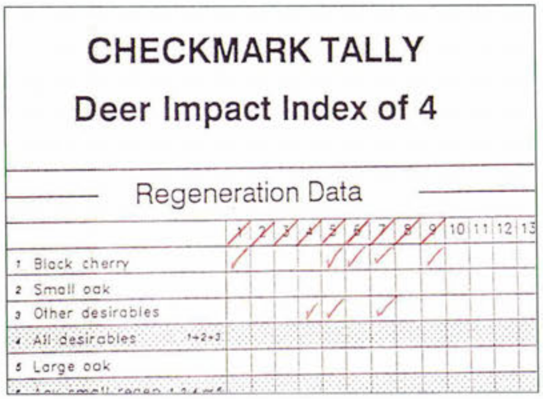


Advance Regen Stocking

Weighted Number per Plot

Deer Index	Black Cherry	Small Oak	Other Des.	All Des.	Large Oak
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

100. An alternative method for assessing the understory condition is to determine at each plot if the criteria for your appropriate deer density is met or not. The amount of advanced seedlings for a plot to be stocked varies tremendously with the deer impact index. In this example, use a deer impact index of 4, which requires that a plot contain at least 25 black cherry, 40 small oak, or 100 other desirables for a plot to be considered stocked.



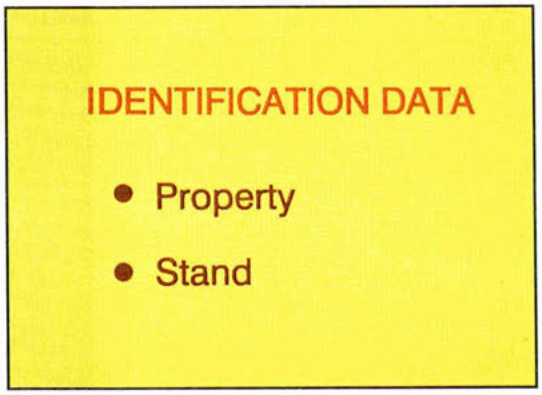
CHECKMARK TALLY

Deer Impact Index of 4

Regeneration Data

	1	2	3	4	5	6	7	8	9	10	11	12	13
1 Black cherry	✓				✓	✓	✓		✓				
2 Small oak													
3 Other desirables				✓	✓		✓						
4 All desirables 1+2+3													
5 Large oak													

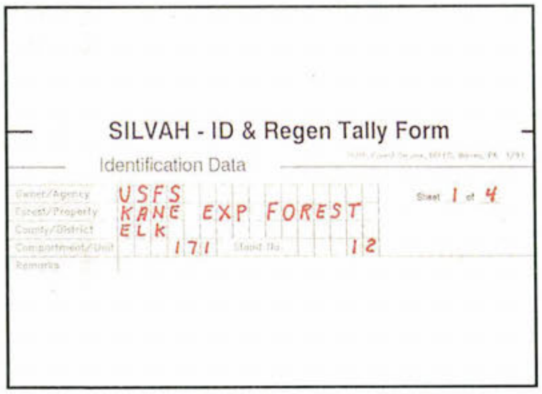
101. You just make a checkmark if the stocking criteria for your deer impact index is met. A completed checkmark tally would look like this.



IDENTIFICATION DATA

- Property
- Stand

102. 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.



SILVAH - ID & Regen Tally Form

Identification Data

Owner/Agency USFS

Forest/Property KANE EXP FOREST

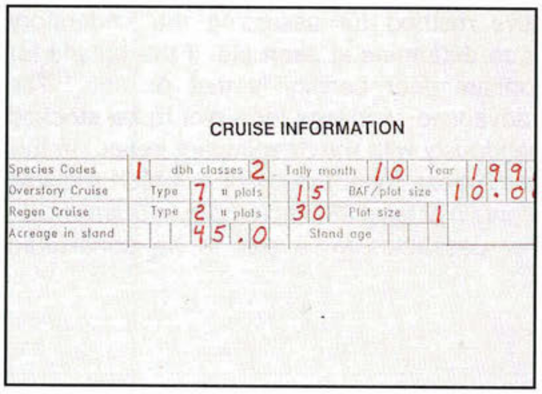
County/District ELK

Compartment/Unit 171 Stand No. 12

Remarks

Sheet 1 of 4

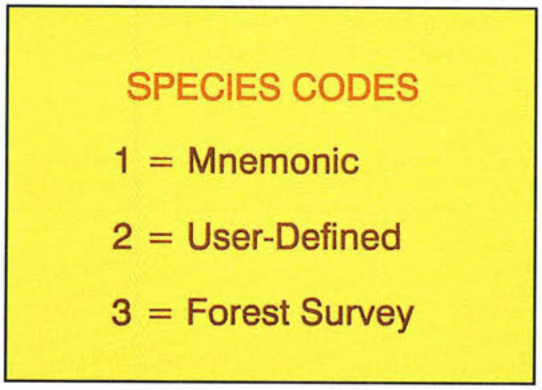
103. The information requested at the beginning of this block identifies the particular stand by ownership and location.



CRUISE INFORMATION

Species Codes	1	dbh classes	2	Tally month	10	Year	199
Overstory Cruise	Type	7	# plots	15	BAF/plot size	10.0	
Regen Cruise	Type	2	# plots	30	Plot size	1	
Acreage in stand	45.0			Stand age			

104. The middle section requests specific information on the type of cruise used. It is important to fill out this section very carefully. The most important coded values in this section are reviewed here.



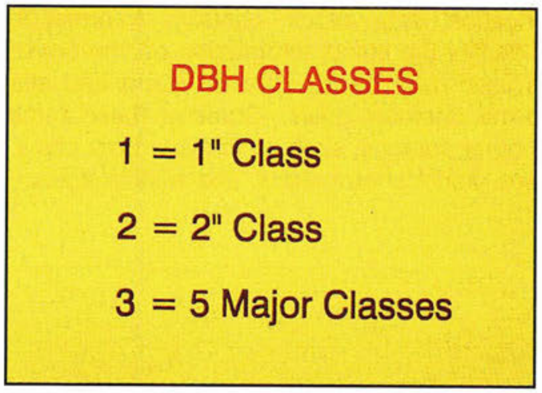
SPECIES CODES

1 = Mnemonic

2 = User-Defined

3 = Forest Survey

105. Species codes are coded values telling the computer which particular system you used.



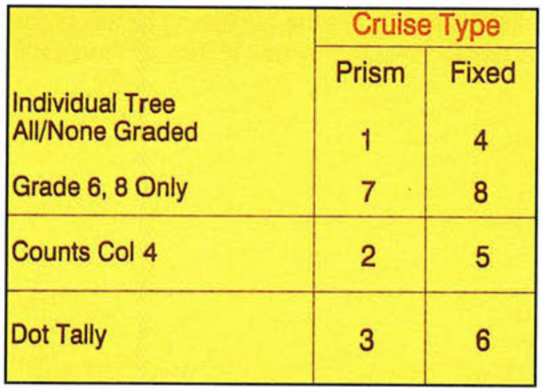
DBH CLASSES

1 = 1" Class

2 = 2" Class

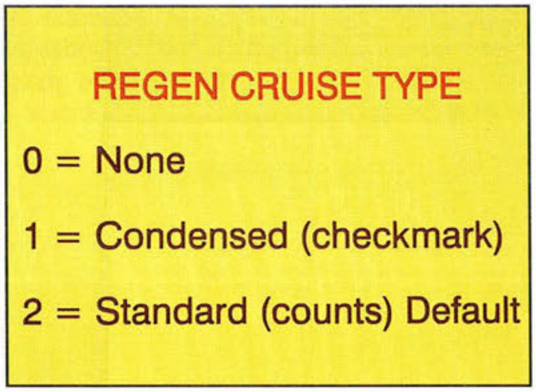
3 = 5 Major Classes

106. Likewise, record a coded value for the d.b.h. class.



	Cruise Type	
	Prism	Fixed
Individual Tree All/None Graded	1	4
Grade 6, 8 Only	7	8
Counts Col 4	2	5
Dot Tally	3	6

107. The coded value for the type of overstory cruise is necessary for the computer to know how you used the various fields on the tally form so the data can be properly summarized.


REGEN CRUISE TYPE

0 = None

1 = Condensed (checkmark)

2 = Standard (counts) Default

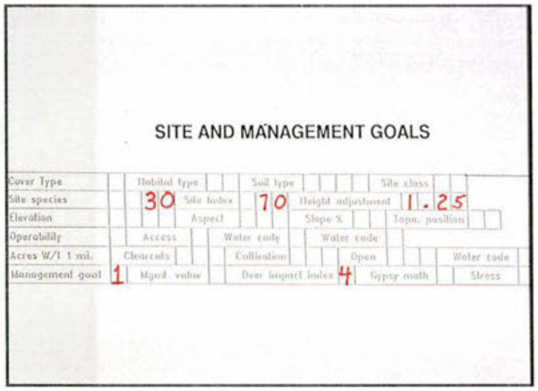
108. Code the appropriate value for the type of regeneration cruise.


PLOT SIZE

1 = 6' Radius (default)

2 = Milacre

109. Finally, record the coded value for the size of plot used to assess advanced seedling stocking.


SITE AND MANAGEMENT GOALS

Cover Type | Habitat type | Soil type | Site class
Site species 30 | Site index 70 | Height adjustment 1.25
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 | Deer impact index 4 | Gypsy moth | Stress

110. The final portion of the identification block describes particular site factors and management goals that may influence the final prescription. If you are in an oak stand, it is necessary to take site index.


HEIGHT ADJUSTMENT

1.50 = High

1.00 = Medium (Default)

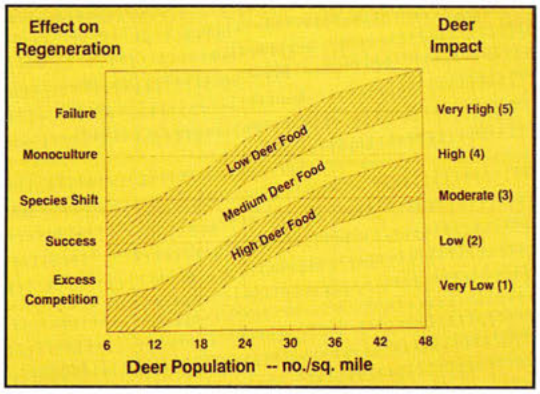
0.50 = Low

111. If you did not record actual heights, you may make an adjustment in the local heights used in SILVAH.

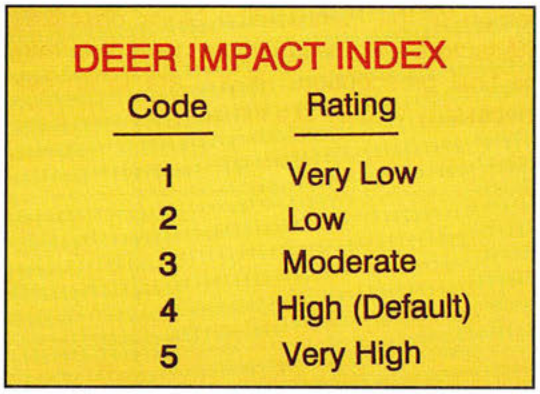
MANAGEMENT GOALS

Code	
1	No Restrictions (Default)
2	Even/Uneven Age - No Clearcut
3	Uneven-Age - Maximize for Timber
4	Uneven-Age - Large Trees

112. The final prescription that SILVAH will generate is dictated by your specific management goals. Codes 2, 3, and 4 indicate restrictions that visual or wildlife goals for this stand may impose on timber cutting methods.



113. Deer impact index is a function of deer density and the amount of alternative food available within a 1-mile radius of the stand. Deer population can be estimated using pellet group counts or from your State Game agency's estimate for your area. Using this chart, determine the deer impact index for your stand.



DEER IMPACT INDEX

Code	Rating
1	Very Low
2	Low
3	Moderate
4	High (Default)
5	Very High

114. Then, enter the appropriate coded value on the tally form.

115. You have completed the first step in the three-step process--the stand inventory. You are now ready to enter the data into the computer to begin the second step--stand analysis.

Selected References

Beers, T. W.; Miller, C. I. 1964. Point sampling: research results theory and applications. Res. Bull. 786. Lafayette, IN: Purdue University. 56 p.

Marquis, David A. 1981. 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. 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 Experimant Station. 7 p.

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.; 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.

APPENDIX 1

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

APPENDIX 2

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

APPENDIX 3

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*

APPENDIX 4

SILVAH - ID & Regen Tally Form

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

Identification Data

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 intrfr. 10, 11, 12, or 13																						
15 Grapevines																						
16 Site limitations																						

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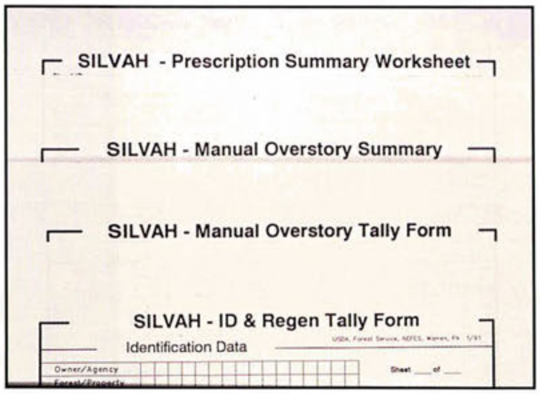
Stand Data Summary and Analysis

Susan L. Stout

Stand Analysis

1. The second step in the SILVAH process is to summarize and analyze inventory data from forest stands.

2. Here we review the process by which you use a computer or calculator to summarize the inventory data you collect and use that summary to select a prescription outlining appropriate treatment of the stand. Usually, a computer makes these calculations, but working through the calculations step by step gives you a better understanding of the way the SILVAH program works and of the results that appear on SILVAH printouts.



SILVAH - Prescription Summary Worksheet

SILVAH - Manual Overstory Summary

SILVAH - Manual Overstory Tally Form

SILVAH - ID & Regen Tally Form

Identification Data

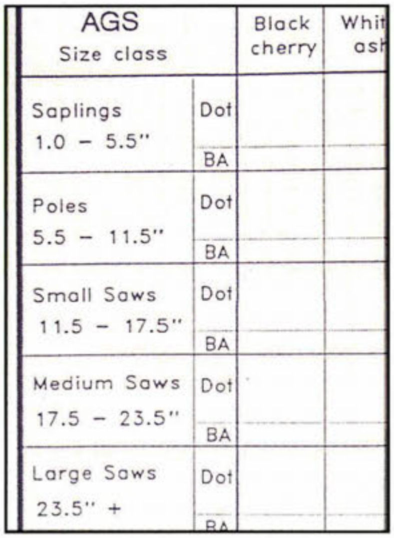
USDA, Forest Service, NEFES, Warren, PA 1/91

Owner/Agency

Forest/Property

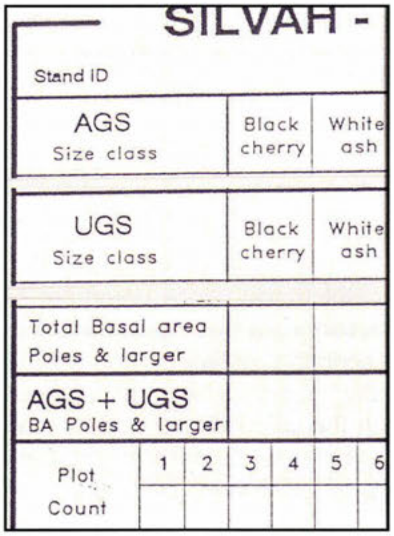
Sheet ___ of ___

3. The forms used for the calculations are shown in Appendices 1-5. They are provided blank so the reader may practice the procedures described and as an example. The forms have two main purposes: they give users without a computer access to the SILVAH system, and they help computer users learn what the computer does with inventory data.



AGS Size class		Black cherry	Whi as
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		

4. If data are collected on the Computer Overstory Tally form, the data can be transferred to the Manual Overstory Tally form (Appendix 1 and 2), but the reverse is not true because of the groupings by size class.

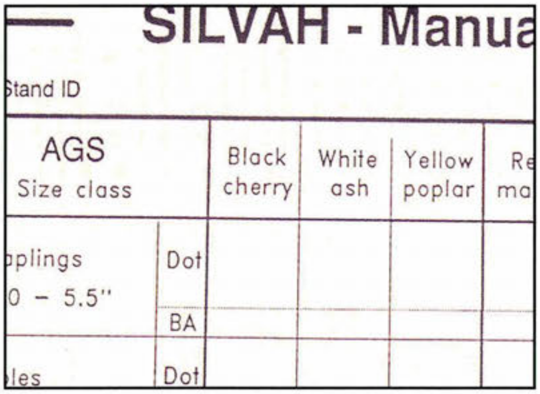


SILVAH -

Stand ID

AGS Size class			Black cherry		White ash	
UGS Size class			Black cherry		White ash	
Total Basal area Poles & larger						
AGS + UGS BA Poles & larger						
Plot Count	1	2	3	4	5	6

5. On the Manual Overstory Tally form, data are organized by broad size class, quality class, and species group -- AGS (Acceptable Growing Stock) and UGS (Unacceptable Growing Stock)--definitions for the quality classes are shown in Appendix 6. Rows to total basal area in poles and larger for each species group by quality class and for both quality classes combined are provided.

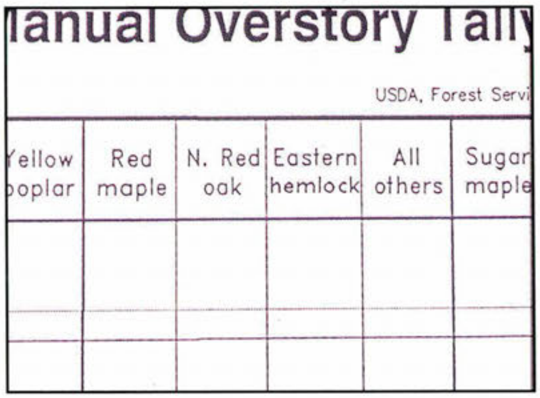


SILVAH - Manua

Stand ID

AGS Size class		Black cherry	White ash	Yellow poplar	Re ma
plings 0 – 5.5"	Dot				
	BA				
les	Dot				

6. The species are grouped based on the growing space requirements of the different species. The basis for the groups is described in more detail later. However, make note of the groups. The black cherry, white ash, yellow-poplar group includes only these three species.

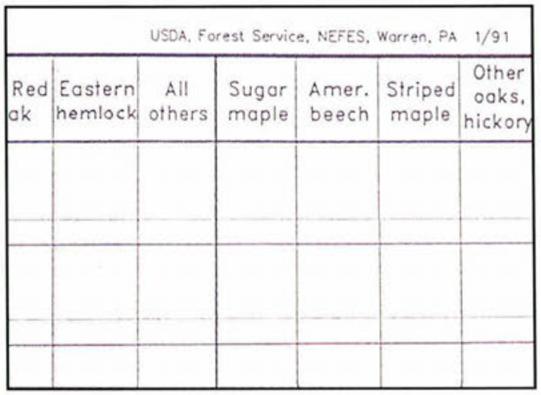


anual Overstory Tall

USDA, Forest Servi

ellow oplar	Red maple	N. Red oak	Eastern hemlock	All others	Sugar maple

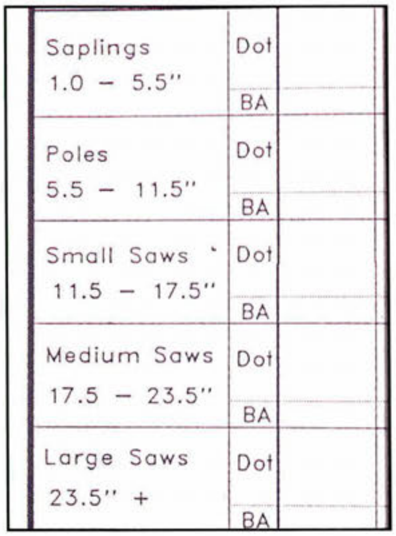
7. The red maple, red oak, eastern hemlock, and others group includes northern red oak, red maple, birch, pin cherry, cucumbertree, and basswood. Because it is the intermediate group in growth rate, growing space, crown size, and tolerance, we assign other species to this group when growth patterns and growing-space requirements are unknown. Eastern hemlock is tallied here as are other conifers.



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

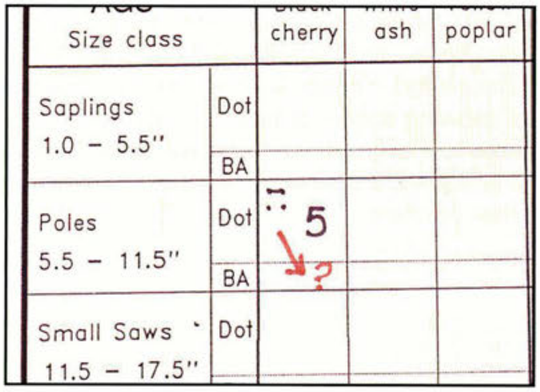
Red ak	Eastern hemlock	All others	Sugar maple	Amer. beech	Striped maple	Other oaks, hickory

8. The sugar maple, American beech, striped maple, and other oak group includes sugar and striped maple: American beech: white, chestnut, black, and scarlet oak; and the hickories.



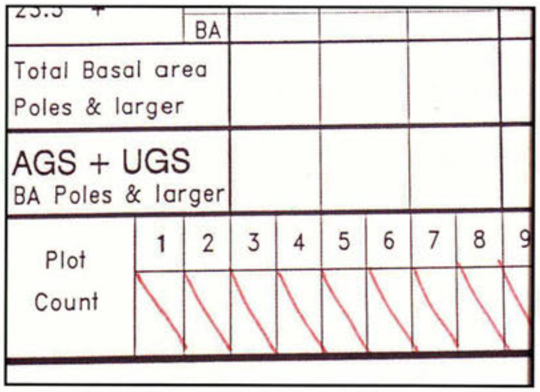
Saplings 1.0 – 5.5"	Dot	
	BA	
Poles 5.5 – 11.5"	Dot	
	BA	
Small Saws 11.5 – 17.5"	Dot	
	BA	
Medium Saws 17.5 – 23.5"	Dot	
	BA	
Large Saws 23.5" +	Dot	
	BA	

9. The diameter ranges for the five size classes are shown on the Manual Overstory Tally form. These broad groupings are adequate for characterizing and controlling stand structure.



Size class		cherry	ash	poplar
Saplings 1.0 - 5.5"	Dot			
	BA			
Poles 5.5 - 11.5"	Dot	⁚ 5		
	BA	?		
Small Saws 11.5 - 17.5"	Dot			

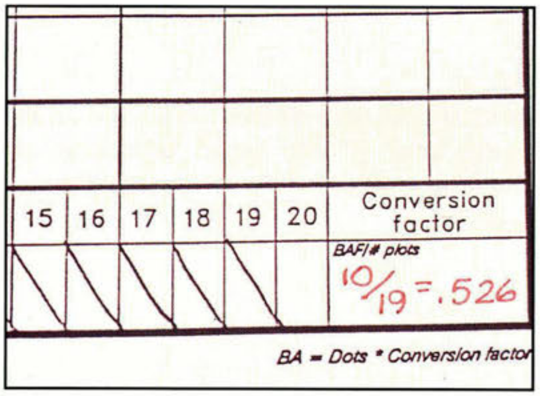
10. The first set of overstory calculations is to be completed on the tally form. We convert the dot tally inventory to estimates of basal area per acre in each size/species/quality cell.



	BA			
Total Basal area Poles & larger				
AGS + UGS BA Poles & larger				

Plot Count	1	2	3	4	5	6	7	8
	\	\	\	\	\	\	\	\

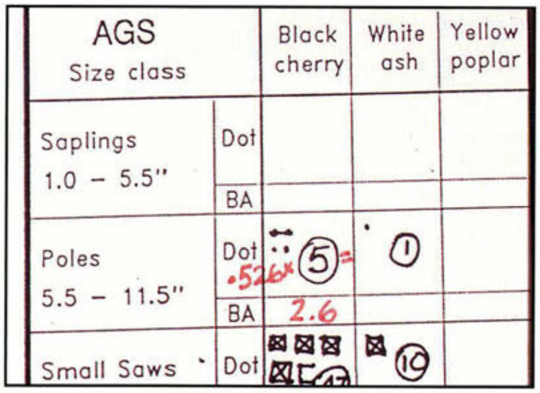
11. To make this conversion, we must record the number of overstory plots tallied. The plot count row may be checked off or the number of trees intercepted by the prism at each plot may be noted. If you note the number of trees per plot, you can determine the variability of basal area from plot to plot and decide whether your inventory represents an adequate sample.



15	16	17	18	19	20	Conversion factor
\	\	\	\	\		BAF/# plots 10/19 = .526

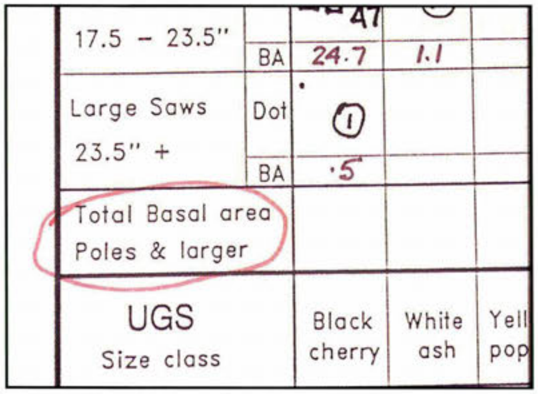
BA = Dots * Conversion factor

12. The prism conversion factor in the lower right corner of the tally form equals the prism factor--in our example, 10--divided by the number of prism plots. For the sample stand, there were 19 prism plots, so the conversion factor is 10/19, or 0.526. That is, every dot in the sample dot tally represents slightly more than half a square foot of basal area per acre. We recommend that you record this number to three decimal places to minimize rounding error.



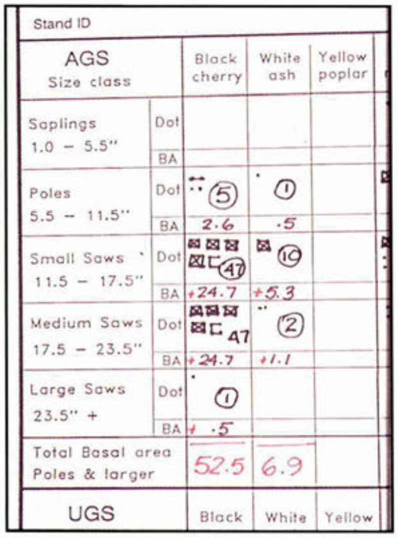
AGS Size class		Black cherry	White ash	Yellow poplar
Saplings 1.0 - 5.5"	Dot			
	BA			
Poles 5.5 - 11.5"	Dot	.526× ⑤ =	①	
	BA	2.6		
Small Saws	Dot	⊠ ⊠ ⊠ ⊠	⊠ ⑩	

13. Now, multiply the number of dots in each cell times the prism conversion factor. This gives an estimate of the basal area per acre for that cell. For example, our tally form shows five dots in the black cherry/pole/AGS cell. Five times 0.526 is 2.6 square feet per acre for that cell. Record this estimate below the dot tally in each cell. There are 110 cells: 5 size classes x 2 quality classes x 11 species. Record these values to one decimal place to minimize rounding error.



		47		
17.5 - 23.5"	BA	24.7	1.1	
Large Saws 23.5" +	Dot	①		
	BA	·5		
Total Basal area Poles & larger				
UGS Size class		Black cherry	White ash	Yell pop

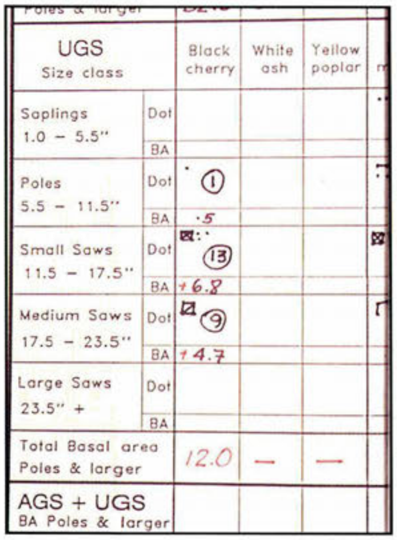
14. We only calculate one subtotal for each species group on the form: the basal area in trees of pole size or larger. We will use this number later to calculate an index value for probable seed production in this stand. The computer makes this calculation using trees 8 inches or larger, since 8 inches is about the threshold for seed production. Since we have grouped trees by size class, we calculate this value for trees 6 inches or larger, that is, the poles and larger size classes.



Stand ID

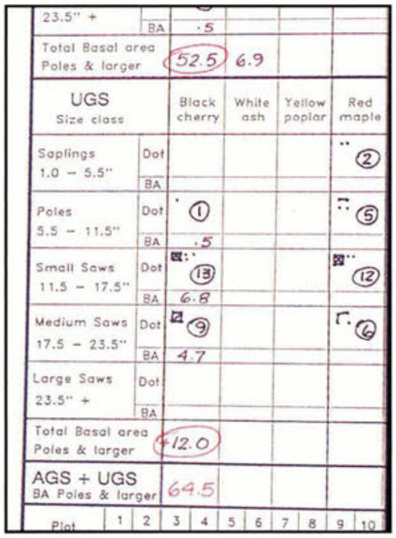
AGS Size class		Black cherry	White ash	Yellow poplar
Saplings 1.0 - 5.5"	Dot			
	BA			
Poles 5.5 - 11.5"	Dot	⑤	①	
	BA	2.6	.5	
Small Saws 11.5 - 17.5"	Dot	(47)	⑩	
	BA	+24.7	+5.3	
Medium Saws 17.5 - 23.5"	Dot	47	②	
	BA	+24.7	+1.1	
Large Saws 23.5" +	Dot	①		
	BA	+ .5		
Total Basal area Poles & larger		52.5	6.9	
UGS		Black	White	Yellow

15. For each species, add and record the basal areas for poles and larger AGS and record this on the appropriate line in the middle of the tally form,



UGS Size class		Black cherry	White ash	Yellow poplar
Saplings 1.0 - 5.5"	Dot			
	BA			
Poles 5.5 - 11.5"	Dot	①		
	BA	·5		
Small Saws 11.5 - 17.5"	Dot	⑬		
	BA	+6.8		
Medium Saws 17.5 - 23.5"	Dot	⑨		
	BA	+4.7		
Large Saws 23.5" +	Dot			
	BA			
Total Basal area Poles & larger		12.0	—	—
AGS + UGS BA Poles & larger				

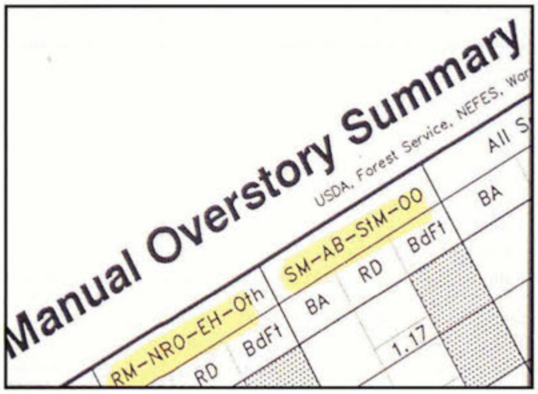
16. then record the basal areas for poles and larger UGS near the bottom of the form



23.5" +	BA	.5			
Total Basal area Poles & larger		52.5	6.9		
UGS Size class		Black cherry	White ash	Yellow poplar	Red maple
Saplings 1.0 – 5.5"	Dot				②
	BA				
Poles 5.5 – 11.5"	Dot	①			⑤
	BA	.5			
Small Saws 11.5 – 17.5"	Dot	⑬			⑫
	BA	6.8			
Medium Saws 17.5 – 23.5"	Dot	⑨			⑥
	BA	4.7			
Large Saws 23.5" +	Dot				
	BA				
Total Basal area Poles & larger		+12.0			
AGS + UGS BA Poles & larger		64.5			

Plot 1 2 3 4 5 6 7 8 9 10

17. and finally record the sum of the values for AGS and UGS on the summary line at the bottom of the form.



Manual Overstory Summary

USDA, Forest Service, NEFES, Wa

All S

SM-AB-StM-OO

BA

RD

BdFt

RM-NRO-EH-Oth

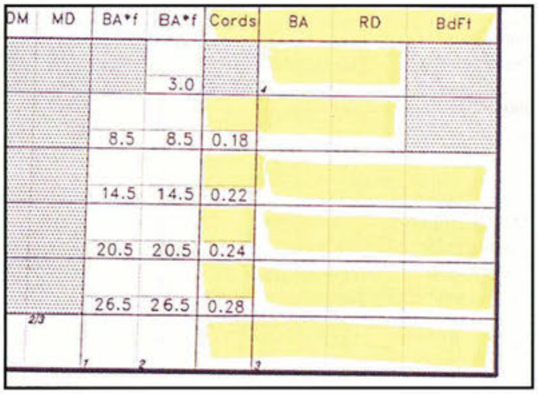
RD

BdFt

BA

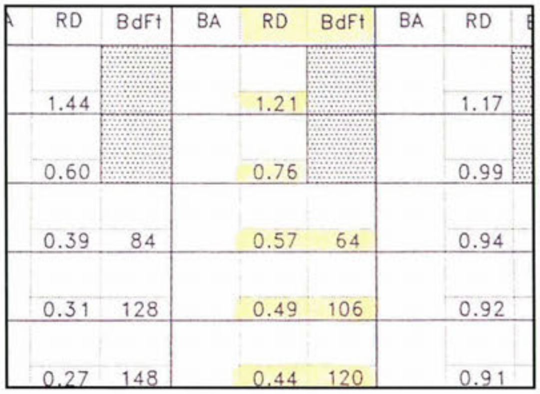
1.17

18. At this point, transfer basal area values to the Manual Overstory Summary form (Appendix 3). Two copies are provided so that you can use one to summarize the data from Appendix 2. On this form, fill in basal area data for each of the three species groups, by size and quality class.



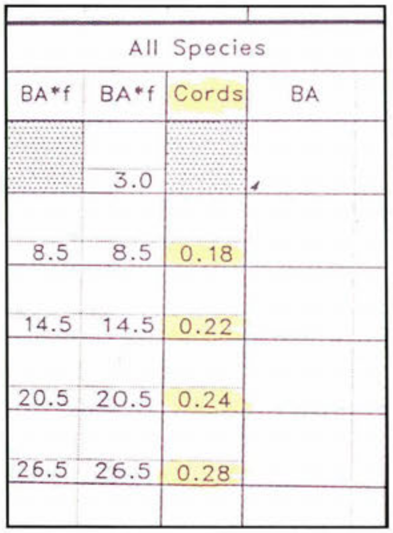
DM	MD	BA*f	BA*f	Cords	BA	RD	BdFt
			3.0				
		8.5	8.5	0.18			
		14.5	14.5	0.22			
		20.5	20.5	0.24			
		26.5	26.5	0.28			
2/3							

19. In the lower right corner of this form, final estimates of basal area per acre, relative density per acre, board-foot volume per acre, and cordwood volume per acre for the entire stand will be recorded. Elsewhere on the form, subtotals of these values by species group, size class, and quality class will be recorded.



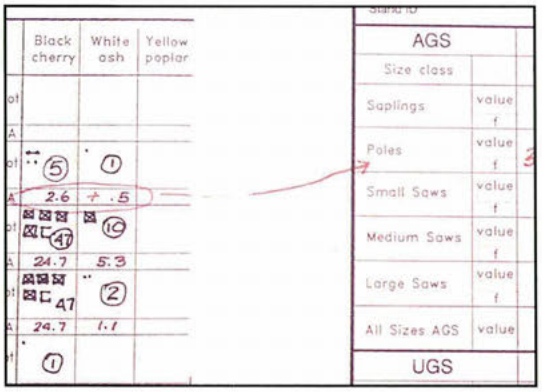
RD	BdFt	BA	RD	BdFt	BA	RD
1.44	▨		1.21	▨		1.17
0.60	▨		0.76	▨		0.99
0.39	84		0.57	64		0.94
0.31	128		0.49	106		0.92
0.27	148		0.44	120		0.91

20. The calculations are straightforward. From extensive research, we have developed basal area conversion factors for each size/quality/species combination; so, we can convert the basal area estimates from the inventory to other values that we need. There are factors in the relative density column, factors in the board-foot column,



All Species			
BA*f	BA*f	Cords	BA
▨	3.0	▨	
8.5	8.5	0.18	
14.5	14.5	0.22	
20.5	20.5	0.24	
26.5	26.5	0.28	

21. and factors in the cords column. Each of these factors is multiplied by basal area for the appropriate size/quality/species combination, and the subtotals added, to get the stand estimates.



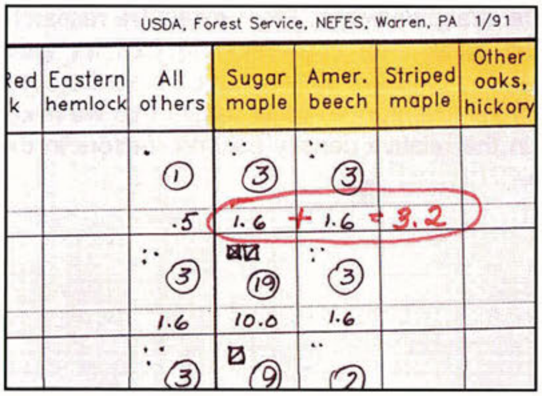
Black cherry	White ash	Yellow poplar
⑤	①	
2.6	÷ .5	
47	10	
24.7	5.3	
47	②	
24.7	1.1	
①		

AGS

Size class	
Saplings	value f
Poles	value f
Small Saws	value f
Medium Saws	value f
Large Saws	value f
All Sizes AGS	value

UGS

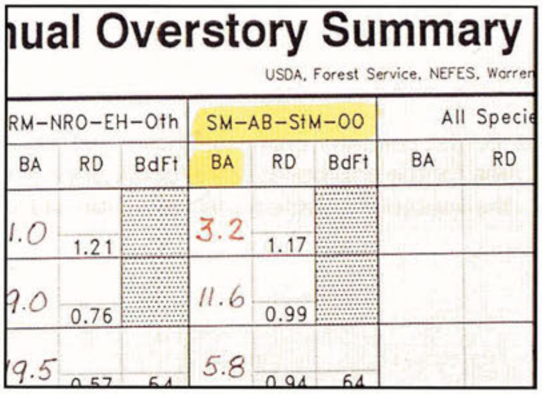
22. The first step in using this form is to transfer the summary basal area information from the tally form to the summary form.



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

ed k	Eastern hemlock	All others	Sugar maple	Amer. beech	Striped maple	Other oaks, hickory
		①	③	③		
		.5	1.6 +	1.6 = 3.2		
		③	⑲	③		
		1.6	10.0	1.6		
		③	⑨	②		

23. To make this transfer, add the basal areas for the species in each species group, by size and quality class. For example, the sample stand has 1.6 square feet of American beech, 1.6 square feet of sugar maple in sapling acceptable growing stock, and no basal area in striped maple or other oaks and hickory.

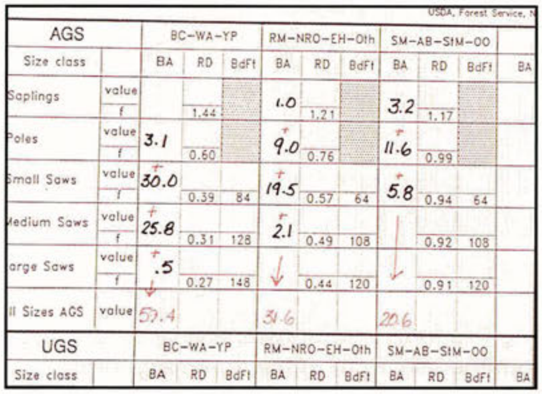


ual Overstory Summary

USDA, Forest Service, NEFES, Warren

RM-NRO-EH-Oth			SM-AB-StM-OO			All Specie	
BA	RD	BdFt	BA	RD	BdFt	BA	RD
1.0	1.21		3.2	1.17			
9.0	0.76		11.6	0.99			
9.5	0.57	64	5.8	0.94	64		

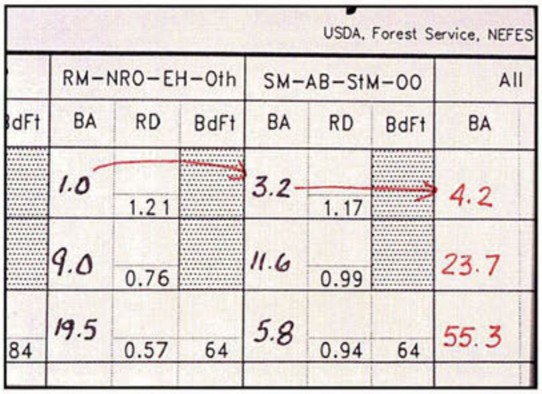
24. So, record 3.2 in the SM-AB-StM-OO sapling acceptable growing stock cell. There are 30 target cells.



USDA, Forest Service, N

AGS		BC-WA-YP			RM-NRO-EH-Oth			SM-AB-StM-OO			
Size class		BA	RD	BdFt	BA	RD	BdFt	BA	RD	BdFt	BA
Saplings	value				1.0			3.2			
	f		1.44			1.21			1.17		
Poles	value	3.1			+ 9.0			+ 11.6			
	f		0.60			0.76			0.99		
Small Saws	value	+ 30.0			+ 19.5			+ 5.8			
	f		0.39	84		0.57	64		0.94	64	
Medium Saws	value	+ 25.8			+ 2.1			↓			
	f		0.31	128		0.49	108		0.92	108	
Large Saws	value	+ .5			↓			↓			
	f	↓	0.27	148		0.44	120		0.91	120	
All Sizes AGS	value	59.4			31.6			20.6			
UGS		BC-WA-YP			RM-NRO-EH-Oth			SM-AB-StM-OO			
Size class		BA	RD	BdFt	BA	RD	BdFt	BA	RD	BdFt	BA

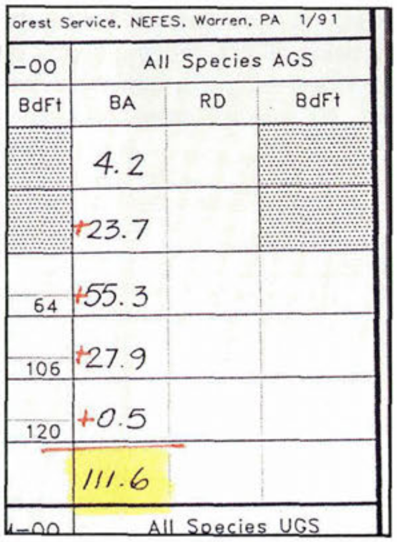
25. After transferring the appropriate basal area sums to all 30 cells, calculate several subtotals. For each quality class, calculate species totals for all size classes, and record at the bottom of the quality class,



USDA, Forest Service, NEFES

	RM-NRO-EH-Oth			SM-AB-StM-OO			All
dFt	BA	RD	BdFt	BA	RD	BdFt	BA
	1.0 →	1.21		3.2 →	1.17		4.2
	9.0	0.76		11.6	0.99		23.7
84	19.5	0.57	64	5.8	0.94	64	55.3

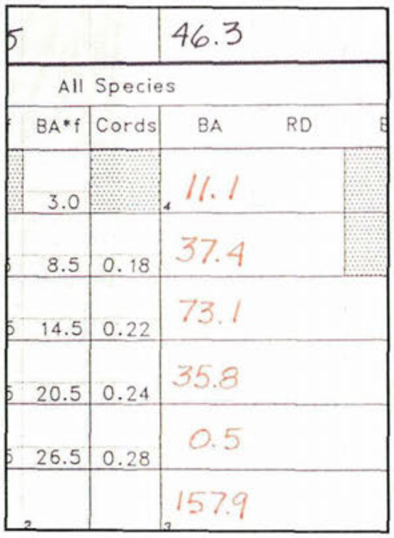
26. and calculate size class totals for all species groups, and record to the right of each size class.



orest Service, NEFES, Warren, PA 1/91

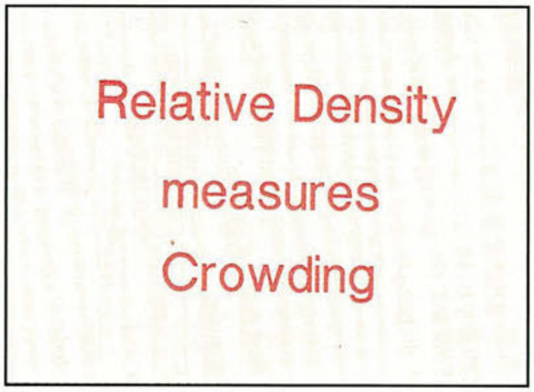
-00	All Species AGS		
BdFt	BA	RD	BdFt
	4.2		
	+23.7		
64	+55.3		
106	+27.9		
120	+0.5		
	111.6		
-00	All Species UGS		

27. Calculate overall totals for each quality class as well.



5		46.3	
All Species			
BA*f	Cords	BA	RD
3.0		11.1	
8.5	0.18	37.4	
14.5	0.22	73.1	
20.5	0.24	35.8	
26.5	0.28	0.5	
		157.9	

28. Overall totals for each size class and the whole stand are recorded in the BA column of the summary block. After this first step, we know how much basal area is in our stand, and we have a sense of how that basal area is divided by quality, size, and species group. In the sample stand basal area is 158 square feet per acre, of which about 46 square feet are unacceptable growing stock.

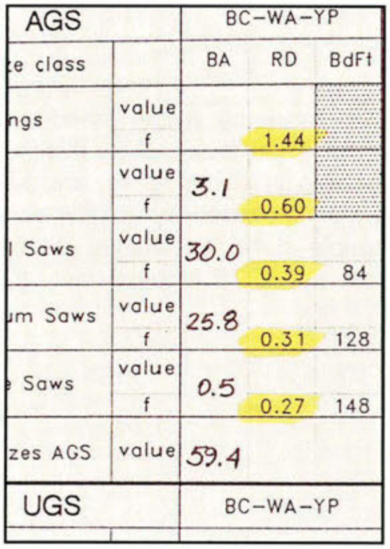


Relative Density

measures

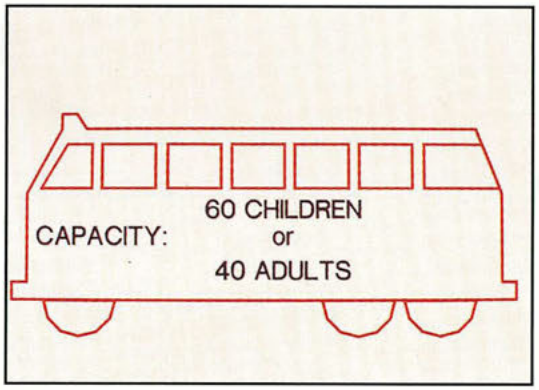
Crowding

29. But how crowded are these trees? Is their growth likely to be optimal for the stand? Are they using all the growing space on the site and converting it to the wood products that we would like? To answer these questions, we need to know the relative density of the stand.

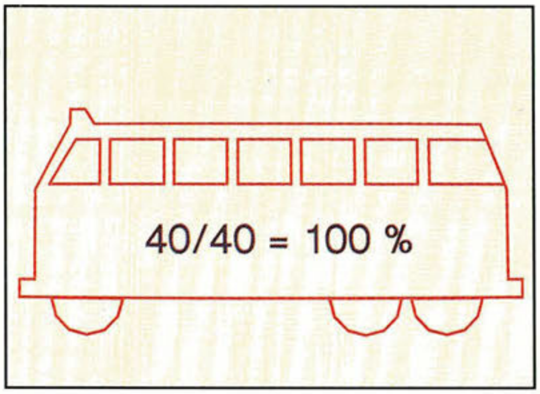


AGS		BC-WA-YP		
e class		BA	RD	BdFt
ngs	value			▨
	f		1.44	▨
	value	3.1		▨
	f		0.60	▨
Saws	value	30.0		
	f		0.39	84
m Saws	value	25.8		
	f		0.31	128
Saws	value	0.5		
	f		0.27	148
zes AGS	value	59.4		
UGS		BC-WA-YP		

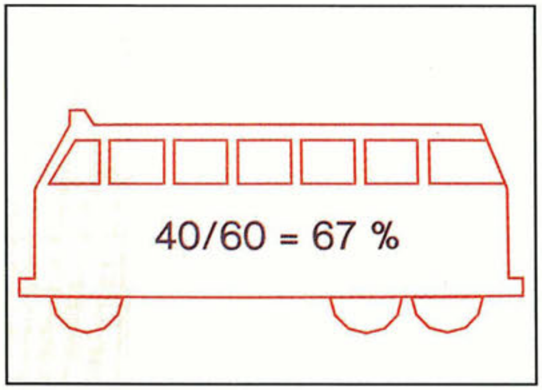
30. Relative density compares the crowding in a forest stand to the crowding in a stand at the average maximum density observed in stands of similar average tree size and species composition. Our research has shown us how much growing space a tree of a given size and species needs in undisturbed, maximum density stands, and we have translated these to the Relative Density factors on this work sheet.



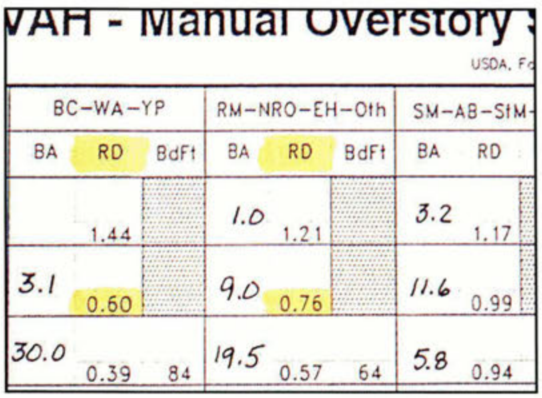
31. Relative density is easy to understand if we consider school bus capacity. School buses usually have two capacities printed on the side: 60 children or 40 adults, for example.



32. So, how crowded is the bus if there are 40 people on it? Well, that depends. If the 40 people on the bus are adults, then the "relative density" of the bus is 40/40, or 100 percent.



33. But if the 40 people are children, then the relative density is 40/60, or about 67 percent, and there is still some room for the kids to spread out or for a few more passengers, perhaps even some adults.



VAH - Manual Overstory

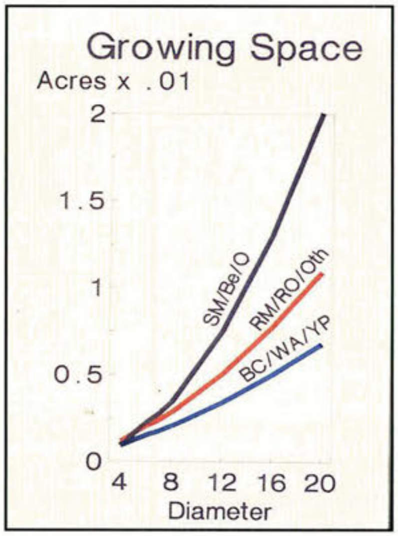
USDA, F

BC-WA-YP			RM-NRO-EH-Oth			SM-AB-StM	
BA	RD	BdFt	BA	RD	BdFt	BA	RD
	1.44		1.0	1.21		3.2	1.17
3.1	0.60		9.0	0.76		11.6	0.99
30.0	0.39	84	19.5	0.57	64	5.8	0.94

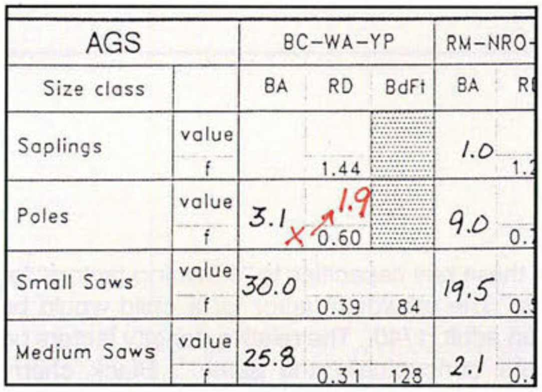
34. We could translate these bus capacities to "crowding factors" for children and adults: The crowding factor for a child would be 1/60, and that for an adult, 1/40. The relative density factors on this work sheet are conceptually the same. Black cherry poletimber, for example, regardless of quality, contributes about 0.6 percent per square foot to the crowding of a stand, while red maple poletimber contributes about 0.76 percent per square foot.

SPECIES COMP.	DIAM.	BA	# TREES
80% BC	10"	191 FT.^{2}	350
80% SM/BE	10"	135 FT.^{2}	246

35. The species groupings on this worksheet are based on differences in the relative density factors. In undisturbed stands with a high percentage of black cherry, basal area and number of trees per acre will be much higher than they are in stands of similar tree size with a high proportion of sugar maple and beech. Stands with a high proportion of red maple will have intermediate levels of basal area and number of trees per acre.

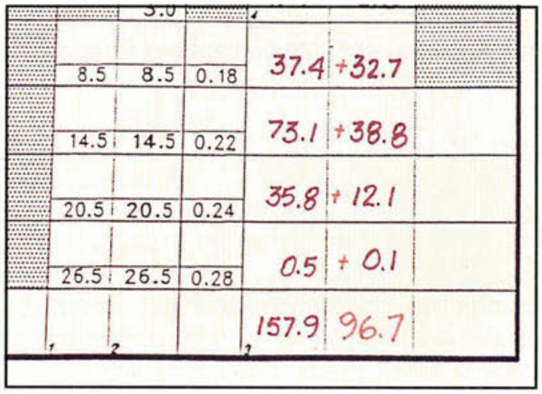


36. This graph shows the growing space required by trees in the three species groups by size class. Trees in the black cherry group have the lowest growing space requirements--that is why natural stands with a high proportion of this species carry higher basal area and number of trees per acre than similar stands with other species. The sugar maple/American beech group has the largest growing space requirements, and those of the red maple group are intermediate.



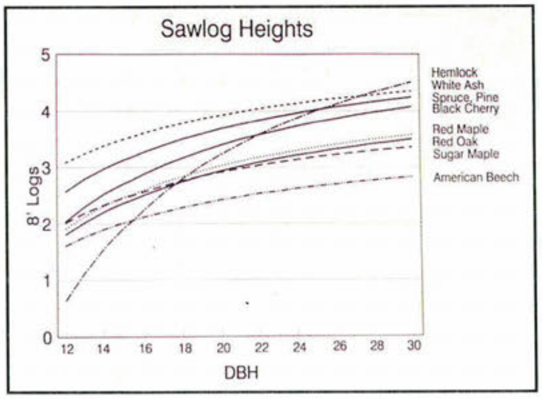
AGS		BC-WA-YP			RM-NRO-	
Size class		BA	RD	BdFt	BA	R
Saplings	value				1.0	
	f		1.44			1.
Poles	value	3.1	1.9		9.0	
	f		0.60			0.
Small Saws	value	30.0			19.5	
	f		0.39	84		0.
Medium Saws	value	25.8			2.1	
	f		0.31	128		0.

37. We have estimated the basal area in each size/quality/species cell, so calculating the relative density for that cell is a matter of a multiplication: Basal area per acre times relative density factor equals relative density per acre. Do that 30 times,

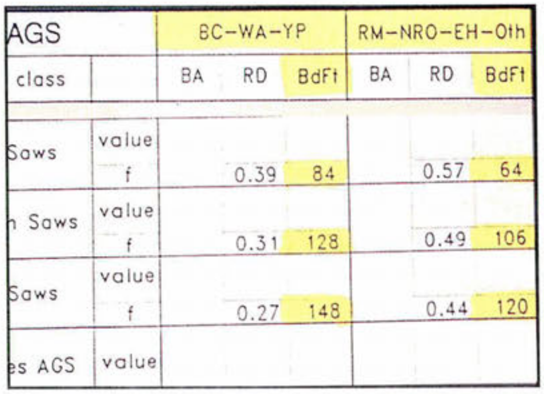


		3.0				
	8.5	8.5	0.18	37.4	+32.7	
	14.5	14.5	0.22	73.1	+38.8	
	20.5	20.5	0.24	35.8	+ 12.1	
	26.5	26.5	0.28	0.5	+ 0.1	
				157.9	96.7	

38. and then calculate the various subtotals again. The relative density of this stand is approximately 97 percent, or very close to the maximum that we expect in a stand of that size and species composition.

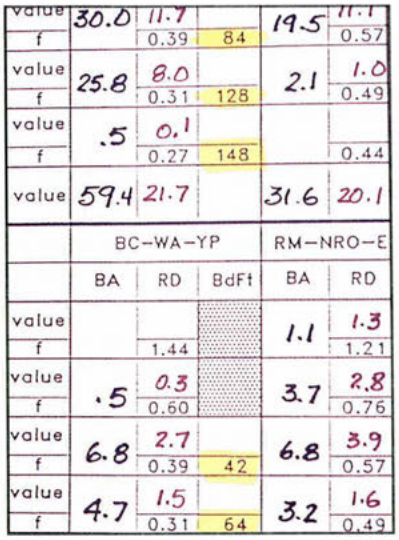


39. The next set of calculations is used to estimate the board-foot volume of the stand. Again, we have calculated a board foot factor for each species group, by quality and sawtimber size class. In the SILVAH program, the volume of each tree is calculated by an equation based on species, diameter, and height. If you do not record height, SILVAH uses the heights on this chart, based on data from the Allegheny National Forest and Hammermill Paper Company. For the manual calculations, we have developed factors to give a rough estimate of the average volume per square foot of basal area in each size and species group. The total will be a very rough estimate of the actual board-foot volume in the stand, but the relative volume calculated for different stands should give you an idea of which ones are carrying high volumes and which ones are not.



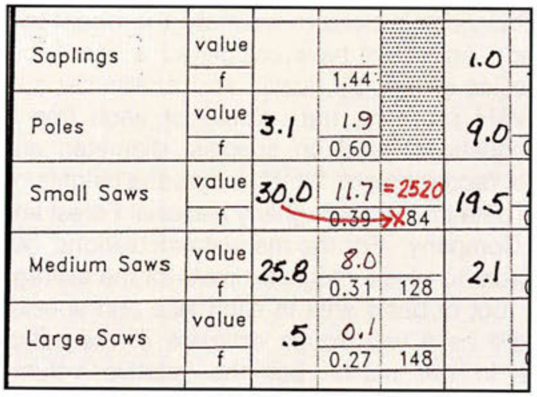
AGS		BC-WA-YP			RM-NRO-EH-Oth		
class		BA	RD	BdFt	BA	RD	BdFt
Saws	value						
	f		0.39	84		0.57	64
h Saws	value						
	f		0.31	128		0.49	106
Saws	value						
	f		0.27	148		0.44	120
es AGS	value						

40. Note that the black cherry/white ash/yellow-poplar species group has different board foot factors than the other two groups. The black cherry group has more volume per square foot than do trees in the other groups.



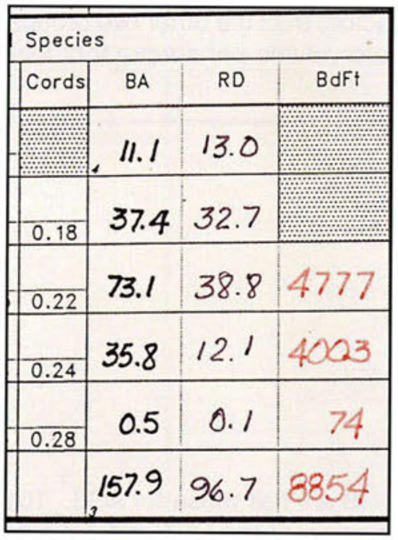
value	30.0	11.7		19.5	11.1
f		0.39	84		0.57
value	25.8	8.0		2.1	1.0
f		0.31	128		0.49
value	.5	0.1			
f		0.27	148		0.44
value	59.4	21.7		31.6	20.1
	BC-WA-YP			RM-NRO-E	
	BA	RD	BdFt	BA	RD
value				1.1	1.3
f		1.44			1.21
value	.5	0.3		3.7	2.8
f		0.60			0.76
value	6.8	2.7		6.8	3.9
f		0.39	42		0.57
value	4.7	1.5		3.2	1.6
f		0.31	64		0.49

41. Note, too, that the factors for UGS are half those for AGS. This allows for the fact that at least some of the UGS will have no sawtimber volume, and, in general, the volume will be less per square foot.



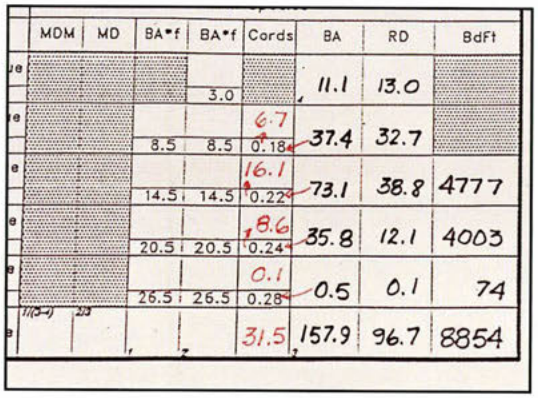
Saplings	value			▨	1.0
	f		1.44	▨	
Poles	value	3.1	1.9	▨	9.0
	f		0.60	▨	
Small Saws	value	30.0	11.7	=2520	19.5
	f		0.39	×84	
Medium Saws	value	25.8	8.0		2.1
	f		0.31	128	
Large Saws	value	.5	0.1		
	f		0.27	148	

42. Again, the calculation involves multiplying basal area per acre in each size/species/quality cell by the board foot factor. Be sure to multiply the board foot factor by the basal area, not the relative density. There are only 18 cells this time, since we are dealing with sawtimber only.



Species			
Cords	BA	RD	BdFt
▨	11.1	13.0	▨
0.18	37.4	32.7	▨
0.22	73.1	38.8	4777
0.24	35.8	12.1	4003
0.28	0.5	0.1	74
	157.9	96.7	8854

43. But we have just as many subtotals, by size classes within qualities, by species within qualities, and overall.



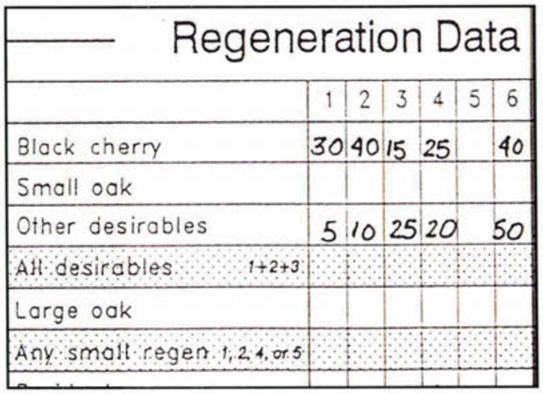
MDM	MD	BA•f	BA•f	Cords	BA	RD	BdFt
▨	▨	▨	3.0	▨	11.1	13.0	▨
▨	▨	8.5	8.5	6.7 0.18	37.4	32.7	▨
▨	▨	14.5	14.5	16.1 0.22	73.1	38.8	4777
▨	▨	20.5	20.5	8.6 0.24	35.8	12.1	4003
▨	▨	26.5	26.5	0.1 0.28	0.5	0.1	74
1/(3-4)	2/3			31.5	157.9	96.7	8854

44. Finally, we need to estimate the cordwood volume in the stand. Again, we have developed factors that convert basal area to cordwood volume, and these do not vary enough by species or quality to perform separate calculations. So, the cordwood factors are printed in the cord column near the grand total block. Multiply basal area per acre times the cordwood factor to obtain an estimate for each size class. This total is the last of our four grand totals.

Cordwood Only (rough estimate):

$$\text{Total Cords} - \frac{\text{BdFt}}{600}$$

45. This figure represents the total--cordwood including the sawtimber. A rough estimate of the cordwood excluding sawlogs can be made by dividing the board foot volume by 600 and subtracting the quotient from the total cordwood volume.



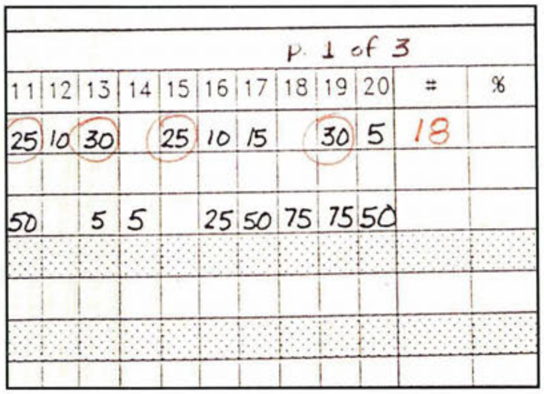
Regeneration Data

	1	2	3	4	5	6
Black cherry	30	40	15	25		40
Small oak						
Other desirables	5	10	25	20		50
All desirables 1+2+3						
Large oak						
Any small regen 1, 2, 4, or 5						

46. We will extract other overstory values to use in determining the prescription, but first we need to summarize the understory values collected in the form of weighted counts on the ID & Regen Tally Form (Appendix 4). The form contains inventory data to be used in completing a sample summary. The procedure for making these counts is reviewed in the article "Stand Examination Procedures."

Deer Index	Black Cherry	Small Oak
5	50	60
4	25	40
3	20	30
2	15	20
1	10	10

47. The first step in data summary on this form is to summarize data for advance regeneration. You must calculate the total number of plots that have sufficient regeneration stocking for the level of deer pressure on that stand in the black cherry, small oak, all desirables, and large oak categories. The criteria are partially displayed on this table, see Appendix 6B. Choose the appropriate level of deer pressure, and for each advance regeneration category, count the number of plots that meet or exceed the count in the table. For example, in the sample stand, the deer pressure index is 4. That means we need a weighted count of at least 25 black cherry seedlings for a plot to be considered stocked.



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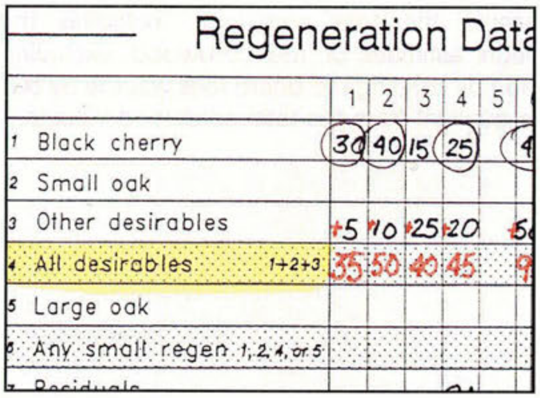
11	12	13	14	15	16	17	18	19	20	#	%
25	10	30		25	10	15		30	5	18	
50		5	5		25	50	75	75	50		

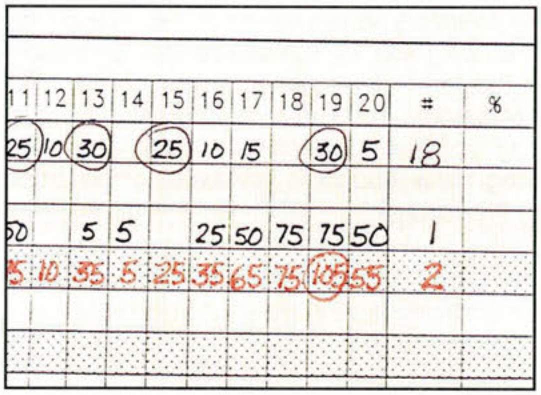
48. The stocked plots are circled on the tally form, and the count recorded in the # column to the right.



Regeneration Data

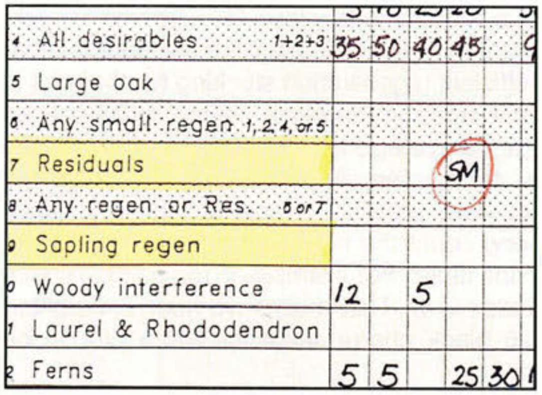
		1	2	3	4	5
1	Black cherry	30	40	15	25	
2	Small oak					
3	Other desirables	+5	+10	+25	+20	
4	All desirables 1+2+3	35	50	40	45	
5	Large oak					
6	Any small regen 1, 2, 4, or 5					

49. Add the counts in rows 1, 2 and 3 (black cherry, small oak, and other desirables) to calculate an "all desirables" total to compare with the appropriate "all desirables" criterion.



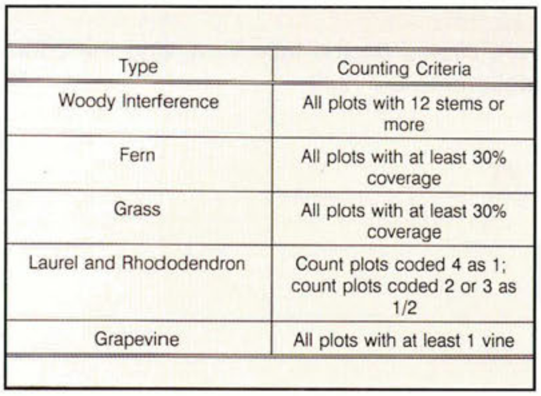
11	12	13	14	15	16	17	18	19	20	#	%
25	10	30		25	10	15		30	5	18	
50		5	5		25	50	75	75	50	1	
5	10	35	5	25	35	65	75	105	55	2	

50. Record this number in the "all desirables" # column.



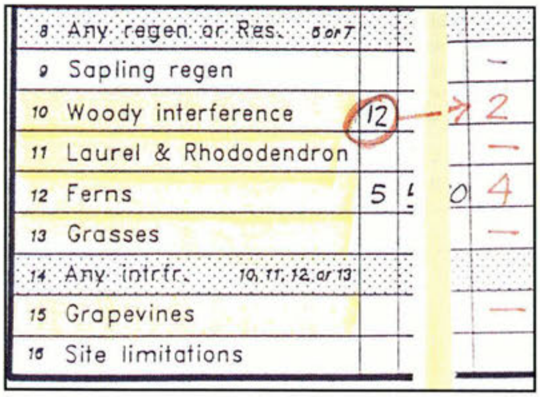
		1	2	3	4	5
4	All desirables 1+2+3	35	50	40	45	
5	Large oak					
6	Any small regen 1, 2, 4, or 5					
7	Residuals				SM	
8	Any regen or Res. 6 or 7					
9	Sapling regen					
0	Woody interference	12		5		
1	Laurel & Rhododendron					
2	Ferns	5	5		25	30

51. For the residuals and sapling regen rows, count the number of plots that have an entry and record the value in the # column.



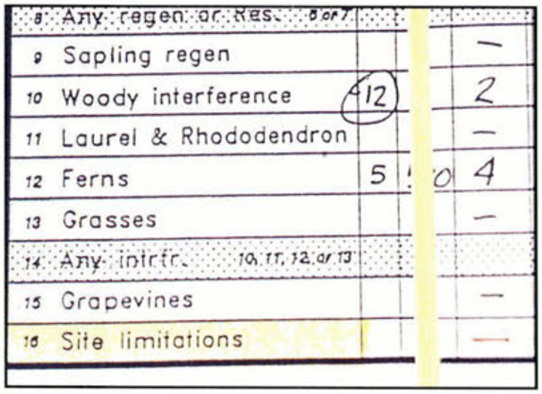
Type	Counting Criteria
Woody Interference	All plots with 12 stems or more
Fern	All plots with at least 30% coverage
Grass	All plots with at least 30% coverage
Laurel and Rhododendron	Count plots coded 4 as 1; count plots coded 2 or 3 as 1/2
Grapevine	All plots with at least 1 vine

52. Critical levels of interference are listed on this table, also found in Appendix 6C.



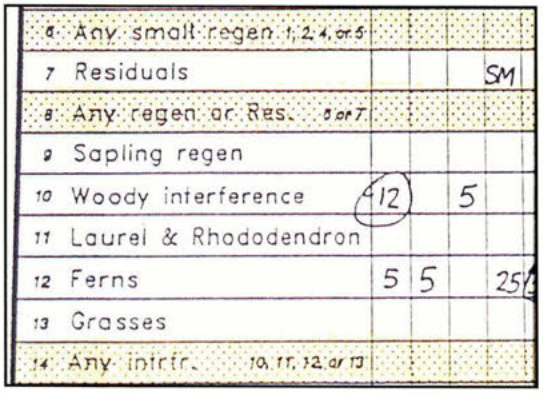
8 Any regen or Res. 5 or 7				
9 Sapling regen				—
10 Woody interference	12			2
11 Laurel & Rhododendron				—
12 Ferns	5		0	4
13 Grasses				—
14 Any intrfr. 10, 11, 12 or 13				
15 Grapevines				—
16 Site limitations				

53. For the woody interference, laurel and rhododendron, fern, grass, and grapevine rows, count the number of plots that meet these criteria and record in the # column.



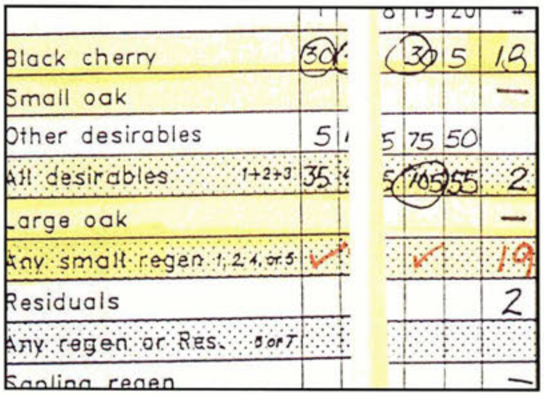
8 Any regen or Res. 5 or 7				
9 Sapling regen				—
10 Woody interference	12			2
11 Laurel & Rhododendron				—
12 Ferns	5		0	4
13 Grasses				—
14 Any intrfr. 10, 11, 12 or 13				
15 Grapevines				—
16 Site limitations				—

54. For the site limitations row, count the number of plots with an entry and record this value in the # column.



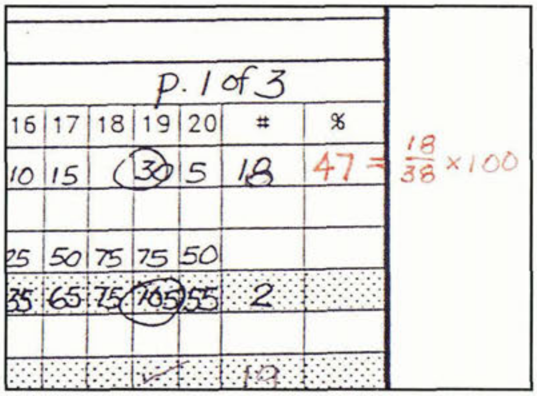
6 Any small regen 1, 2, 4, or 5				
7 Residuals				SM
8 Any regen or Res. 5 or 7				
9 Sapling regen				
10 Woody interference	12		5	
11 Laurel & Rhododendron				
12 Ferns	5	5		25
13 Grasses				
14 Any intrfr. 10, 11, 12 or 13				

55. Three rows of regeneration data are combinations of other categories: any small regen, any regen or residuals, and any interference. Each of these is highlighted on the tally sheet, and a list of row numbers combined to form this row is in the title block.



Black cherry	30			30	5	19
Small oak						—
Other desirables	5		5	75	50	
All desirables 1+2+3	35		5	105	55	2
Large oak						—
Any small regen 1, 2, 4, or 5	✓			✓		19
Residuals						2
Any regen or Res. 5 or 7						
Sapling regen						—

56. To complete these combined rows, determine whether any of the rows listed meet the appropriate criteria. For example, the numbers in the any small regen block are 1,2,4, and 5, or black cherry, small oak, all desirables, and large oak. So, for each plot that met the criteria for one or more of those rows, put a check mark in the any small regen, or sixth, row. Total the number of check marks and record the value in the # column. Do likewise for any regen or residuals (row 8) and for any interference (row 14).



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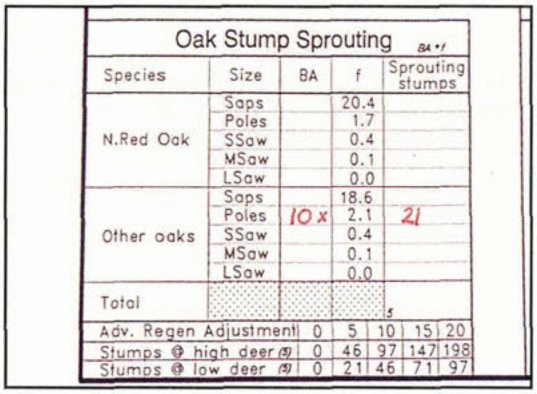
16	17	18	19	20	#	%	
10	15	(	30	5	18	47 =	$\frac{18}{38}$ × 100
25	50	75	75	50			
35	65	75	105	55	2		
			✓		18		

57. To determine the percentage that meet the various criteria divide by the number of plots taken. This is why it is critical to cross off the number of each plot that you take, whether or not it has any countable seedlings or interference. The prescription selection for any stand is based on the percentage of regeneration plots meeting stocking criteria. The percentage can be correct only if the total number of regeneration plots is accurately reflected on the form, so it is critical to record plots that had no recordable data.

WHAT ABOUT
OAK STUMP SPROUTS?

58. There is one exception to this procedure for summarizing regeneration data. In stands with a significant component of oak, the probable contribution of oak stump sprouts to the next stand can be calculated from overstory data and added to advance regeneration stocking.

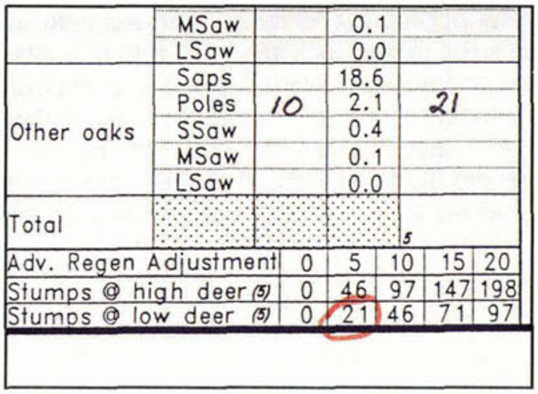


Oak Stump Sprouting BA*f

Species	Size	BA	f	Sprouting stumps
N.Red Oak	Saps		20.4	
	Poles		1.7	
	SSaw		0.4	
	MSaw		0.1	
	LSaw		0.0	
Other oaks	Saps		18.6	
	Poles	10 x	2.1	21
	SSaw		0.4	
	MSaw		0.1	
	LSaw		0.0	
Total				5

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

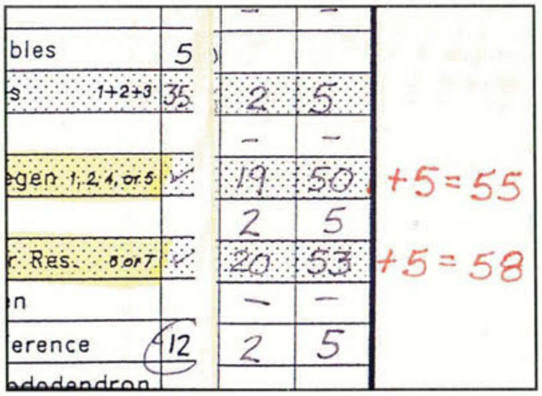
59. The Prescription Summary Worksheet (Appendix 5) contains the oak stump sprouting section required to complete this calculation. To calculate the expected number of stump sprouts per acre, record the basal area for each size class and each oak species group represented in the stand in the BA column. Multiply the basal area times the appropriate factor on the table. Add these to estimate the total number of stumps that will contribute sprouts to the next stand. For example, 10 square feet of white oak poletimber would yield 21 sprouting stumps per acre.



	MSaw		0.1	
	LSaw		0.0	
Other oaks	Saps		18.6	
	Poles	10	2.1	21
	SSaw		0.4	
	MSaw		0.1	
	LSaw		0.0	
Total				5

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

60. The bottom of this section has figures used to determine the adjustment to advance regeneration stocking represented by oak stump sprouts. Locate the number of sprouts you calculated in the last step in the column for the appropriate deer pressure, then read the adjustment factor in the first column. The maximum adjustment for stump sprouts is 20 percent. For example, the 21 sprouts per acre we expected from our 10 square feet of white oak poletimber would add 5 percent to our advance regeneration stocking in a low deer pressure area. In a high deer pressure area, we would interpolate from the table and add about 2 percent to advance regeneration stocking.



		—	—	
bles	5			
s 1+2+3	35	2	5	
		—	—	
gen 1, 2, 4, or 5	✓	19	50	+5 = 55
		2	5	
r Res. 6 or 7	✓	20	53	+5 = 58
n		—	—	
erence	12	2	5	
ododendron				

61. Add this adjustment percentage to the any regen or residuals row of the regeneration data summary (row 8) on the ID & Regen Tally Form.

SUMMARY DATA SHOWS:

Overstory species composition, basal area, density, structure and quality

Understory species composition, seedling numbers, residual trees, interfering plants, and site problems

62. After completing the three summary forms, we know a great deal about the present overstory--species composition, density, basal area, structure, and quality. We also know a great deal about the present understory--seedlings, potential residual trees or saplings of a different age class, site problems, and interfering plants.

ANALYSIS:

Extract 17 variables that will uniquely determine a prescription for this stand

63. The next step is to extract the particular overstory and understory values needed to determine the best prescription for this stand. Record the values on the Prescription Summary worksheet (Appendix 5).

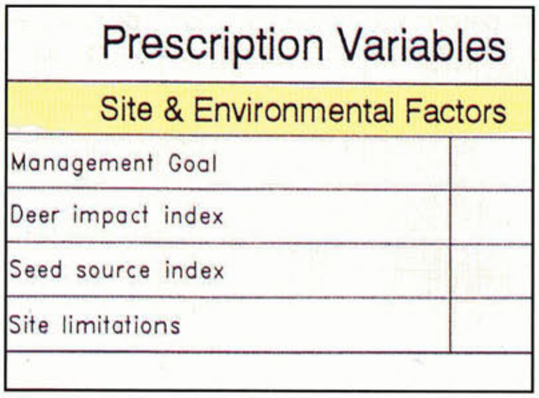
Prescription Variables

Site & Environmental Factors

Understory Factors

Overstory Factors

64. The values we will extract are those needed to use SILVAH'S decision charts. In concept, we are extracting key information about management objectives and constraints, the regeneration capacity of the stand, and the maturity and present growing conditions of the overstory.

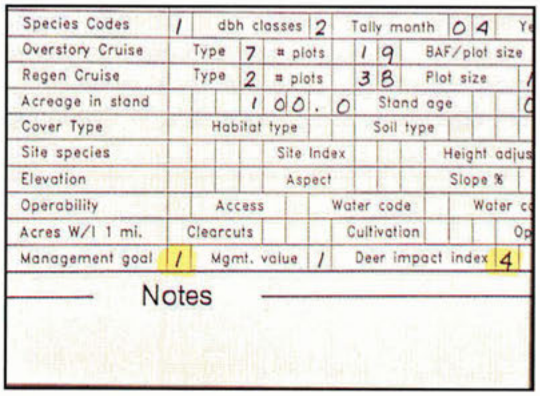


Prescription Variables

Site & Environmental Factors

Management Goal	
Deer impact index	
Seed source index	
Site limitations	

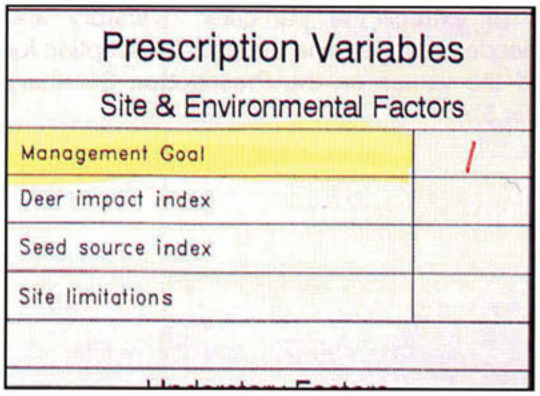
65. The first group of considerations are site and environmental factors. Management goal and deer impact index are the first of these factors.



Species Codes / dbh classes 2 Tally month 0 4 Ye
Overstory Cruise Type 7 # plots 1 9 BAF/plot size
Regen Cruise Type 2 # plots 3 8 Plot size
Acreage in stand 1 00.0 Stand age
Cover Type Habitat type Soil type
Site species Site Index Height adjus
Elevation Aspect Slope %
Operability Access Water code Water c
Acres W/I 1 mi. Clearcuts Cultivation Op
Management goal 1 Mgmt. value 1 Deer impact index 4

Notes

66. They are found in the identification data block of the ID & RegenTally Form (Appendix 4).

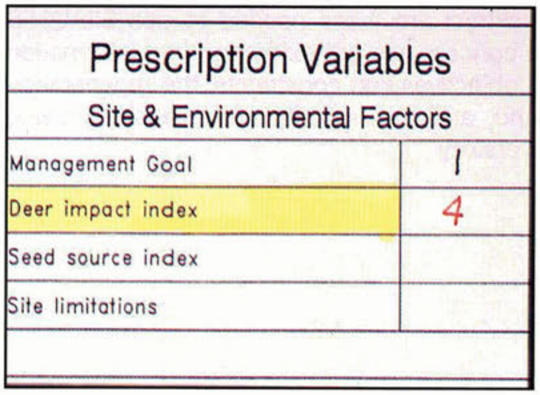


Prescription Variables

Site & Environmental Factors

Management Goal	1
Deer impact index	
Seed source index	
Site limitations	

67. The codes for these values are reviewed in the article "Stand Examination Procedures." Management goal is the code that represents management objectives and constraints for the stand. Management goal ranges from 1 for those whose goal is maximum timber production with even-age practices to 4 for those whose goal includes some timber production while retaining many large trees.

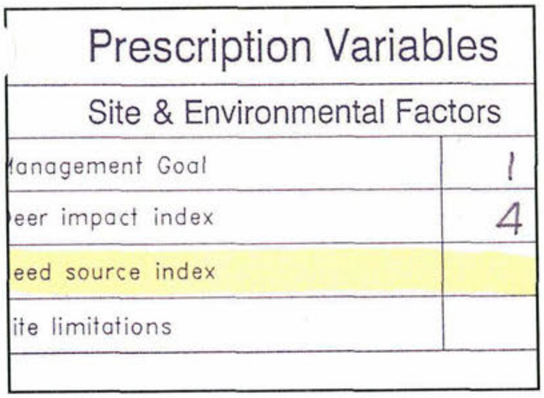


Prescription Variables

Site & Environmental Factors

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

68. The values for deer pressure range from 5 for very high to 1 for very low.

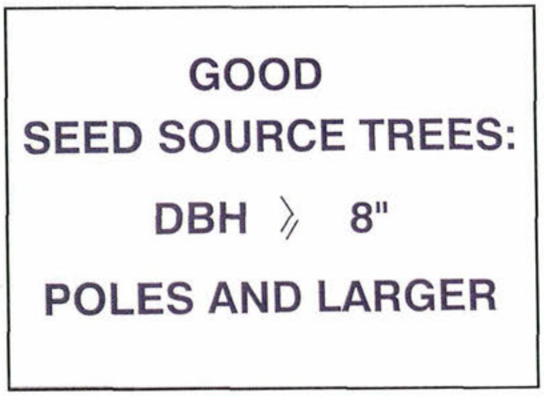


Prescription Variables

Site & Environmental Factors

lanagement Goal	1
eer impact index	4
eed source index	
ite limitations	

69. The third of the site and environmental factors is seed source index. It indicates the adequacy of seed source, which, if too low, is a very important limiting factor for regeneration.



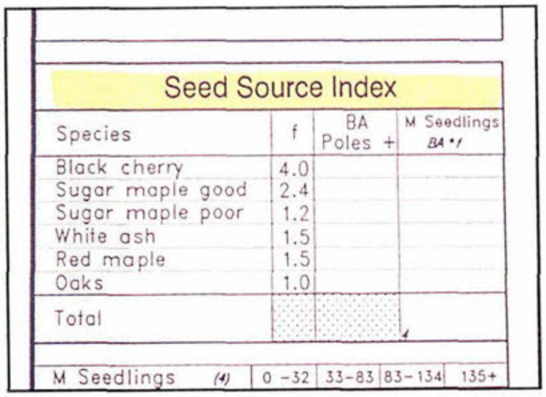
GOOD

SEED SOURCE TREES:

DBH ≥ 8"

POLES AND LARGER

70. Our research indicates that trees 8 inches and larger are the principal sources of seed in Allegheny hardwood and oak stands. Using the manual form, we can not break out trees 8 inches and larger, as the computer does. However, we can total the basal area in trees 6 inches--or pole size--and larger. Make this compromise when using the manual procedures.

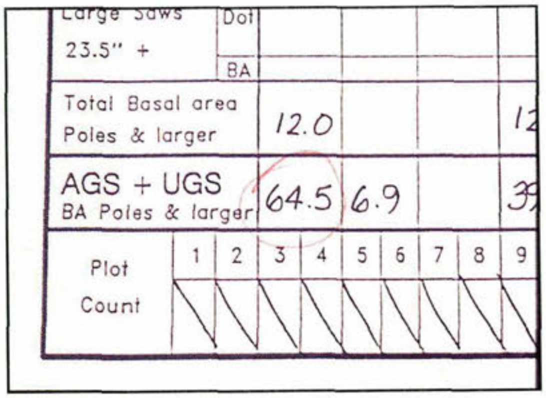


Seed Source Index

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	▨	▨	

M Seedlings (4)	0 -32	33-83	83-134	135+

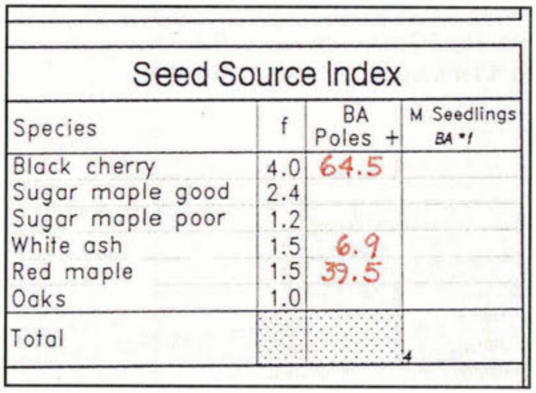
71. This calculation is performed in the Seed Source Index column in the left hand column of the Prescription Summary worksheet.



Large Saws 23.5" +	Dot				
	BA				
Total Basal area Poles & larger		12.0			12
AGS + UGS BA Poles & larger		64.5	6.9		39

Plot	1	2	3	4	5	6	7	8	9
Count									

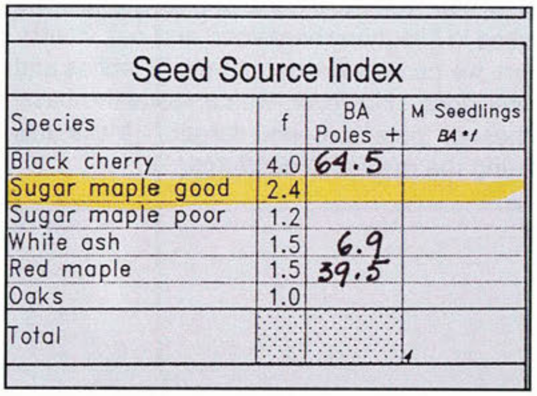
72. We have already calculated the basal area in poles and larger for each species or species group on the Manual Overstory Tally form. In the sample stand, there are 64.5 square feet of basal area in pole size and larger black cherry trees. Record this value in the BA column of the Seed Source Index section on the Prescription Summary worksheet.



Seed Source Index

Species	f	BA Poles +	M Seedlings BA •f
Black cherry	4.0	64.5	
Sugar maple good	2.4		
Sugar maple poor	1.2		
White ash	1.5	6.9	
Red maple	1.5	39.5	
Oaks	1.0		
Total			[4]

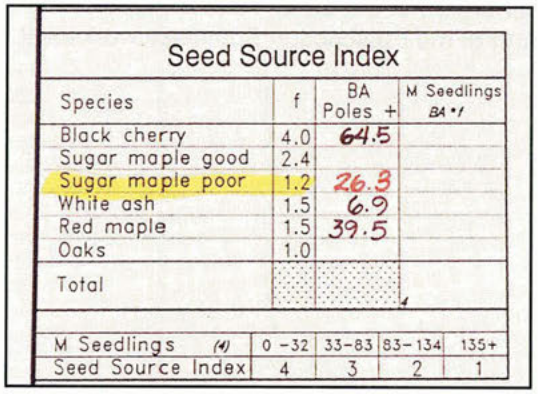
73. Our data on seed production cover the major species in the Allegheny hardwood and oak forests of the Allegheny Plateau region. Record the basal area in poles and larger for black cherry, white ash, red maple, the oaks, and sugar maple in the Seed Source Index section.



Seed Source Index

Species	f	BA Poles +	M Seedlings BA •f
Black cherry	4.0	64.5	
Sugar maple good	2.4		
Sugar maple poor	1.2		
White ash	1.5	6.9	
Red maple	1.5	39.5	
Oaks	1.0		
Total			[4]

74. Two rows are provided for sugar maple basal area. In some parts of the Allegheny region, such as southwestern New York state, sugar maple trees tend to be in the main crown canopy, have vigorous healthy crowns, and produce ample seed. If the stand you have sampled is similar, record the basal area in poles and larger trees on the sugar maple good row.

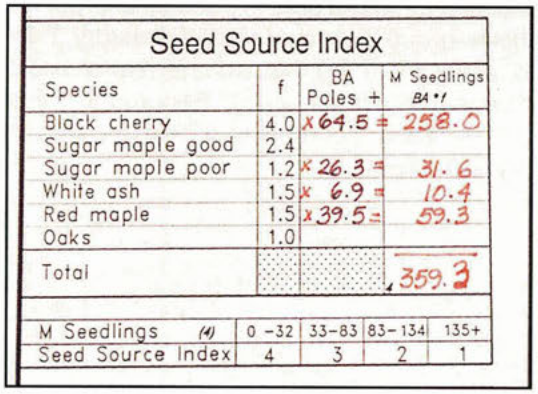


Seed Source Index

Species	f	BA Poles +	M Seedlings BA •f
Black cherry	4.0	64.5	
Sugar maple good	2.4		
Sugar maple poor	1.2	26.3	
White ash	1.5	6.9	
Red maple	1.5	39.5	
Oaks	1.0		
Total			[4]

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

75. In other regions of the Plateau, however, such as the Allegheny National Forest, sugar maple rarely reaches into the main crown canopy. The crowns of sugar maple in such stands are often small and lack vigor. In some stands, seed production is also limited by disease, insect defoliation, or decline. When the stand you have sampled is similar, record its basal area in pole and larger trees in the sugar maple poor row.

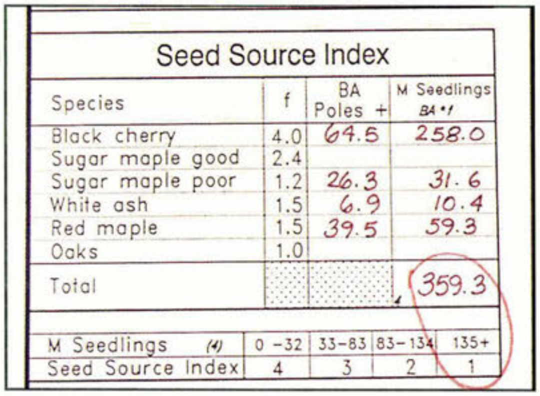


Seed Source Index

Species	f	BA Poles +	M Seedlings BA •f
Black cherry	4.0	× 64.5 =	258.0
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			[4] 359.3

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

76. Next, multiply each basal area by the seed source factor in the column labeled f. Record the answer, which is an estimate of the number of seedlings in thousands of that species likely to be produced per acre over the 5-year period of a shelterwood seed cut, in the last column of the section, and sum the values.

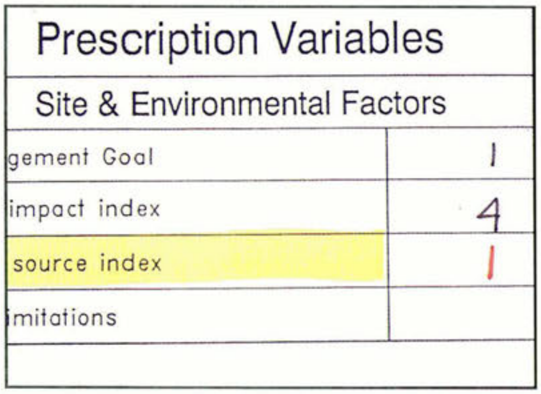


Seed Source Index

Species	f	BA Poles +	M Seedlings BA*f
Black cherry	4.0	64.5	258.0
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			359.3

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

77. Finally, match your total to the values in the M seedlings row, and read the appropriate index value below. An index value of 1 indicates abundant seed production, while an index value of 4 indicates severe limitations to regeneration due to seed production.

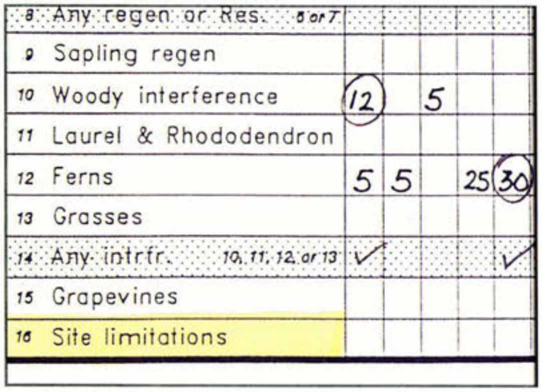


Prescription Variables

Site & Environmental Factors

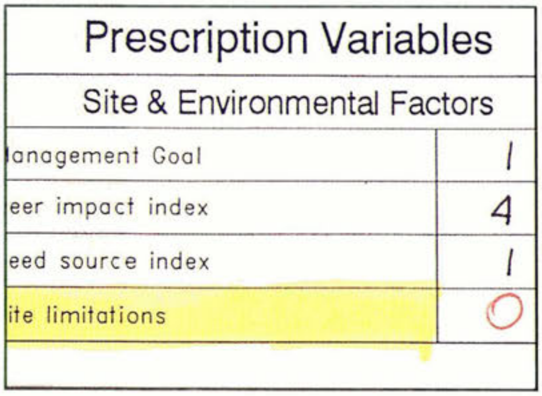
gement Goal	1
impact index	4
source index	1
imitations	

78. Record the index value in the seed source index row in the SIte and Environmental Factors section.



8 Any regen or Res. 5 or 7					
9 Sapling regen					
10 Woody interference	12		5		
11 Laurel & Rhododendron					
12 Ferns	5	5		25	30
13 Grasses					
14 Any intrfr. 10, 11, 12, or 13	✓				✓
15 Grapevines					
16 Site limitations					

79. The final row in the Site and Environmental Factors section, site limits, is the percentage of regen plots that were checked off as either wet or rocky.

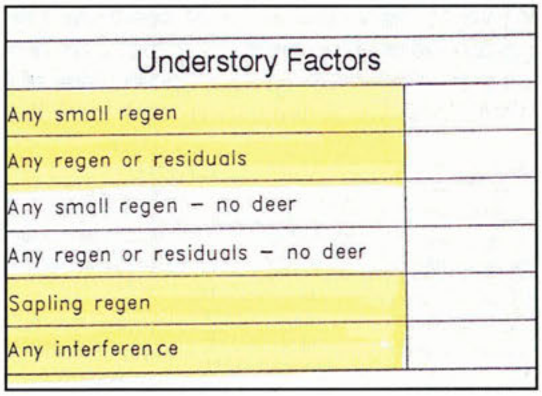


Prescription Variables

Site & Environmental Factors

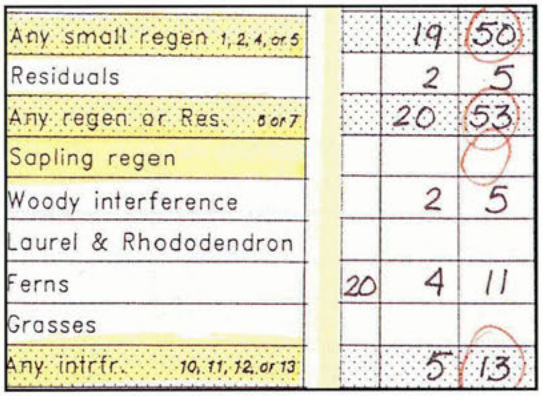
anagement Goal	1
eer impact index	4
eed source index	1
ite limitations	0

80. The value for this prescription variable can be transferred directly from the ID & Regen Tally Sheet (Appendix 4). In the sample stand, it was zero.



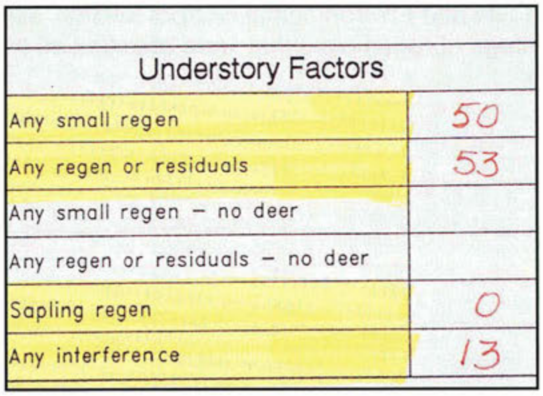
Understory Factors	
Any small regen	
Any regen or residuals	
Any small regen - no deer	
Any regen or residuals - no deer	
Sapling regen	
Any interference	

81. Most of the Understory Factors also can be transferred directly from the understory summary (Appendix 5) to the appropriate space on this form.



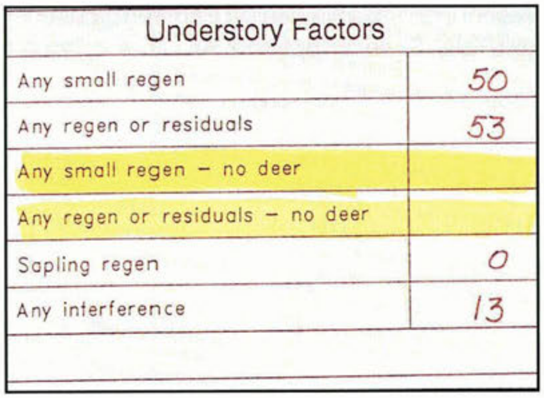
Any small regen 1, 2, 4, or 5		19	50
Residuals		2	5
Any regen or Res. 6 or 7		20	53
Sapling regen			
Woody interference		2	5
Laurel & Rhododendron			
Ferns	20	4	11
Grasses			
Any intrfr. 10, 11, 12, or 13		5	13

82. We have already calculated the values for any small regen, any regen or residuals, sapling regen, and any interference.



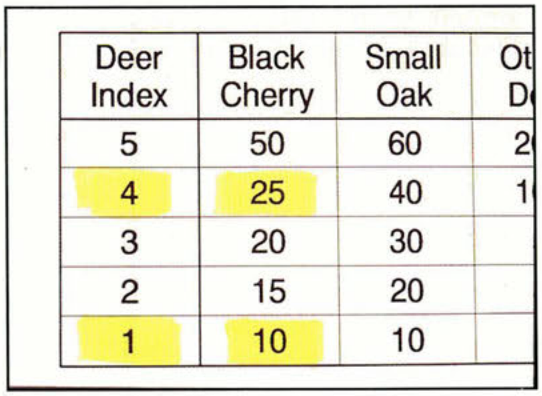
Understory Factors	
Any small regen	50
Any regen or residuals	53
Any small regen - no deer	
Any regen or residuals - no deer	
Sapling regen	0
Any interference	13

83. So, we record the values: 50 percent of understory plots stocked with any small regen, 53 percent with any regen and residuals, none with sapling regen, and 13 percent with any interference.



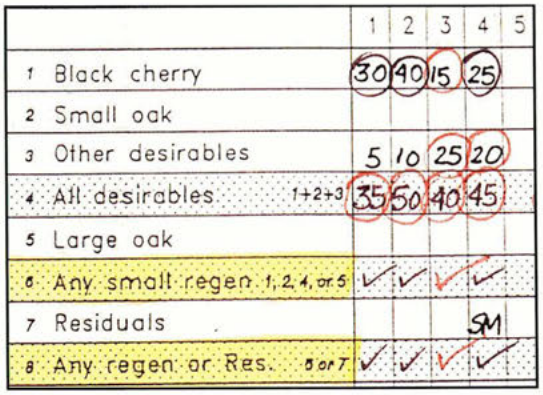
Understory Factors	
Any small regen	50
Any regen or residuals	53
Any small regen - no deer	
Any regen or residuals - no deer	
Sapling regen	0
Any interference	13

84. We need to make two new calculations, however. Because seedlings inside fences are protected from deer browsing and the associated losses, the regen stocking required for successful regeneration cuts inside a fence is lower than that in moderate to high deer pressure areas. The values that we need for any small regen-no deer and for any regen or residuals-no deer are calculated from our weighted counts, just as the original values for any regen and any regen or residuals were calculated. For the no deer values, however, we use the criteria for plot stocking associated with a deer pressure of 1 on the advance regen stocking table in Appendix 6B.



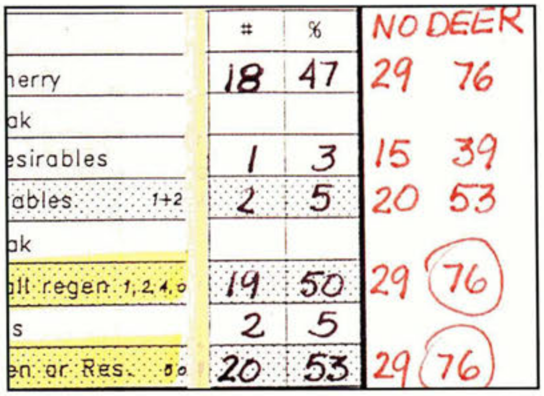
Deer Index	Black Cherry	Small Oak	Ot D
5	50	60	2
4	25	40	1
3	20	30	
2	15	20	
1	10	10	

85. For example, we only considered those plots with 25 or more black cherry seedlings stocked in our original calculations, since 25 was the criterion associated with our ambient deer pressure level of 4. But if we were inside a fence, 10 seedlings per plot would be ample stocking.



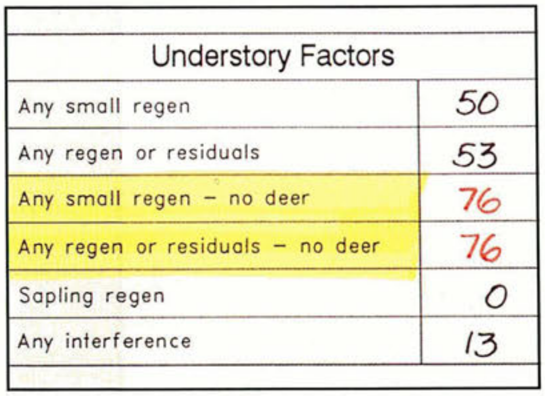
		1	2	3	4	5
1 Black cherry		30	40	15	25	
2 Small oak						
3 Other desirables		5	10	25	20	
4 All desirables	1+2+3	35	50	40	45	
5 Large oak						
6 Any small regen	1, 2, 4, or 5	✓	✓	✓	✓	
7 Residuals					SM	
8 Any regen or Res.	5 or 7	✓	✓	✓	✓	

86. With this criteria, many more of the understory plots can be considered stocked with the various categories of advance regeneration. The criteria for other desirables and all desirables under a Deer Impact Index of 1, for example, is 15 seedlings; so, there is a very big change in these figures.



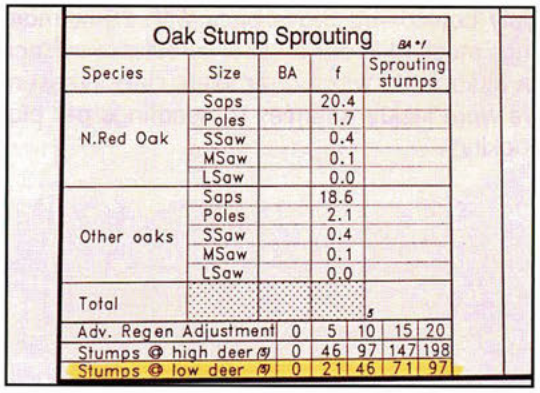
	#	%	NO DEER	
herry	18	47	29	76
ak				
esirables	1	3	15	39
ables 1+2	2	5	20	53
ak				
ll regen 1, 2, 4, o	19	50	29	76
s	2	5		
en or Res. 5 o	20	53	29	76

87. In the sample stand, using these changed criteria, 30 of the regeneration plots in the sample stand, or 76 percent, can be considered stocked with any regen, and with any regen and residuals.



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

88. We transfer these values to the Understory Factors section.

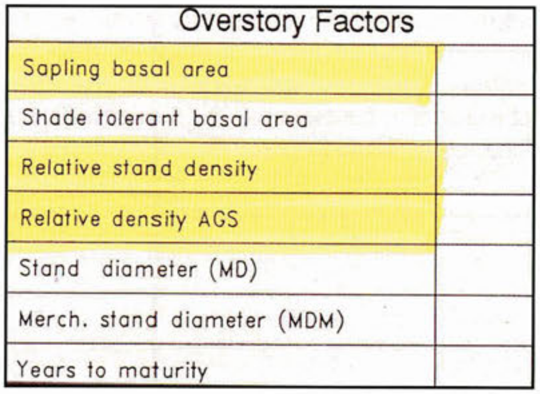


Oak Stump Sprouting BA*f

Species	Size	BA	f	Sprouting stumps
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	▨	▨	▨	

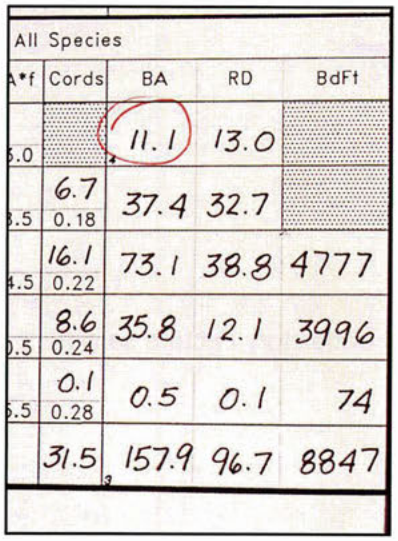
Adv. Regen Adjustment	0	5	10	15	20
Stumps @ high deer (5)	0	46	97	147	198
Stumps @ low deer (5)	0	21	46	71	97

89. To these values, we would add the oak stump sprouting adjustment for low deer pressure in a stand with oak.



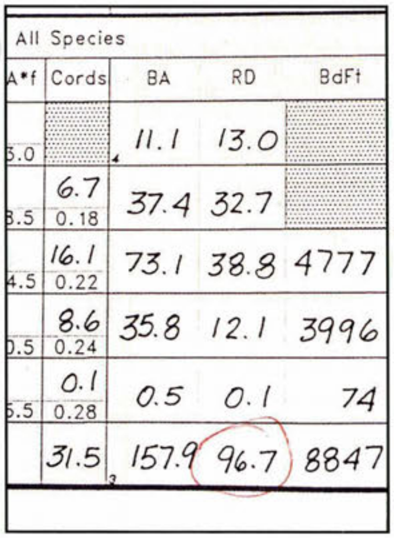
Overstory Factors	
Sapling basal area	
Shade tolerant basal area	
Relative stand density	
Relative density AGS	
Stand diameter (MD)	
Merch. stand diameter (MDM)	
Years to maturity	

90. The final category of values that we need to extract from our data summary is Overstory Factors. Three of these can be transferred directly from the Manual Overstory Summary sheet (Appendix 3).



All Species				
*f	Cords	BA	RD	BdFt
.0	▨	11.1	13.0	▨
.5	6.7 0.18	37.4	32.7	▨
.5	16.1 0.22	73.1	38.8	4777
.5	8.6 0.24	35.8	12.1	3996
.5	0.1 0.28	0.5	0.1	74
	31.5	157.9	96.7	8847

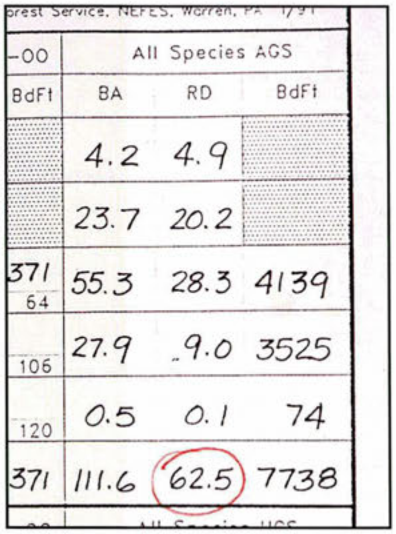
91. Sapling basal area is the grand total for saplings, all species, all qualities. For this stand, the value is 11 square feet, and it is found in the sapling cell of the basal area totals column, and recorded on the Prescription Summary worksheet.



All Species

A*f	Cords	BA	RD	BdFt
5.0		11.1	13.0	
3.5	6.7 0.18	37.4	32.7	
4.5	16.1 0.22	73.1	38.8	4777
0.5	8.6 0.24	35.8	12.1	3996
5.5	0.1 0.28	0.5	0.1	74
	31.5	157.9	96.7	8847

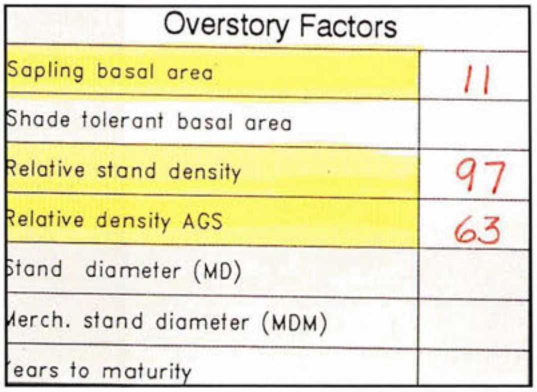
92. Relative stand density is also the total, for the whole stand. The total relative density is in the lower right corner of the Manual Overstory Summary sheet.



orest Service. NEFES. Warren, PA 1/91

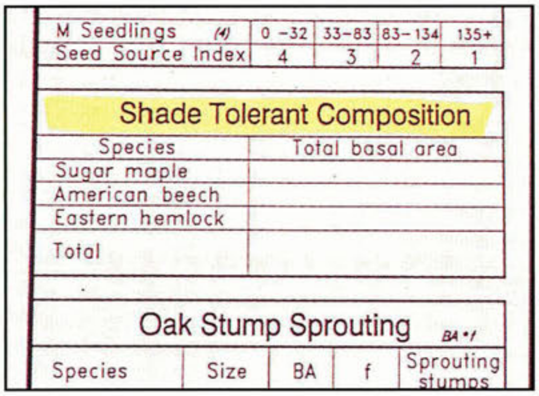
-00	All Species AGS		
BdFt	BA	RD	BdFt
	4.2	4.9	
	23.7	20.2	
371 64	55.3	28.3	4139
106	27.9	9.0	3525
120	0.5	0.1	74
371	111.6	62.5	7738

93. The relative density AGS is the total relative density for the Acceptable Growing Stock only. This is found in the AGS summary block near the top of the Manual Overstory Summary sheet. For this stand, the value is 63 percent.



Overstory Factors	
Sapling basal area	11
Shade tolerant basal area	
Relative stand density	97
Relative density AGS	63
Stand diameter (MD)	
Merch. stand diameter (MDM)	
ears to maturity	

94. Record all three values on the Overstory Factors section of the Prescription Summary worksheet (Appendix 5).



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

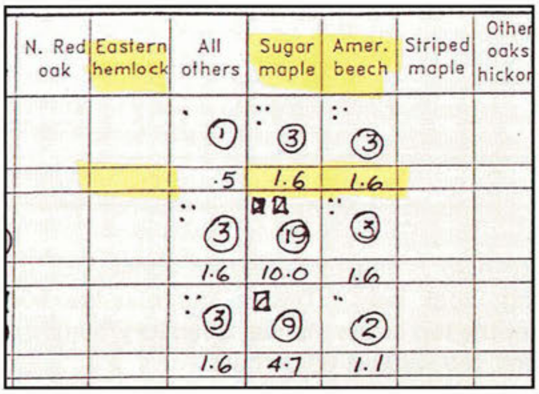
Shade Tolerant Composition

Species	Total basal area
Sugar maple	
American beech	
Eastern hemlock	
Total	

Oak Stump Sprouting BA•f

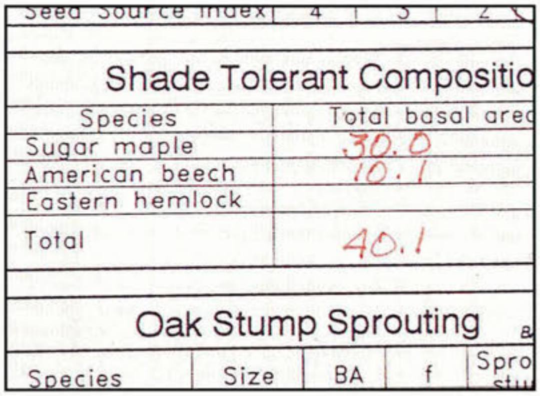
Species	Size	BA	f	Sprouting stumps

95. The next value is shade tolerant basal area. We are interested in this value because we need ample basal area in shade tolerant species if uneven-age management techniques are to succeed in this stand. A section is provided for this calculation on the left side of the Prescription Summary worksheet.



N. Red oak	Eastern hemlock	All others	Sugar maple	Amer. beech	Striped maple	Other oaks hickor
		①	③	③		
		.5	1.6	1.6		
		③	⑲	③		
		1.6	10.0	1.6		
		③	⑨	②		
		1.6	4.7	1.1		

96. Calculate the total basal area in sugar maple, American beech, and eastern hemlock. The total you calculate should include all size classes and both quality classes.



Seed Source Index	4	3	2

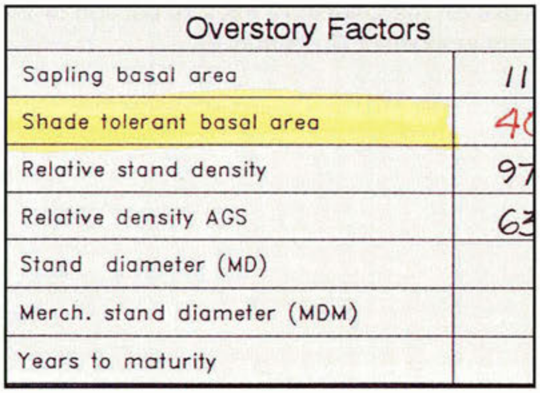
Shade Tolerant Compositio

Species	Total basal are
Sugar maple	30.0
American beech	10.1
Eastern hemlock	
Total	40.1

Oak Stump Sprouting

Species	Size	BA	f	Spro

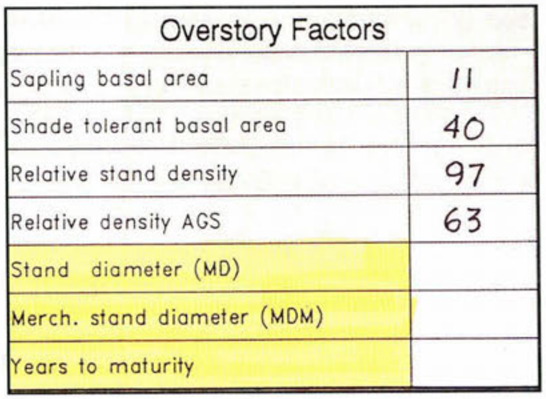
97. Record each species total on the appropriate line and sum these values. For this stand, the total is 40 square feet.



Overstory Factors

Sapling basal area	11
Shade tolerant basal area	4
Relative stand density	97
Relative density AGS	6
Stand diameter (MD)	
Merch. stand diameter (MDM)	
Years to maturity	

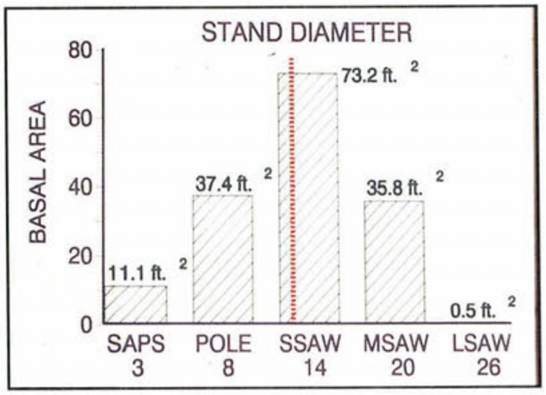
98. Record the sum as the shade tolerant basal area in the Overstory Factors section.



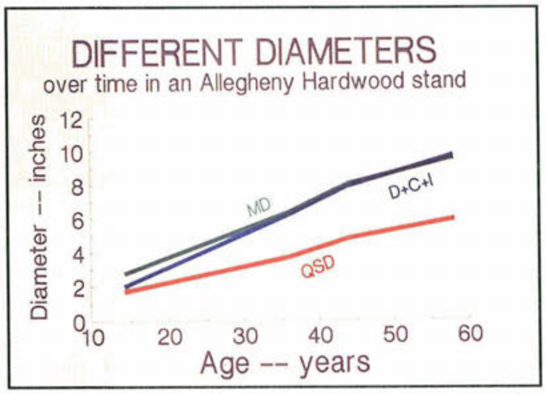
Overstory Factors

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

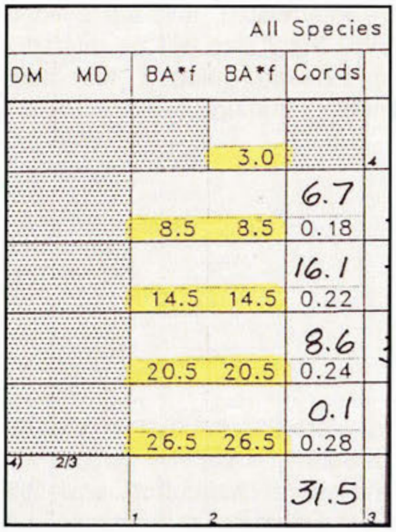
99. The next three calculations are interrelated, and are used to assess the maturity of the stand. They also will be reference values for development of a marking guide if the stand prescription calls for any intermediate cuttings.



100. The stand diameters that we calculate are the diameters at the midpoint of the basal-area distribution. Diameter (MD) is the diameter at the midpoint of the entire distribution, while the merchantable diameter (MDM) is the diameter at the midpoint of the distribution of merchantable stems, or poles and sawtimber. We choose these diameters because they reflect the diameter of the trees that will be managed. We can also determine these diameters accurately from prism data.

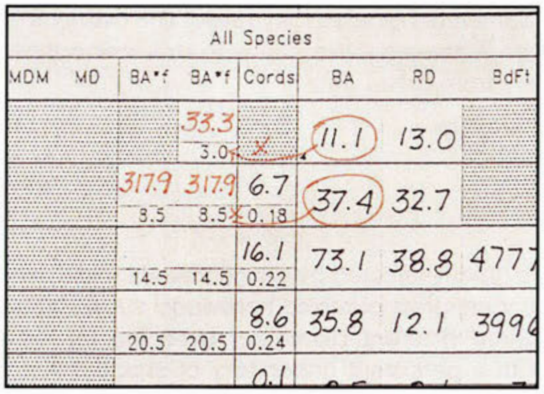


101. Other diameters are greatly affected by the numerous small trees that persist in the understories of mixed hardwood stands. This graph compares three different diameters over the life of a hardwood stand with a persistent understory of shade tolerant species. You can see that "MD", the diameter used in the SILVAH calculations, tracks right along with the diameter of the dominants, codominants, and intermediates, whereas the diameter of the tree of average basal area (QSD, or quadratic stand diameter) falls behind early. This occurs because its calculation is heavily influenced by the numerous small trees.



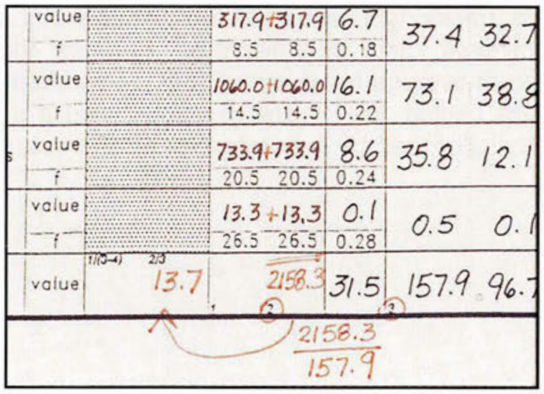
All Species				
DM	MD	BA*f	BA*f	Cords
			3.0	
		8.5	8.5	6.7 0.18
		14.5	14.5	16.1 0.22
		20.5	20.5	8.6 0.24
		26.5	26.5	0.1 0.28
	2/3			31.5

102. A section is provided at the bottom of the Manual Overstory Summary sheet to help calculate these diameters. The factors are the mid-point diameters for each size class: 8.5 is midway between 5.5 and 11.5, 14.5 is midway between 11.5 and 17.5, and so on. There is one column for calculating MD, the medial diameter of the whole stand, and another, to the left, for calculating MDM, the medial diameter of the merchantable portion of the stand.



All Species							
MDM	MD	BA*f	BA*f	Cords	BA	RD	BdFt
			33.3 3.0		11.1	13.0	
		317.9 8.5	317.9 8.5	6.7 0.18	37.4	32.7	
		14.5	14.5	16.1 0.22	73.1	38.8	477
		20.5	20.5	8.6 0.24	35.8	12.1	399
				0.1			

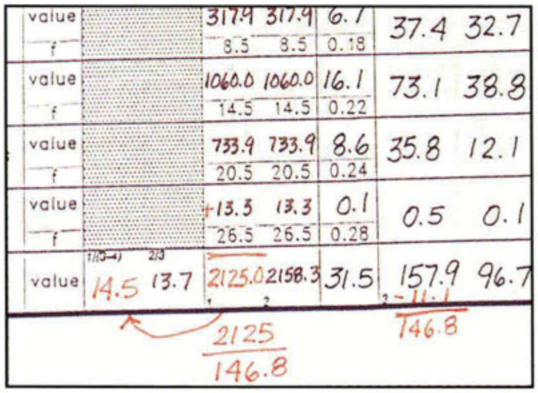
103. Multiply the basal area in each size class times the appropriate diameter, and record these products on the form. Record the answers for poles and larger trees twice, to make the calculation for the whole stand and another for the merchantable trees.



value f		317.9+317.9 8.5 8.5	6.7 0.18	37.4	32.7
value f		1060.0+1060.0 14.5 14.5	16.1 0.22	73.1	38.8
value f		733.9+733.9 20.5 20.5	8.6 0.24	35.8	12.1
value f		13.3+13.3 26.5 26.5	0.1 0.28	0.5	0.
value	1/(3-4) 13.7	2/3 2158.3	31.5	157.9	96.7

$\frac{2158.3}{157.9}$

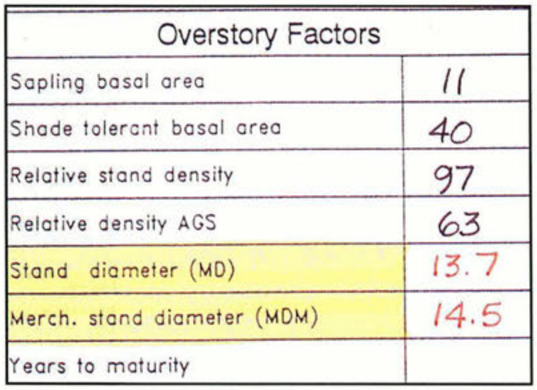
104. Then sum and divide the result by the total basal area of the included classes. For MD, divide the total weighted basal area for all size classes, 2158.3, by the total basal area in the stand, or 157.9, and record this answer in the appropriate cell at the bottom.



	1/(3-4)	2/3					
value			317.9	317.9	6.7	37.4	32.7
f			8.5	8.5	0.18		
value			1060.0	1060.0	16.1	73.1	38.8
f			14.5	14.5	0.22		
value			733.9	733.9	8.6	35.8	12.1
f			20.5	20.5	0.24		
value			+13.3	13.3	0.1	0.5	0.1
f			26.5	26.5	0.28		
value	14.5	13.7	2125.0	2158.3	31.5	157.9 -11.1 146.8	96.7

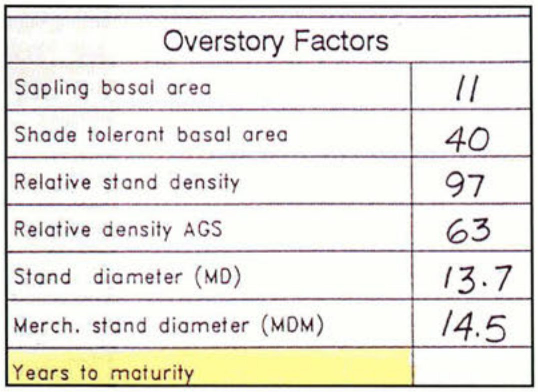
$\frac{2125}{146.8}$

105. For MDM, divide the total in the next column, 2125.0, which excludes the saplings, by the basal area in the merchantable sizes, 157.9 minus 11.1 equals 146.8. The answer, 14.5, is recorded as the MDM.



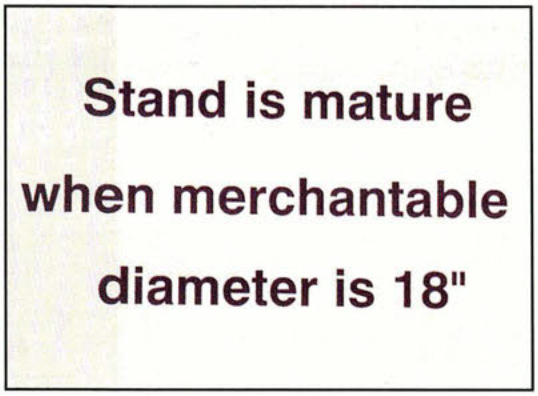
Overstory Factors	
Sapling basal area	11
Shade tolerant basal area	40
Relative stand density	97
Relative density AGS	63
Stand diameter (MD)	13.7
Merch. stand diameter (MDM)	14.5
Years to maturity	

106. Then record the values to one decimal place on the MD and MDM rows in the Overstory Factors section on the Prescription Summary worksheet.



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	

107. The final calculation is that for years to maturity. Our definition of stand maturity is based on many simulations of stand development, using an economic criteria of dollars per acre per year, or the culmination of mean annual increment of dollar value.

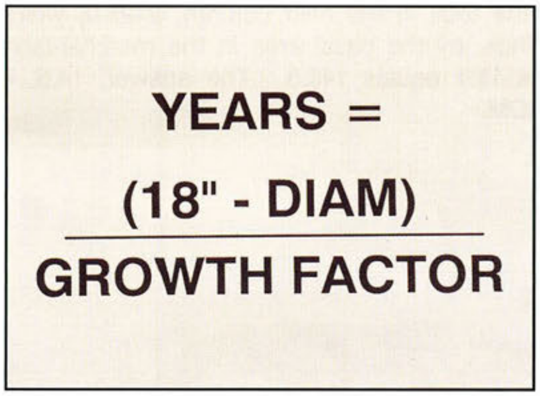


Stand is mature

when merchantable

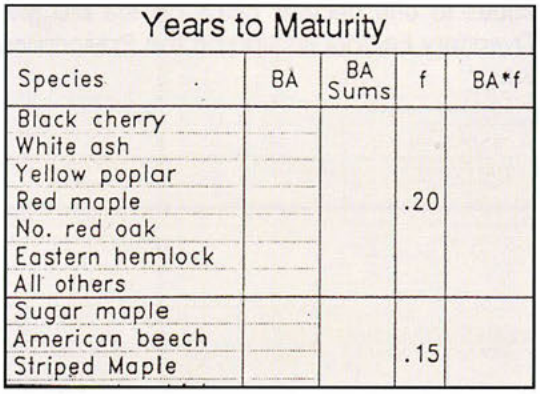
diameter is 18"

108. With this criteria, most Allegheny hardwood stands reach maturity when the medial diameter of the merchantable portion of the stand reaches 18 inches.



$$\text{YEARS} = \frac{(18'' - \text{DIAM})}{\text{GROWTH FACTOR}}$$

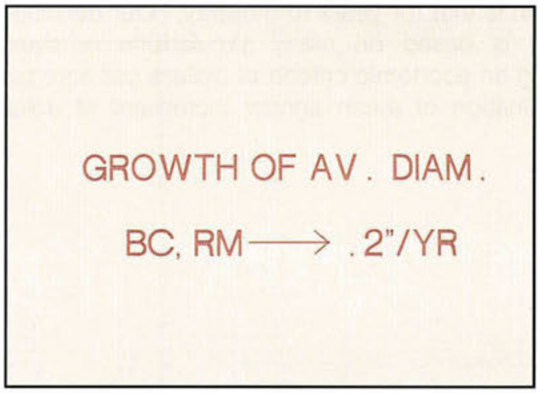
109. Years to maturity is an estimate of how long it will take the stand to reach that point. To make this estimate, we need to know the present merchantable diameter and something about the rate at which that diameter increases. We have used growth data from some 200 plots to develop an equation that will estimate years until MDM equals 18 inches.



Years to Maturity

Species	BA	BA Sums	f	BA*f
Black cherry			.20	
White ash				
Yellow poplar				
Red maple				
No. red oak				
Eastern hemlock				
All others				
Sugar maple			.15	
American beech				
Striped Maple				

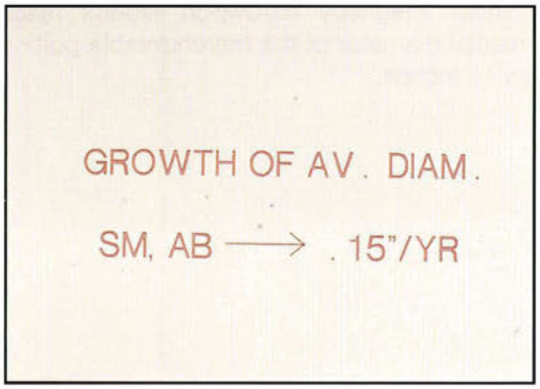
110. Calculate years to maturity in that section in the upper left corner of the Prescription Summary worksheet.



GROWTH OF AV. DIAM.

BC, RM ⟶ .2"/YR

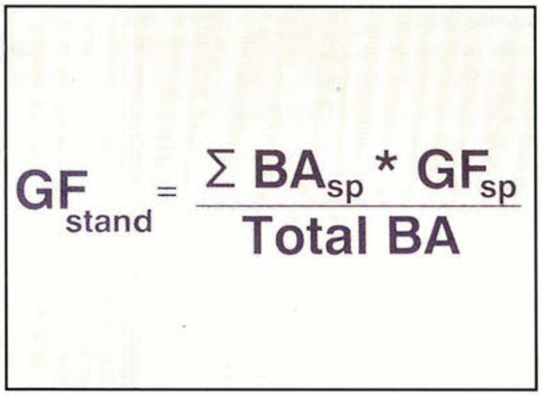
111. The rate of average diameter growth for species in the black cherry and red maple groups is about 0.2 inches per year. This is an increase in average diameter, which comes about both through the growth of living trees and through the mortality of the smaller ones.



GROWTH OF AV. DIAM.

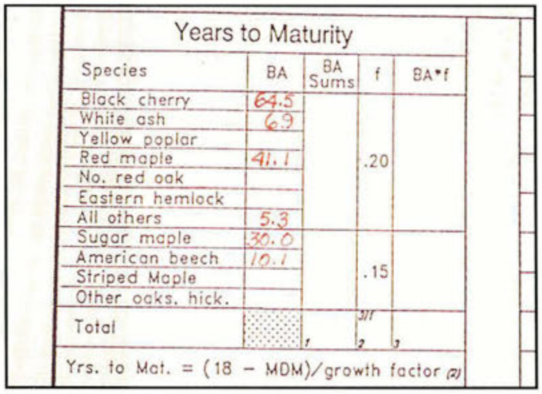
SM, AB ⟶ .15"/YR

112. The rate of average diameter growth for species in the sugar maple/American beech group is about 0.15 inches per year. Both of these factors are recorded in the factor columns of the Years to Maturity section.



$$GF_{stand} = \frac{\Sigma\, BA_{sp} * GF_{sp}}{\text{Total BA}}$$

113. Use the Years to Maturity formula to calculate the years to maturity for each individual species group, or use a weighted average growth rate, reflecting the species composition of the entire stand, and calculate the years to maturity for the stand as a whole. This weighted average growth factor equals the basal area in each species group times its appropriate growth factor, divided by the total basal area of the stand. The answer will always be between 0.15 and 0.2.

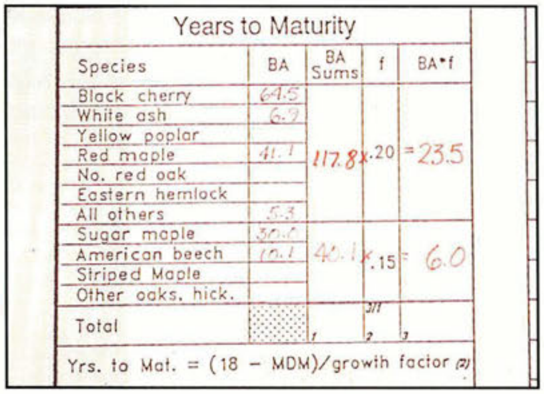


Years to Maturity

Species	BA	BA Sums	f	BA*f
Black cherry	64.5			
White ash	6.9			
Yellow poplar				
Red maple	41.1		.20	
No. red oak				
Eastern hemlock				
All others	5.3			
Sugar maple	30.0			
American beech	10.1		.15	
Striped Maple				
Other oaks, hick.				
Total		1	3/1 2	3

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

114. To determine the answer for the sample stand, record the basal area from each species or species group in the first column of this section. Be sure to include saplings here.

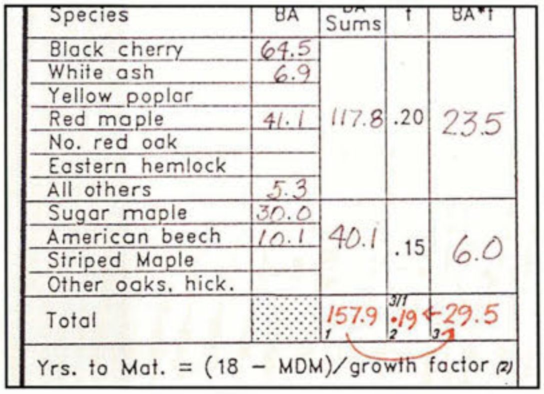


Years to Maturity

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		1	3/1 2	3

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

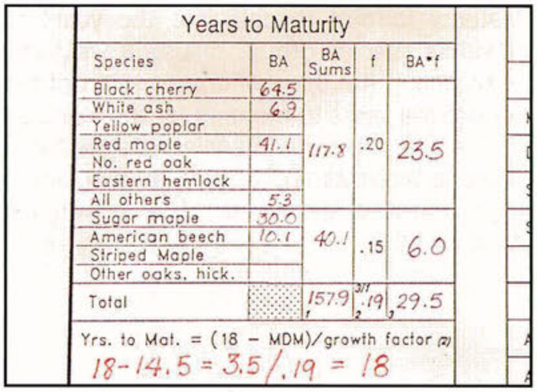
115. Subtotal the basal area by the two species groups in the BA sums column. Multiply each subtotal by the appropriate growth factor and record the product in the BA*f column.



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 1	3/1 .19 2	29.5 3

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

116. Sum these products and divide by the total basal area to determine the weighted average growth factor for the stand: 0.19.



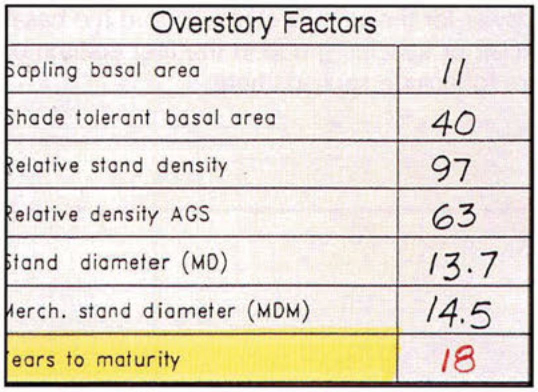
Years to Maturity

Species	BA	BA Sums	f	BA*f
Black cherry	64.5	117.8	.20	23.5
White ash	6.9			
Yellow poplar				
Red maple	41.1			
No. red oak				
Eastern hemlock				
All others	5.3			
Sugar maple	30.0	40.1	.15	6.0
American beech	10.1			
Striped Maple				
Other oaks, hick.				
Total		157.9 1	3/7 .19 2	29.5 3

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

18-14.5 = 3.5/.19 = 18

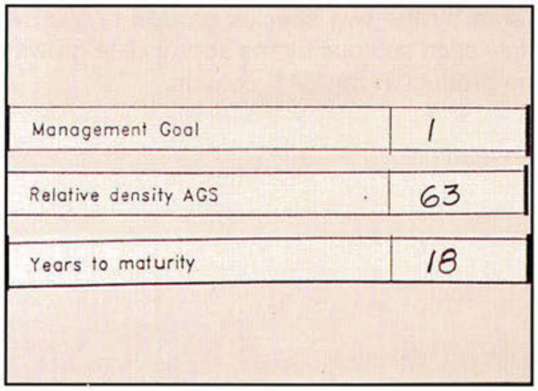
117. The diameter of the merchantable portion of the stand, MDM, is 14.5 inches. With 3.5 inches in merchantable diameter to grow to stand maturity, at a rate of 0.19 inches per year, we anticipate that this stand will mature in about 18 years.



Overstory Factors

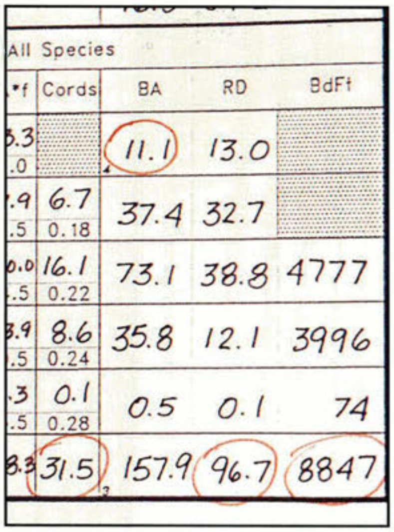
Sapling basal area	11
Shade tolerant basal area	40
Relative stand density	97
Relative density AGS	63
Stand diameter (MD)	13.7
Merch. stand diameter (MDM)	14.5
ears to maturity	18

118. The transfer of this value to the years to maturity row of the Prescription Summary worksheet (Appendix 5) completes the list of prescription variables for this stand. Now we are ready to determine the prescription.



Management Goal	1
Relative density AGS	63
Years to maturity	18

119. What is this prescription? The prescription selection process is described in another chapter. For this stand with a management goal of 1, 63 percent acceptable growing stock, and 18 years to maturity, we are considering intermediate treatments under an even-age silvicultural system.



All Species

f	Cords	BA	RD	BdFt
.3 .0	▨	11.1	13.0	▨
.9 .5	6.7 0.18	37.4	32.7	▨
.0 .5	16.1 0.22	73.1	38.8	4777
.9 .5	8.6 0.24	35.8	12.1	3996
.3 .5	0.1 0.28	0.5	0.1	74
.3	31.5	157.9	96.7	8847

120. The stand's relative density exceeds 80 percent and its sapling basal area is less than 20 square feet, so a commercial thinning should be quite feasible in this stand. In fact, with a board-foot volume of approximately 9,000 board-feet or more than 30 cords, this thinning should make quite an attractive sale.

Prescription:

COMMERCIAL THINNING

121. Thus, the prescription is for a commercial thinning.

- CONCEPTS THE SAME
- PROCESSING MUCH EASIER

122. We hope that this material has helped you understand the processing "inside" the computer program. All of the calculations that I have described are basically what happens--with lightning speed--inside a computer running the SILVAH program. All you have to do is give the program some good data. By going through the calculations by hand once or twice, you really can "see through" the case of your computer to understand the calculations that are being made.

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APPENDIX 1

SILVAH - Computer Overstory Tally Form

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

Overstory Data

Stand ID COMP 171, STAND 123 **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				
R'M	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			

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

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*

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

*BA = Dots * Conversion factor*

APPENDIX 3

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			0.76			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	0.5	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 4	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	1/(3-4) 14.5	2/3 13.7	2125.0 1	2158.3 2	31.5	157.9 3	96.7	8847

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		4		
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		

APPENDIX 4

SILVAH - ID & Regen Tally Form

Identification Data

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

Sheet 1 of 2

Owner/Agency: USFS
Forest/Property: KANE EXP FOREST
County/District: ELK
Compartment/Unit: 171 Stand No. 23
Remarks: P. 1 REGEN DATA
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

(38 plots)

	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		
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																						
5 Large oak																						
6 Any small regen 1, 2, 4, or 5																						
7 Residuals				SM					SM													
8 Any regen or Res. 6 or 7																						
9 Sapling regen																						
10 Woody interference	12		5							8	5	9	25									
11 Laurel & Rhododendron																						
12 Ferns	5	5		25	30	15		5	10	15	20	30	40	50		10	5		15	20		
13 Grasses																						
14 Any intrfr. 10, 11, 12, or 13																						
15 Grapevines																						
16 Site limitations																						

SILVAH - ID & Regen Tally Form

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

Identification Data

Sheet 2 of 2

Owner/Agency	USFS
Forest/Property	KANE EXP FOREST
County/District	ELK
Compartment/Unit	171 Stand No. 23
Remarks	P2 REGEN DATA - ID ON P. 1
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

		21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	19	20	#	%
1	Black cherry	30	50	20	25		10	20	10	5	10		50	75	90	80			25				
2	Small oak																						
3	Other desirables	20	40	5			5	15	5	5			10	30	75	50			15				
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	5					2			8	10	5											
11	Laurel & Rhododendron																						
12	Ferns		25	10	5			5	20	10						10	10	10	10				
13	Grasses																						
14	Any intrfr. 10, 11, 12, or 13																						
15	Grapevines																						
16	Site limitations																						

SILVAH - ID & Regen Tally Form

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

Identification Data

Sheet 2 of 2

Owner/Agency	USFS							
Forest/Property	KANE EXP FOREST							
County/District	ELK							
Compartment/Unit	171	Stand No.	23					
Remarks	EXAMPLE OF SUMMARIZED FORM							
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

(38 plots)

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	19	20	#	%
1 Black cherry	30	50	20	25		10	20	10	5	10		50	75	90	80			25			18	47
2 Small oak																						
3 Other desirables	20	40	5			5	15	5	5			10	30	75	50			15				
4 All desirables 1+2+3	50	90	25	25		15	35	15	10	10		60	105	165	130			40			5	13
5 Large oak																						
6 Any small regen 1, 2, 4, or 5	✓	✓		✓								✓	✓	✓	✓			✓			19	50
7 Residuals																					2	5
8 Any regen or Res. 6 or 7	✓	✓		✓								✓	✓	✓	✓			✓			20	53
9 Sapling regen																						
10 Woody interference	5					2			8	10	5										2	5
11 Laurel & Rhododendron																						
12 Ferns		25	10	5			5	20	10						10	10	10	10			4	11
13 Grasses																						
14 Any intrfr. 10, 11, 12, or 13																					5	13
15 Grapevines																						
16 Site limitations																						

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 intrfr. 10, 11, 12, or 13																						
15 Grapevines																						
16 Site limitations																						

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	117.8	.20	23.5
White ash	6.9			
Yellow poplar				
Red maple	41.1			
No. red oak				
Eastern hemlock				
All others	5.3			
Sugar maple	30.0	40.1	.15	6.0
American beech	10.1			
Striped Maple				
Other oaks, hick.				
Total	▨	157.9 $_1$	$^{3/1}$ .19 $_2$	$_3$ 29.5

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

$(18-14.5)/0.19 = \frac{3.5}{0.19} \div 18$

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	▨	▨	$_4$ 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	10.1
Eastern hemlock	
Total	40.1

Oak Stump Sprouting

BA*f

Species	Size	BA	f	Sprouting stumps
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	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	79
Any regen or residuals – no deer	79
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

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			.15	
Striped Maple				
Other oaks, hick.				
Total		1	3/1 2	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	46	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:

Appendix 6A. Growing Stock Quality Class Definitions

Code	Definition
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 a larger size, so most saplings are 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.

Appendix 6B.

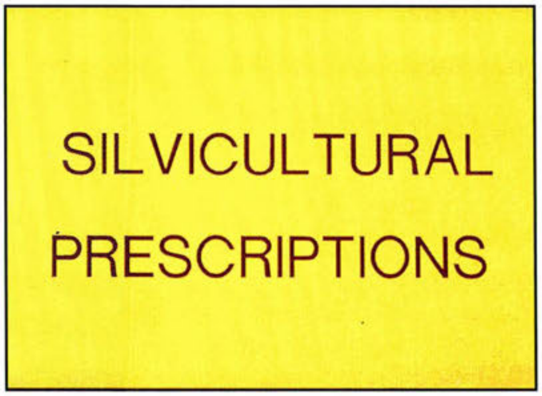
Deer Impact Index	Advance Regen Species Group				
	Black Cherry	Small Oak	Other Desirable Species	All Desirable Species	Large Oak
	Weighted no. per plot				
5	50	60	200	200	1
4	25	40	100	100	1
3	20	30	50	50	1
2	15	20	30	30	1
1	10	10	15	15	1

Appendix 6C.

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

Development of a Silvicultural Prescription

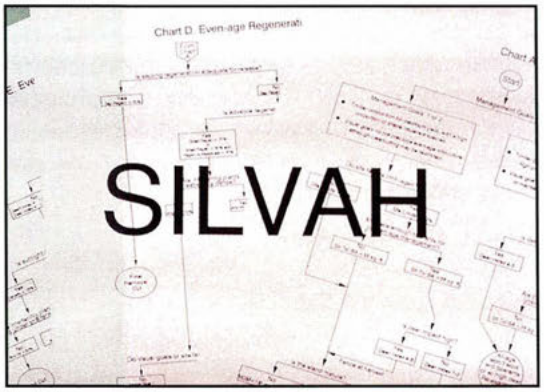
Richard L. Ernst



SILVICULTURAL

PRESCRIPTIONS

1. Once the overstory and understory conditions in a stand are known, you can decide on the best treatment in the stand. The process of deciding the best treatment based on current stand conditions is known as writing a silvicultural prescription.



SILVAH

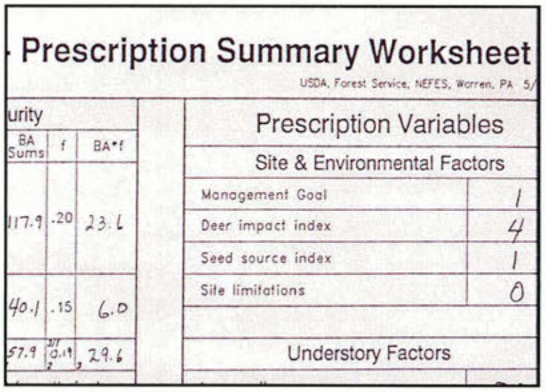
2. The SILVAH system is a set of tools or guidelines that helps the practicing forester decide on a forest stand treatment. It is fully described in "Prescribing Silvicultural Treatments in Hardwood Stands of the Alleghenies (Revised)" by Marquis, Ernst, and Stout (1992). The charts described here and reproduced in Appendix A are from that handbook.

INVENTORY

ANALYSIS

PRESCRIPTION

3. SILVAH has three main steps: inventory, analysis, and prescription. The inventory phase is described by Redding in the article "Stand Examination Procedures", and the analysis phase is described by Stout in the article "Stand Data Summary and Analysis". This article deals with the last of these three steps, the stand prescription process.



Prescription Summary Worksheet

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

urity

BA Sums	f	BA*f
117.9	.20	23.6
40.1	.15	6.0
57.9	0.19	29.6

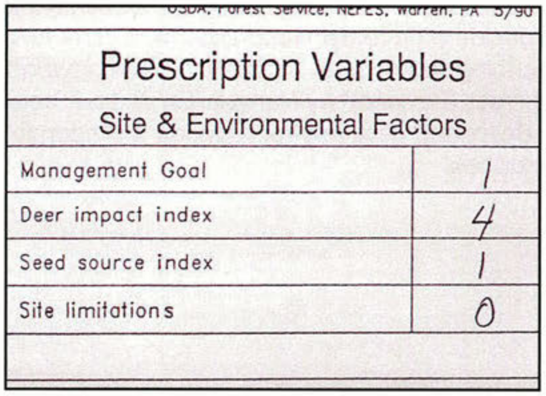
Prescription Variables	
Site & Environmental Factors	
Management Goal	1
Deer impact index	4
Seed source index	1
Site limitations	0
Understory Factors	

4. All the information needed to write a prescription is obtained during stand inventory and analysis, and (if done without a computer) is recorded on the Prescription Summary Worksheet (Appendix B).

DECISION

CRITERIA

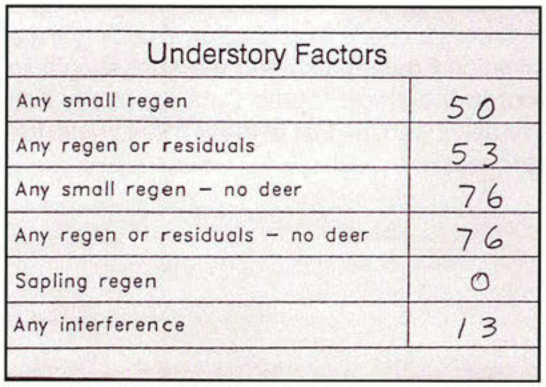
5. The decision criteria summarized on the Prescription Summary Worksheet can be placed conveniently into three groups.



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

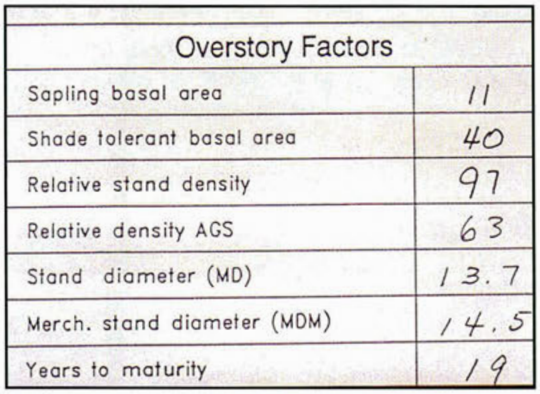
Prescription Variables	
Site & Environmental Factors	
Management Goal	1
Deer impact index	4
Seed source index	1
Site limitations	0

6. The first group of factors includes the site conditions and management objective. These factors may place some restrictions on the types of cutting that are appropriate. For example, the landowner may wish to avoid particular types of cutting for aesthetic reasons, or a large deer herd or poor soil drainage may make regeneration difficult.



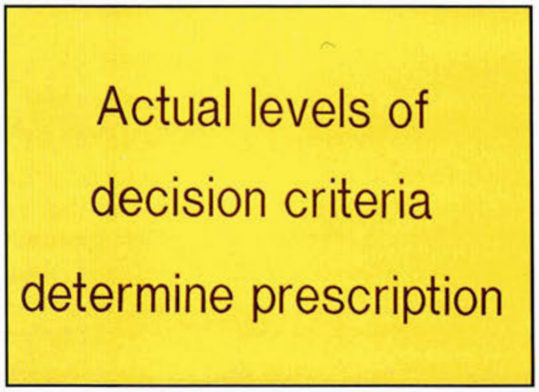
Understory Factors	
Any small regen	50
Any regen or residuals	53
Any small regen – no deer	76
Any regen or residuals – no deer	76
Sapling regen	0
Any interference	13

7. The next group of factors includes understory vegetation. We need to be aware of factors that both aid and hinder regeneration. For example, we need to know if there is enough advance regeneration to establish the next stand if this one is harvested, or if there are interfering plants present that can hinder establishment. These factors suggest what should be done to ensure successful regeneration.



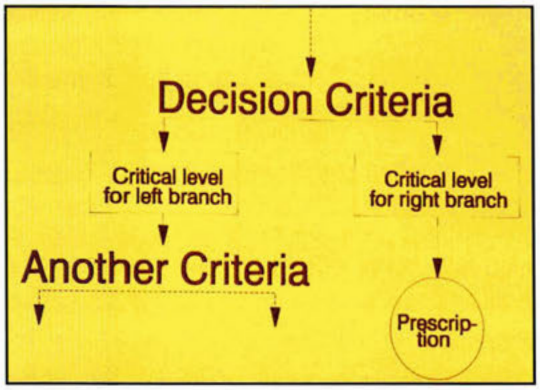
Overstory Factors	
Sapling basal area	11
Shade tolerant basal area	40
Relative stand density	97
Relative density AGS	63
Stand diameter (MD)	13.7
Merch. stand diameter (MDM)	14.5
Years to maturity	19

8. The last group includes the overstory conditions. These criteria provide information on stage of development of the stand, and indicate whether partial cutting or final harvesting is desirable at present.



Actual levels of decision criteria determine prescription

9. Different levels of decision criteria lead to different prescriptions. For example, we would not want to harvest a stand if there were not enough advance seedlings to establish a new stand. We would not want to thin in a stand that did not have enough material to support a cut without ruining the future value of the stand. By examining the stand, then looking at the levels of the decision criteria for that stand, we can decide on a course of action. Here we describe how to systematically look at these overstory and understory conditions when writing a prescription.



Decision Criteria

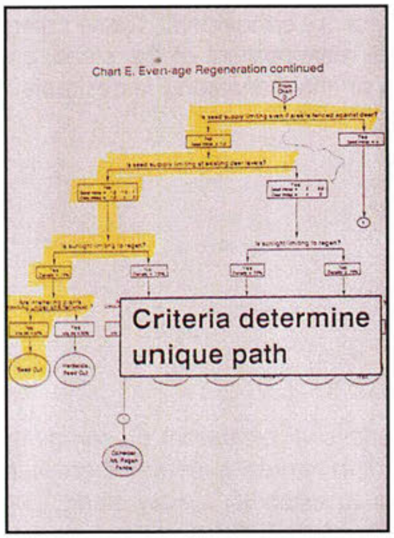
Critical level for left branch

Critical level for right branch

Another Criteria

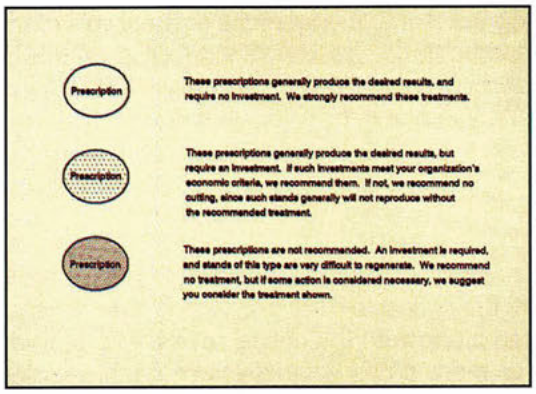
Prescrip-tion

10. The prescription process involves comparing each of the decision criteria with the critical level of that factor. The decision criteria are organized along with the critical levels into decision charts where two or more paths emanate from each decision point. The criterion is printed above the line, and the path is chosen by comparing the sample stand value to the critical levels in the boxes on either path. Each path can lead to another decision criteria branch, or may terminate with a prescription indicated by an oval.



Criteria determine unique path

11. To determine the prescription, trace a path through the chart comparing stand values with critical levels, then follow the indicated path until you reach one of the ovals, or prescriptions.



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, since such 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.

12. Note the prescription legend on chart B; it applies to all of the charts. The unshaded ovals represent prescriptions that we strongly recommend. The lightly shaded ovals represent treatments that require an investment. We believe these investments to be necessary to achieve management objectives. If the investment is considered unprofitable by your organization, we recommend that no cutting be done in these stands. The heavily shaded ovals are problem situations that require considerable investment; even with such investments, the desired results may not be obtained. We recommend postponing treatment of these stands, but list these prescriptions if you find it necessary to proceed with a treatment.

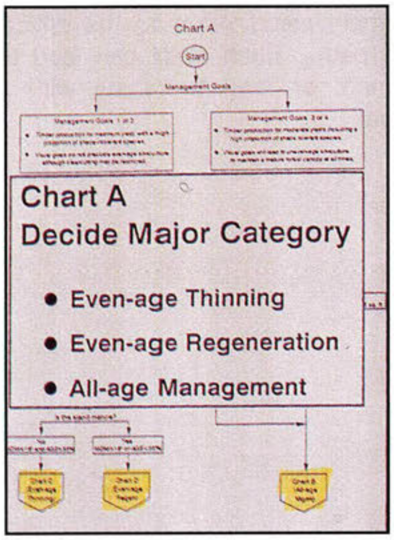
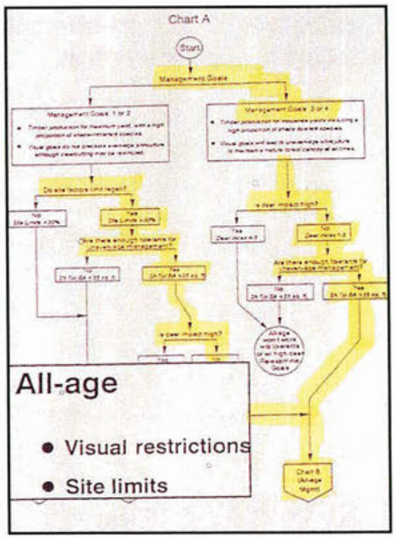


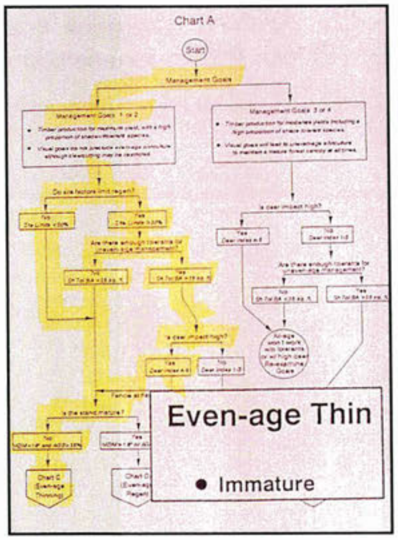
Chart A
Decide Major Category

- Even-age Thinning
- Even-age Regeneration
- All-age Management

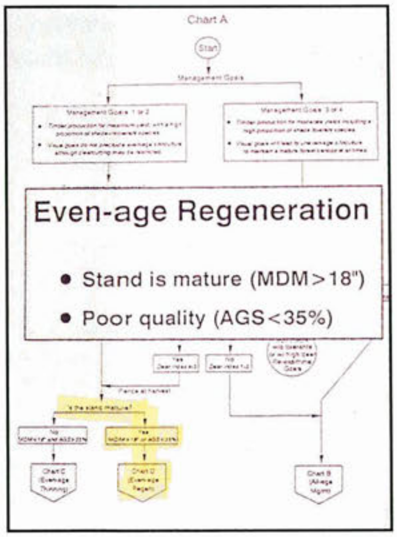
13. There are three major categories of prescriptions with a chart for each. The general categories are all-age management, even-age regeneration, and even-age thinning. Chart A is used to determine which of these major categories of prescription is appropriate, thus, it directs you to the proper prescription chart.



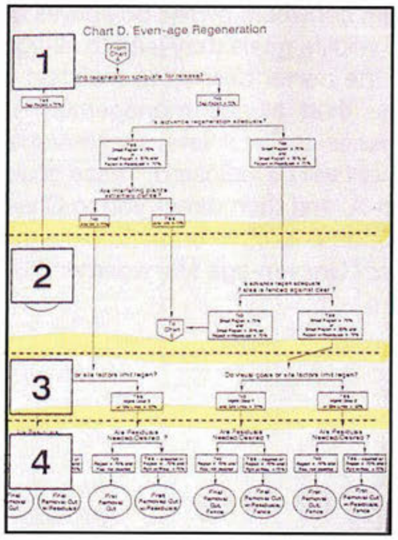
14. In Chart A, the first decision point considers owner objectives or management goals. Visual and wildlife goals may lead to all-age management. For example, if the owner desires to maintain a high forest cover at all times, then all-age management is indicated. Or, if the owner wishes to favor late successional wildlife; again, all-age management will be indicated. These goals lead to the right branch in Chart A, and then direct you to Chart B, uneven-age management. Chart B is covered in detail in the article "Principles and Practices of Uneven-age Management" by Stout.



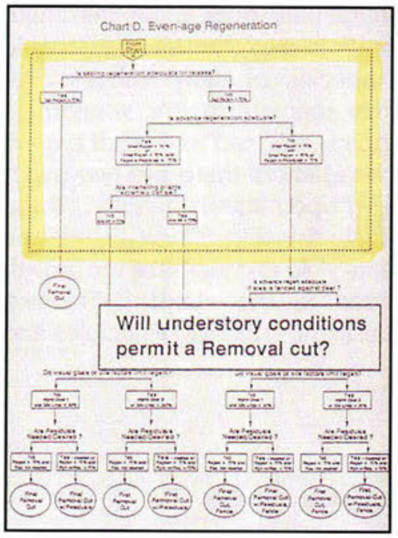
15. If, on the other hand, the management goal is for maximum timber production, a high proportion of intolerant species, a wide variety of wildlife, or wildlife species of early successional vegetation, then an even-age management regime would best meet those objectives. These goals will lead to the left branch in Chart A. Under even-age management there are two major types of prescriptions, depending upon stand maturity. If the stand is immature an intermediate thinning (Chart E) may be appropriate to provide intermediate yield and increase the growth rate on the larger, better trees in the stand. Thinning prescriptions are covered in detail in the "Thinning Principles and Practices" article by Marquis.



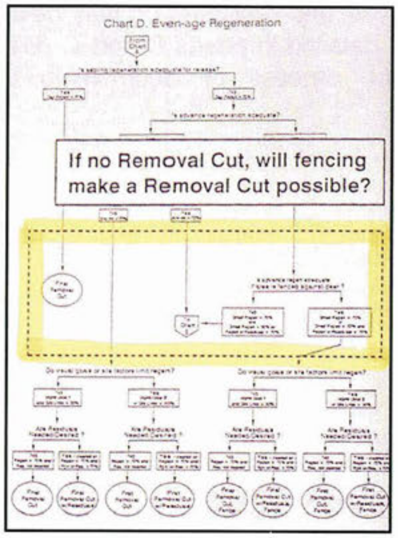
16. If the stand is mature, then harvest and regeneration may be in order. These prescriptions are detailed in charts D and E. We use chart D to illustrate the process of determining a prescription.



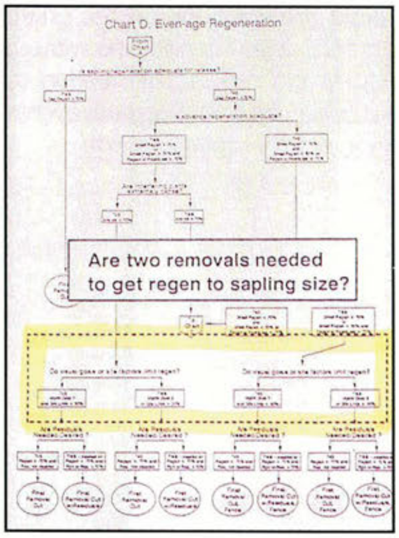
17. We can subdivide chart D into zones that deal with different aspects of determining a regeneration/harvest prescription.



18. In zone 1, consider advance regeneration to determine if a removal cut is feasible. There must be established regeneration without a severe problem of competing vegetation.

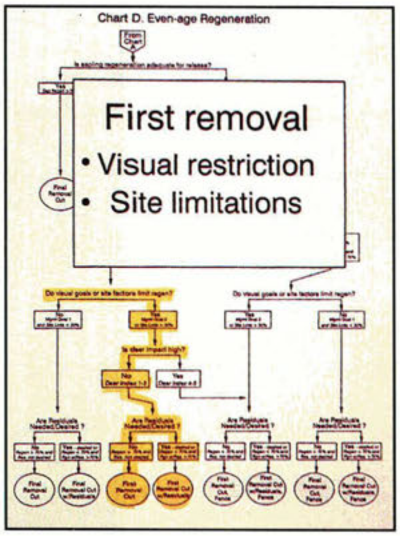


19. In zone 2, if a removal cut is not feasible with current conditions, consider whether it might be if deer browsing was eliminated by fencing the stand.



Are two removals needed to get regen to sapling size?

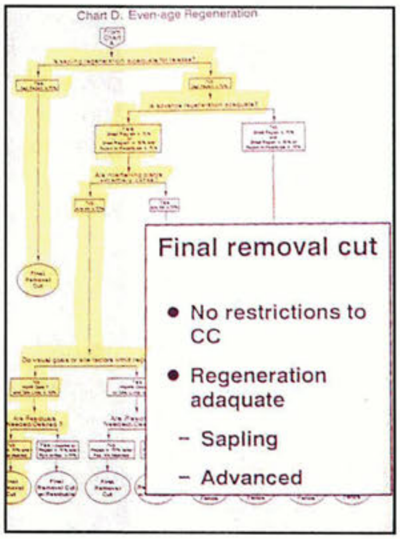
20. In zone 3, if a removal cut is appropriate, consider the need to make the removal over an extended period to bring the advance seedlings to sapling size. Large regeneration may be desirable because of visual objectives or site limitations.



First removal

- Visual restriction
- Site limitations

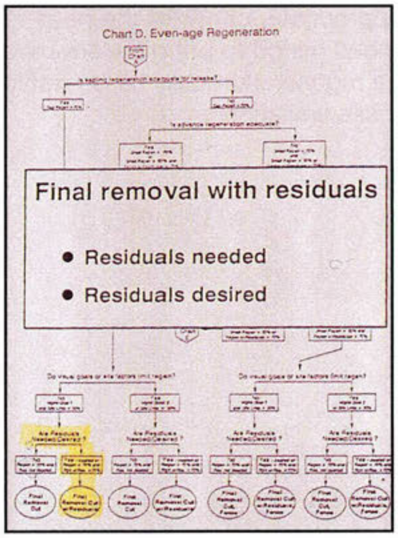
21. And finally, in zone 4, consider retention of residuals as part of the harvest, either out of necessity, or because they are desirable. Reconsider deer impact in this zone, too.



Final removal cut

- No restrictions to CC
- Regeneration adaquate
  - Sapling
  - Advanced

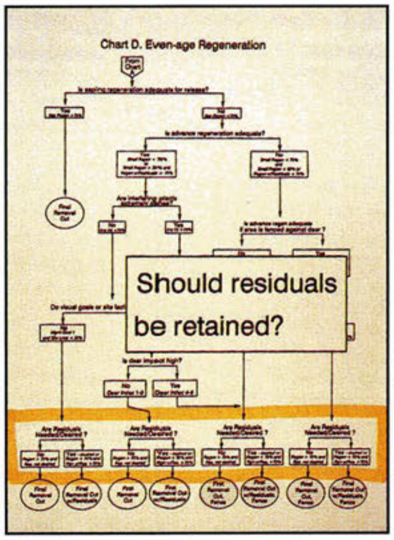
22. Keeping these general zones in mind, look at the individual prescriptions in chart D. Notice that all of the prescriptions deal with removal cuts. The final removal cut, or clearcut is appropriate if adequate sapling regeneration is already present, or advance regeneration is adequate, and there are few interfering plants and few visual or site limitations.



Final removal with residuals

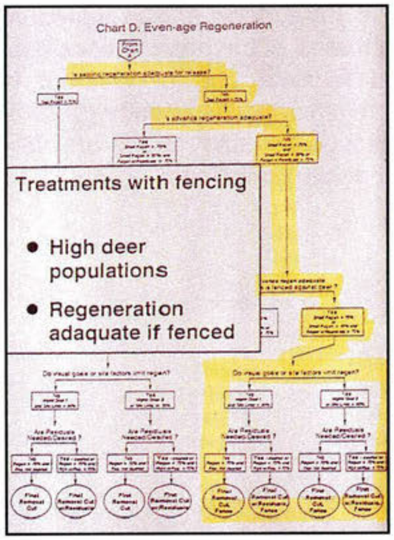
- Residuals needed
- Residuals desired

23. Notice that although there are eight prescriptions on the chart, they represent four pairs of treatments, one with and one without residuals being retained. Residuals are retained if needed to have sufficient numbers of plots stocked, or if your organization's policy required retaining tolerant species in these stands.



Should residuals be retained?

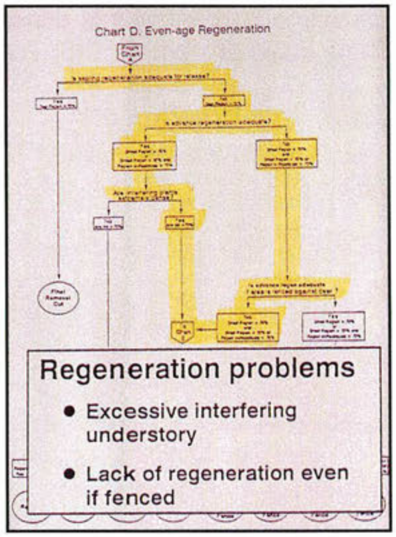
24. Visual restrictions or site limitations would lead to a similar pair of harvest prescriptions, but done over two cuts rather than one. The first removal cut allows the advance regeneration to grow to sapling size before the final removal cut, ameliorating the harsh look of a clearcut for visually sensitive areas, or ensuring establishment of vigorous saplings for either poorly drained or rocky sites. Thus, the prescription now is a first removal cut, rather than final removal. As before, the first harvest may include retention of residuals if they are needed or desired. A first removal cut is usually part of a three-cut shelterwood sequence where the seed cut was made previously, and the advance regeneration is already established. If deer impact is high, fencing will be part of this prescription.



Treatments with fencing

- High deer populations
- Regeneration adaquate if fenced

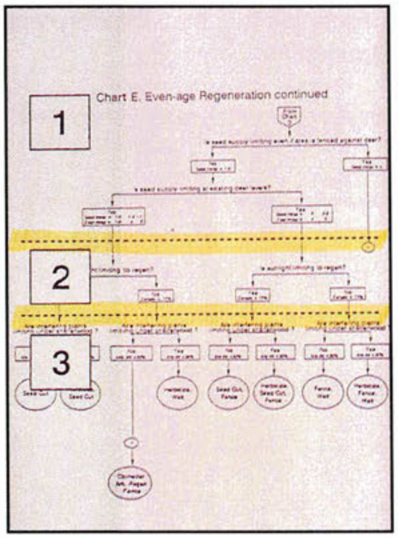
25. Another set of four prescriptions similar to the two final removals, and two first removals just discussed would be obtained if neither sapling regen nor advance regen were adequate at the existing deer level but were adequate at low deer. This leads down the right path in chart D to four prescriptions that are identical to the four just identified with the exception of fencing. Note that the ovals containing these prescriptions are lightly shaded, which indicates an investment, and all cautions regarding these prescriptions should be considered.



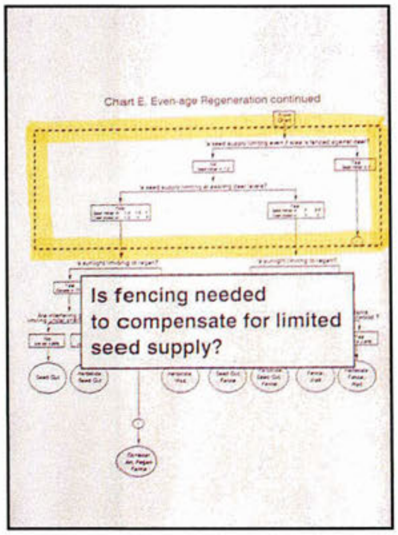
Regeneration problems

- Excessive interfering understory
- Lack of regeneration even if fenced

26. The final path in chart D includes stands that do not have sapling regeneration, and that have either adequate advance regeneration with excessive numbers of interfering plants or inadequate advance regeneration even if fenced to exclude deer browsing. These conditions lead to chart E.



27. As with chart D, chart E can be divided into several zones.



Is fencing needed to compensate for limited seed supply?

28. In zone 1, consider the need for fencing to compensate for situations where the combination of limited seed supply and high deer population make establishment of new seedlings difficult.

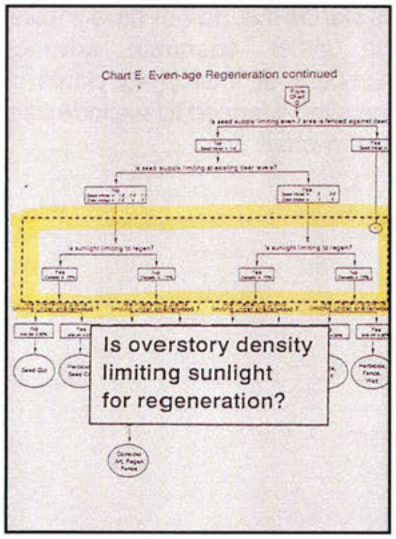


Chart E. Even-age Regeneration continued

Is overstory density limiting sunlight for regeneration?

29. In zone 2, consider overstory density and whether it is dense enough to limit sunlight for seedling establishment.

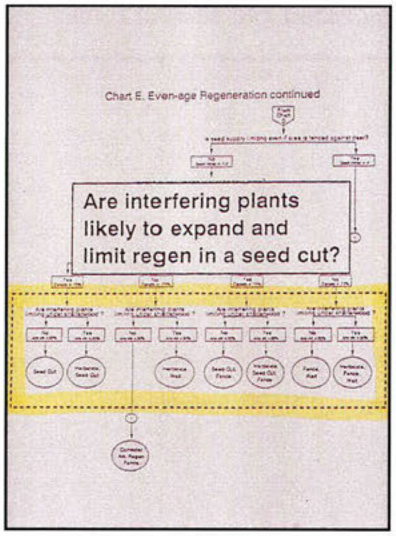


Chart E. Even-age Regeneration continued

Are interfering plants likely to expand and limit regen in a seed cut?

30. In zone 3, consider understory vegetation that may interfere with the establishment of advance regeneration.

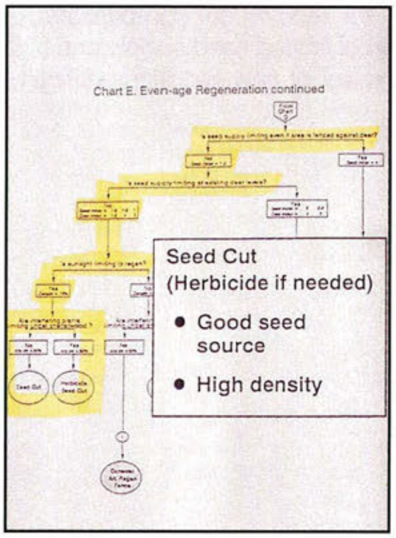
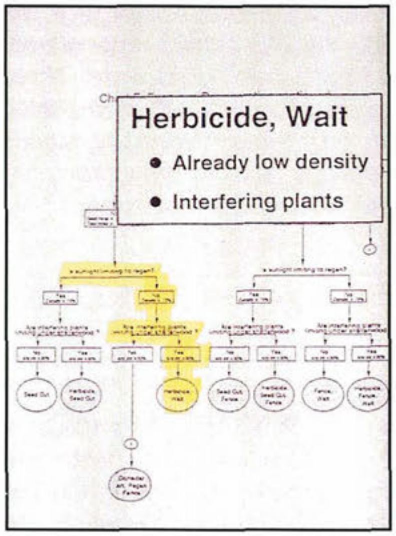


Chart E. Even-age Regeneration continued

Seed Cut
(Herbicide if needed)

- Good seed source
- High density

31. If sunlight is the only limiting factor, then a shelterwood sequence is appropriate to open the canopy.



Herbicide, Wait

- Already low density
- Interfering plants

32. If an interfering understory is a limiting factor, then an herbicide is appropriate to remove it. The herbicide is used in combination with a shelterwood seed cut if sunlight is also limiting, or by itself if sunlight is not limiting.

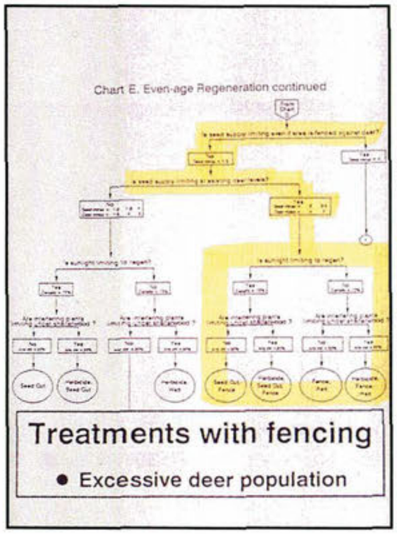


Chart E. Even-age Regeneration continued

Treatments with fencing

- Excessive deer population

33. Another major pathway in chart E concerns stands where seed supply is limiting at current deer levels, but would not be if the area were fenced. This produces a set of prescriptions that include fencing in addition to the previous combinations of shelterwood seed cut and herbicide.

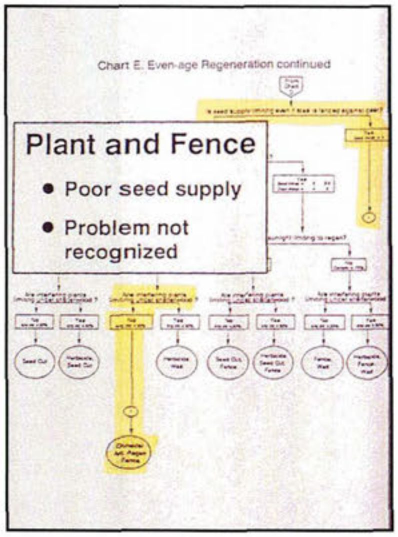


Chart E. Even-age Regeneration continued

Plant and Fence

- Poor seed supply
- Problem not recognized

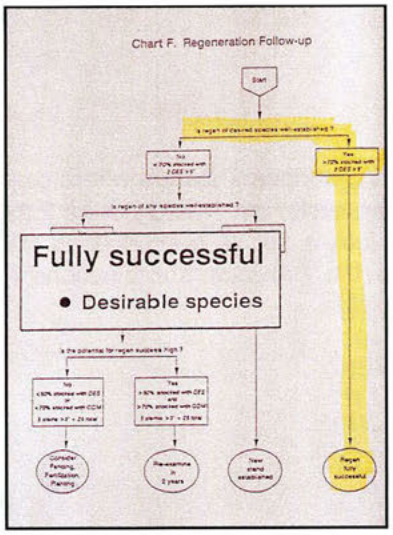
34. The final prescriptions in chart E are heavily shaded ones, one of which is shown here. The heavy shading identifies these prescriptions as ones you might consider, but ones that we do not advocate. They may or may not produce the desired result, and require a substantial investment.

There are two paths that lead to this prescription: stands where advance regeneration and seed supply are limiting even if fenced against deer, and stands where advance regeneration is inadequate even though sunlight, interfering plants, and seed supply do not seem limiting. In both situations, there may be some factor not identified in the SILVAH system that is limiting regeneration, and an attempt should be made to identify the cause of the problem first. Consider planting and fencing as a possible solution.

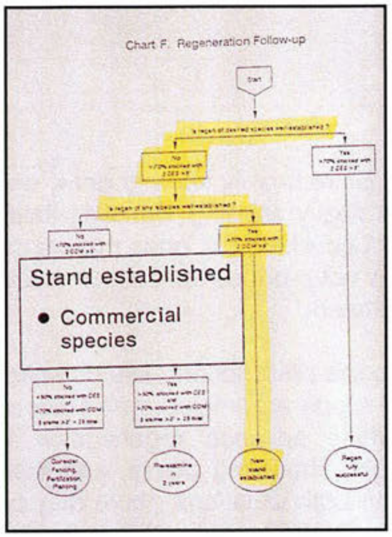
Regeneration follow-up

25 stems total
↓
5 stems over 3 ft.
↓
2 stems over 5 ft.

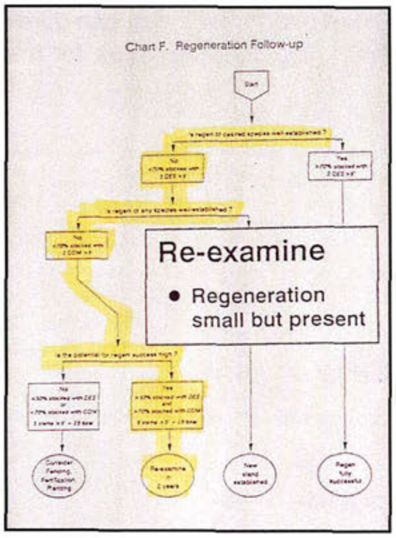
35. After a stand has had a final harvest, you should not forget it; the stand should be examined to see if it has indeed regenerated. Examinations 2 and 5 years after cutting are appropriate. Three criteria are evaluated on the 6-foot radius plots: 25 stems total, 5 stems over 3 feet, and 2 stems over 5 feet. Normally, stands start with large numbers of seedlings, and as they grow, the seedlings grow taller and number of seedlings decreases.



36. If the stand regenerates satisfactorily, it will take 5 to 10 years before 70 percent of the plots have two stems over 5 feet -- the measure we use to judge the regeneration complete. When that regeneration is of desirable species, then the regeneration can be considered fully successfully.



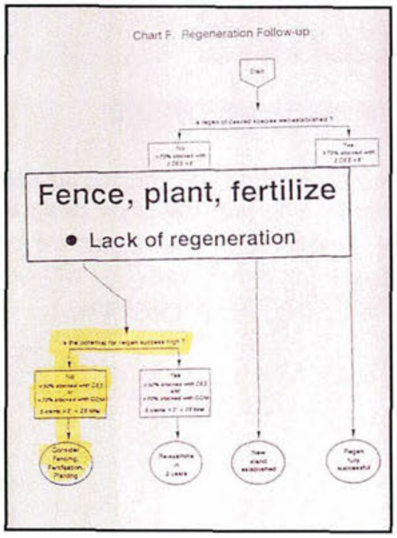
37. When 70 percent of the plots have two stems over 5 feet, but these are of other than the desired species, regeneration is complete but less than fully successful.



Re-examine

- Regeneration small but present

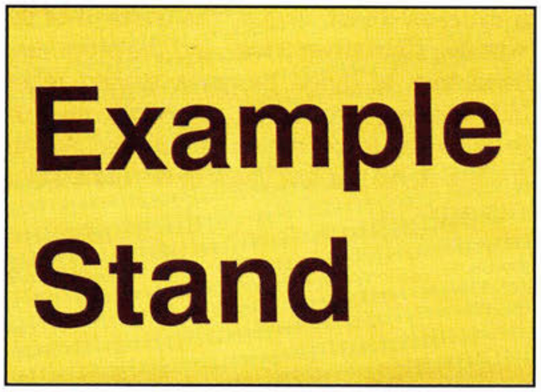
38. Before regeneration exceeds 5 feet, we use the average of the proportion of plots with five stems over 3 feet, and the proportion of plots with 25 stems total to judge progress toward regen establishment. If this average proportion is greater than 70 percent, the stand is on its way to becoming established. All you need do is re-examine the stand in a few years to ensure that the progress continues as expected.



Fence, plant, fertilize

- Lack of regeneration

39. If the average proportion of plots stocked is low, there is high probability that regeneration will not be fully successful. Fertilization, planting, or seedling protection may all be necessary to encourage the successful regeneration of the stand.

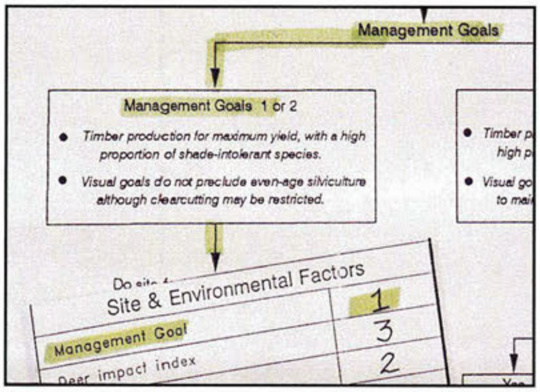


Example Stand

40. Now that we understand how these charts work, we can derive a prescription for a sample stand. The summary data for that stand are:

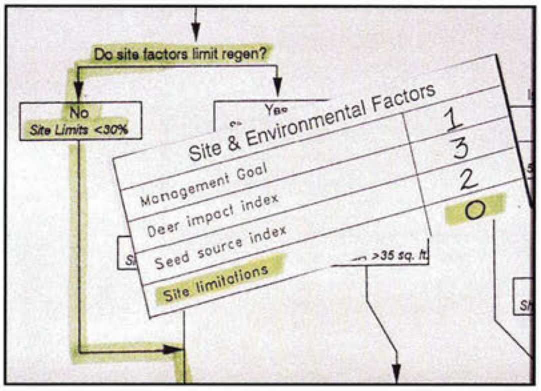
Site:	Management goal	1
	Deer impact index	3
	Seed Source Index	2
	Site limits	0
Understory:	Any regen	33
	Any w/residuals	40
	Any regen no deer	33
	Any w/residuals no deer	40
	Sapling regen	27
	Interfering plants	32
Overstory:	Sapling BA	7
	Basal area shade tolerants	58
	Relative stand density	91
	Density AGS	53
	Stand diameter	18.2
	Merchantable stand diameter	18.8
	Years to maturity	0

Use these values to step through the decision charts.

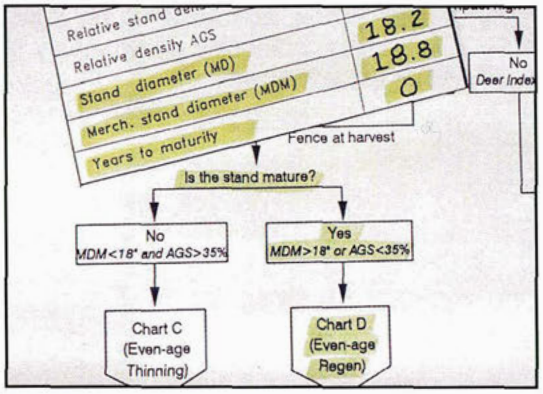


- *Timber production for maximum yield, with a high proportion of shade-intolerant species.*
- *Visual goals do not preclude even-age silviculture although clearcutting may be restricted.*

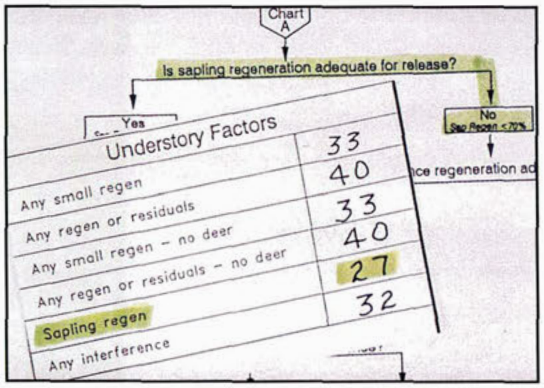
41. Chart A is used to determine which of the other charts to use (which major type of prescription). The first decision point in chart A is the management goal. A goal of 1 -- management for maximum timber yields of shade intolerant species without restrictions on clearcutting -- leads down the left branch.



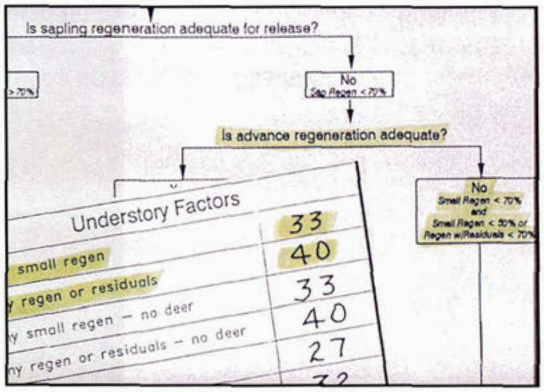
42. The left branch leads to a site limitations decision point. There are no site limitations for regeneration in this stand, which leads down the left branch again.



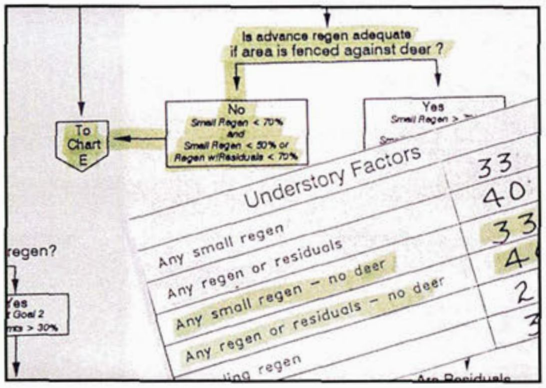
43. The next decision point concerns the stand's stage of maturity. The sample stand is mature, since the years to maturity is 0; that is, the merchantable diameter is greater than 18 inches. This leads down the right branch, which directs us to the even-age regeneration chart D.



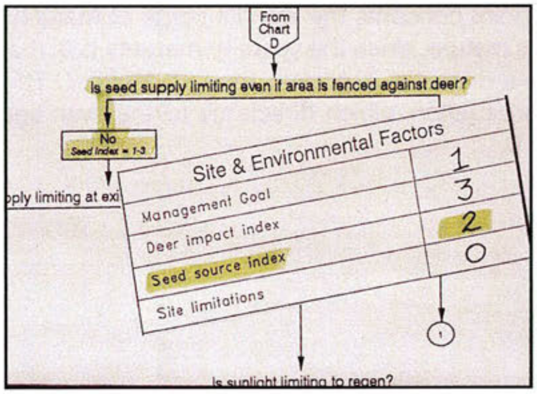
44. In chart D, the first decision point is the sapling regeneration. It is less than 70 percent in this stand, indicating that there is not a sapling understory ready for release. This leads down the right branch



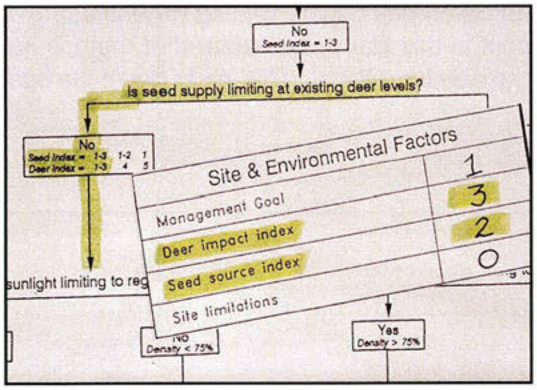
45. to a decision point on advance regeneration stocking. Only 33 percent of the plots are stocked with advance regeneration in this stand, and only 40 percent stocked if you include residuals. Since the advance seedlings are not adequate for final harvest, measures will need to be taken to increase them. This again leads down the right branch to



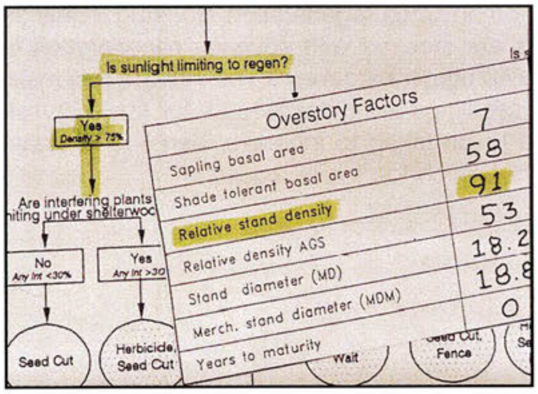
46. a decision point concerning the adequacy of advance regeneration if the stand is fenced against deer. In this stand, regeneration is not adequate even if fenced to exclude deer, which leads down the left branch to chart E.



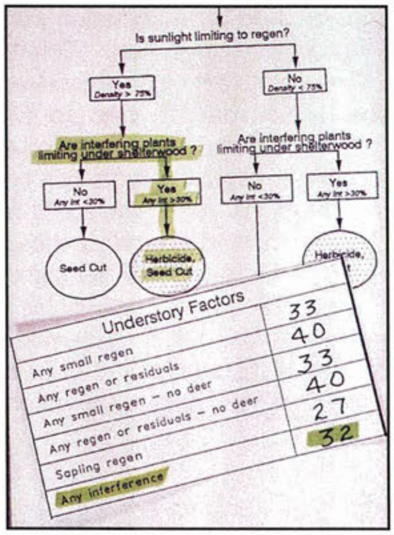
47. The first decision point in chart E concerns seed supply if the area is fenced. With a seed source index of 2, seed supply is not limiting, which leads down the left branch



48. to a decision point concerning the combination of deer level and seed supply. In the sample stand, deer impact index is 3 and seed source index is 2. The combination should not be limiting. This leads down the left branch

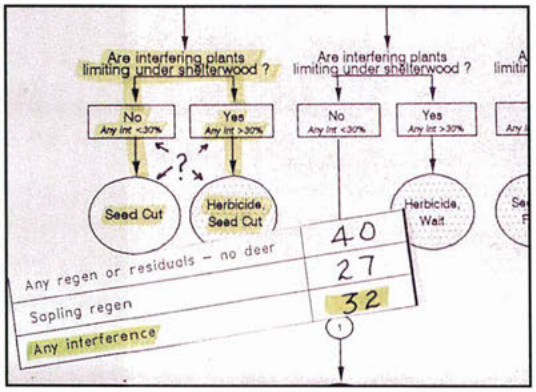


49. to a decision point concerning overstory density. In our sample stand, a density greater than 75 percent, sunlight would be limiting to the establishment of new seedlings. This leads down the left branch



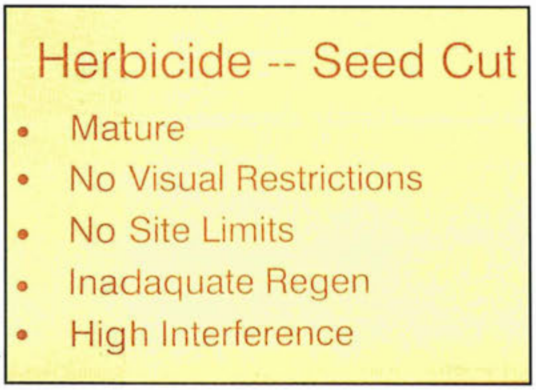
Understory Factors	
Any small regen	33
Any regen or residuals	40
Any small regen – no deer	33
Any regen or residuals – no deer	40
Sapling regen	27
Any interference	32

50. to the final decision point concerning interfering plants. In this stand, they are greater than 30 percent, so an herbicide will be needed to remove them. This leads down the right branch to a prescription of herbicide/shelterwood seed cut.



Any regen or residuals – no deer	40
Sapling regen	27
Any interference	32

51. When a stand value falls just above or below a breaking point consider both paths. Although the breaking points are stated precisely, no such precision is implied. For example, the difference between having 29 percent and 31 percent of the understory plots stocked with fern is not discernible. Yet, these two values send you down two different paths. It is important to understand what question is being considered at each breaking point, and why it is important. This, together with a knowledge of the stand will allow you to make an informed decision. In this situation, the two paths are both shelterwoods, one with an herbicide application, the other without. You will need to consider the need for herbicide carefully in this stand, since it is near the borderline for such treatments.



Herbicide -- Seed Cut

- Mature
- No Visual Restrictions
- No Site Limits
- Inadaquate Regen
- High Interference

52. The final prescription for this stand is an herbicide/seed cut of a shelterwood sequence. That is, this stand is mature and ready for final harvest. There are no restrictions on cutting or site limitations that would prevent a clearcutting. But, advance regeneration is inadequate to do the cutting, so we need to increase the number of advance seedlings. Furthermore, there is an abundance of interfering understory plants that would prevent establishment of the new seedlings, so we need to apply an herbicide before the shelterwood. In this way, we will decrease understory competition, and at the same time, encourage establishment of new regeneration.

GUIDES
assist
professional
judgment

53. These decision charts are guides to be used in combination with professional judgment to help you make a decision. Before using these decision charts, you must consider your objectives and the stand conditions. The guides should lead to an intuitively appropriate decision. If they do not, reconsider your path through the decision chart. Keep in mind the logic behind the flow charts; do not use or accept the recommendations without thinking. There are reasons for looking at each of those overstory and understory factors. By being aware of the stand conditions, and the "ideal" conditions necessary for establishing the next stand, you can properly treat the stand and avoid regeneration failures. Appendix C contains some data from a hypothetical stand that you may use to practice the prescription process described in this article.

SELECTED REFERENCES

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.

Chart A

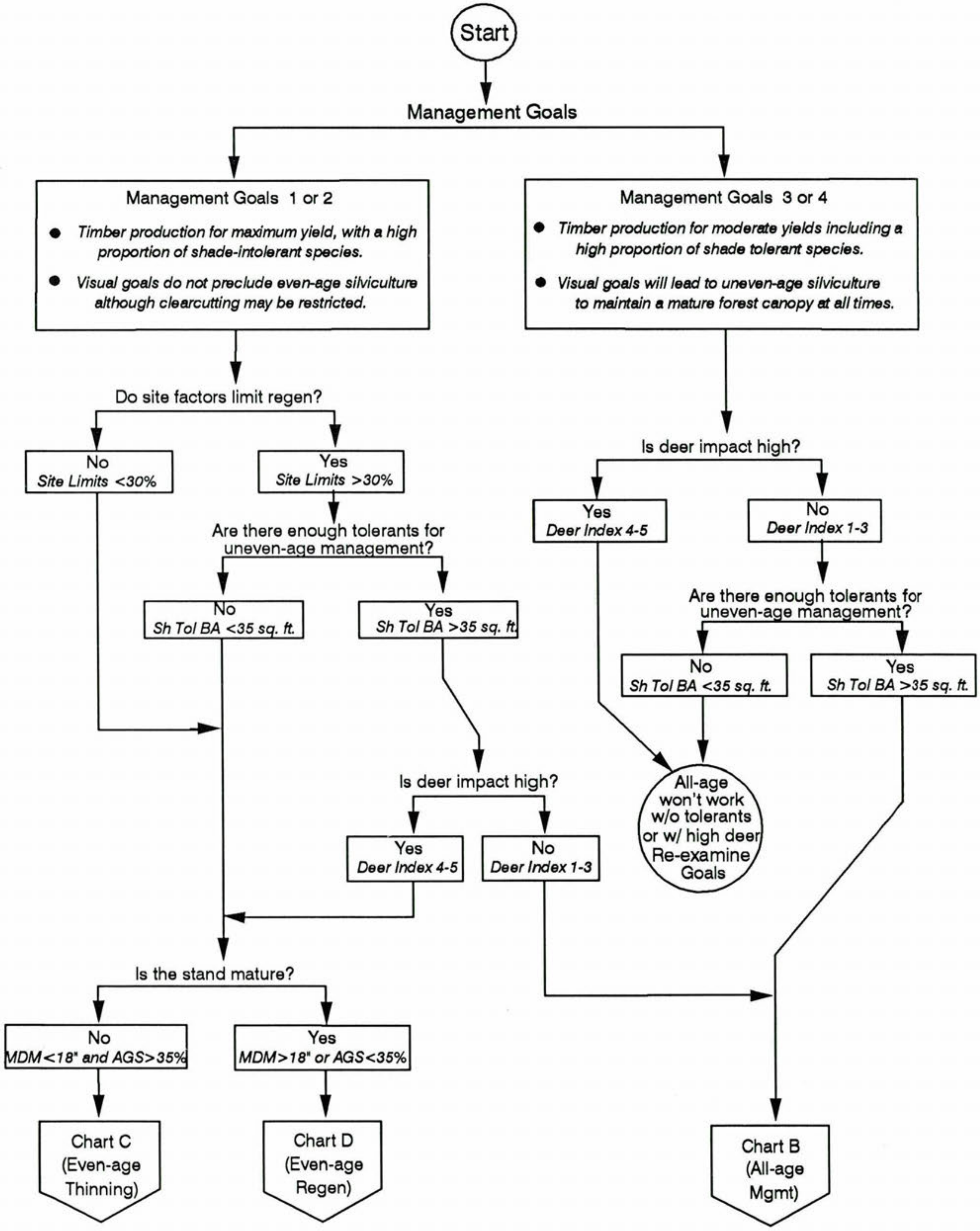
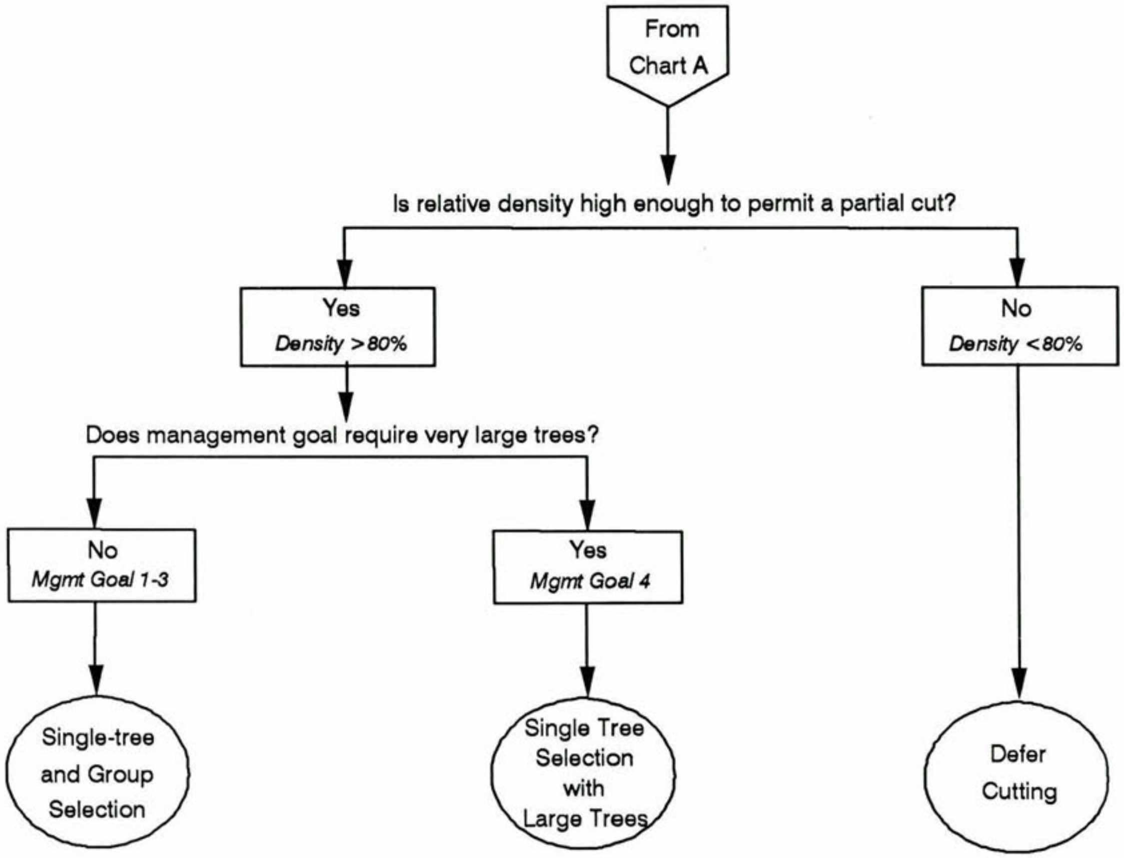

Start
Management Goals
Management Goals 1 or 2
Timber production for maximum yield, with a high proportion of shade-intolerant species.
Visual goals do not preclude even-age silviculture although clearcutting may be restricted.
Management Goals 3 or 4
Timber production for moderate yields including a high proportion of shade tolerant species.
Visual goals will lead to uneven-age silviculture to maintain a mature forest canopy at all times.
Do site factors limit regen?
No
Site Limits <30%
Yes
Site Limits >30%
Are there enough tolerants for uneven-age management?
No
Sh Tol BA <35 sq. ft.
Yes
Sh Tol BA >35 sq. ft.
Is deer impact high?
Yes
Deer Index 4-5
No
Deer Index 1-3
Is deer impact high?
Yes
Deer Index 4-5
No
Deer Index 1-3
Are there enough tolerants for uneven-age management?
No
Sh Tol BA <35 sq. ft.
Yes
Sh Tol BA >35 sq. ft.
All-age won't work w/o tolerants or w/ high deer Re-examine Goals
Is the stand mature?
No
MDM<18" and AGS>35%
Yes
MDM>18" or AGS<35%
Chart C (Even-age Thinning)
Chart D (Even-age Regen)
Chart B (All-age Mgmt)

Chart B. All-age Management



Prescription Type Legend

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

Chart C. Even-age Thinning

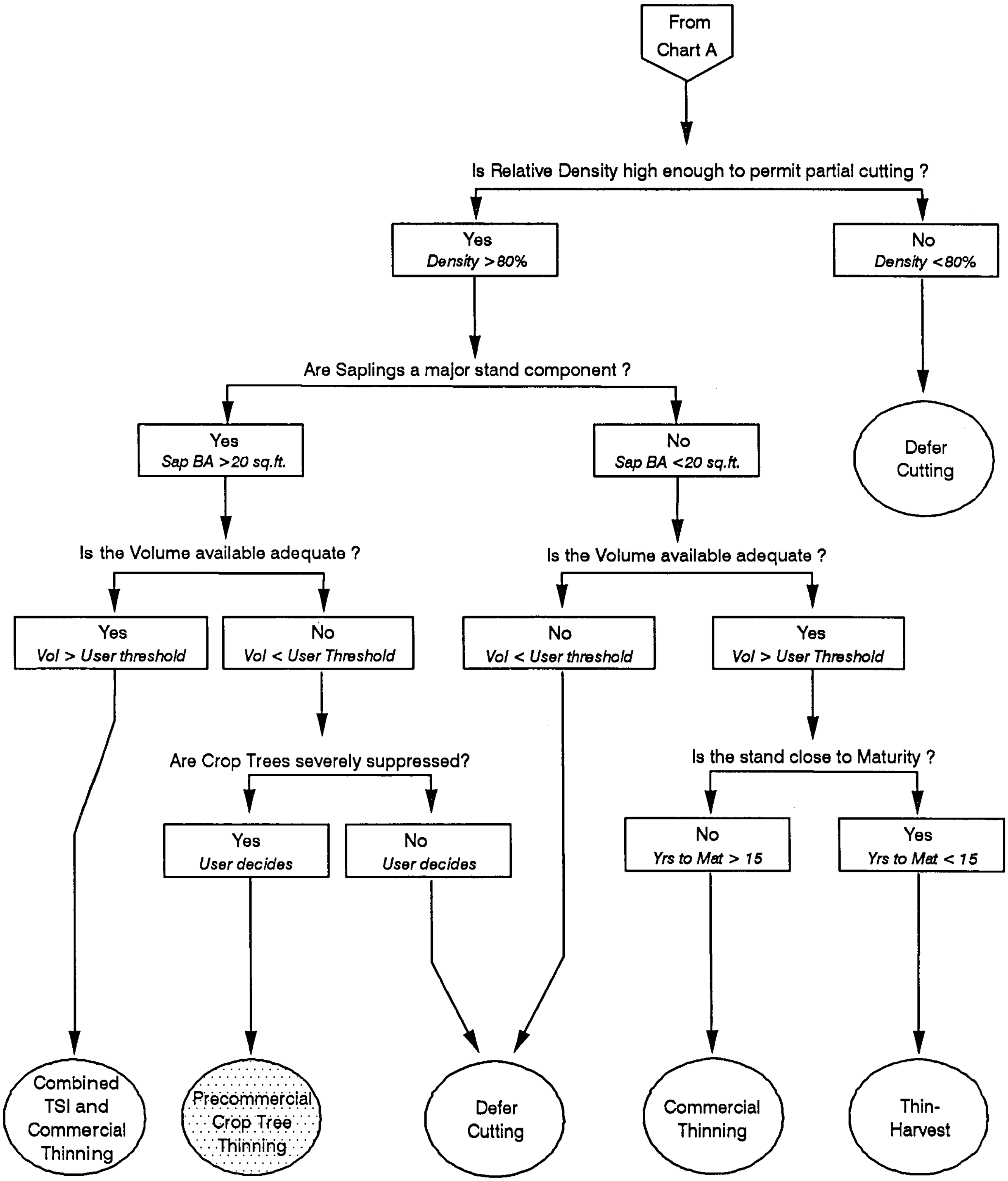


Chart D. Even-age Regeneration

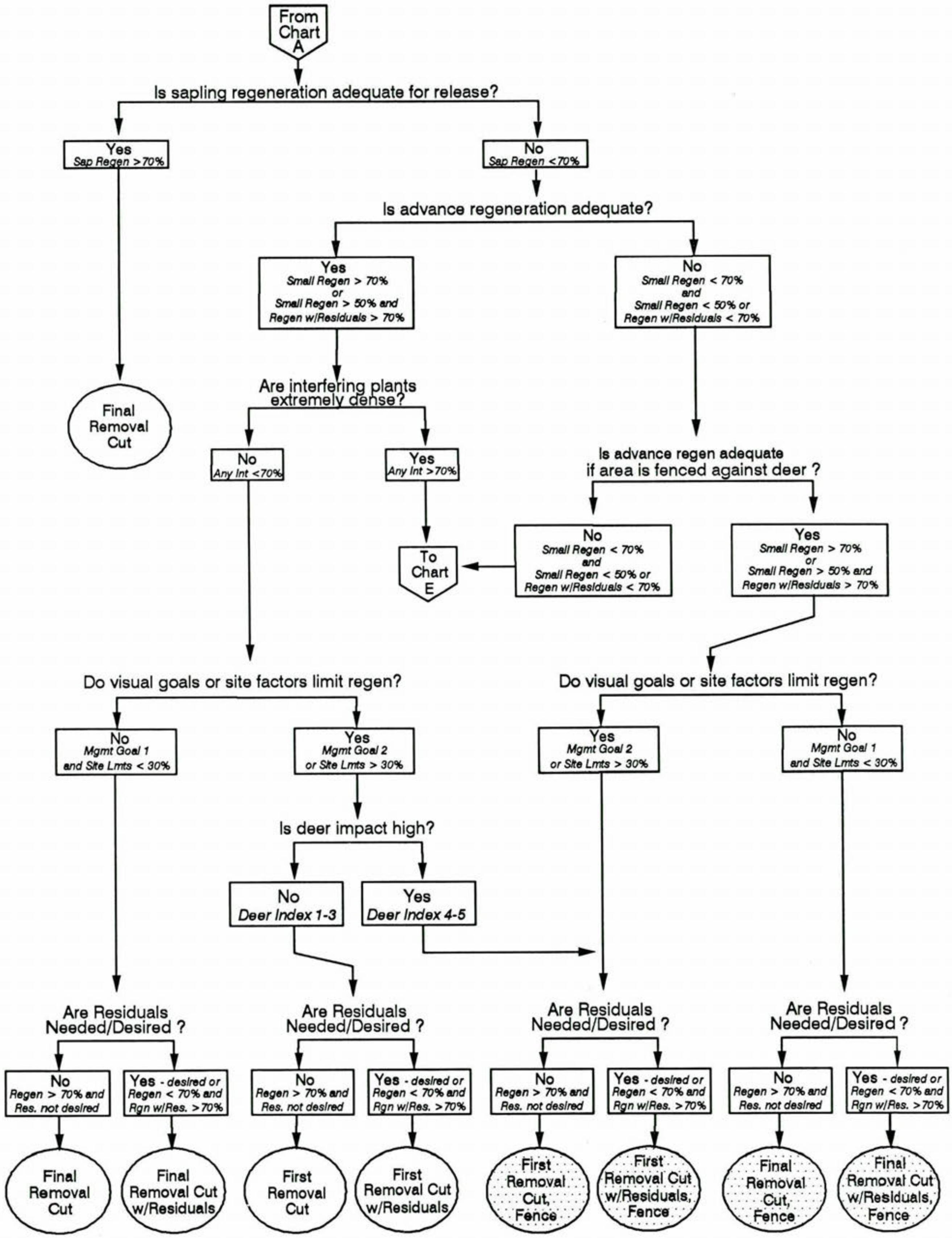


Chart E. Even-age Regeneration continued

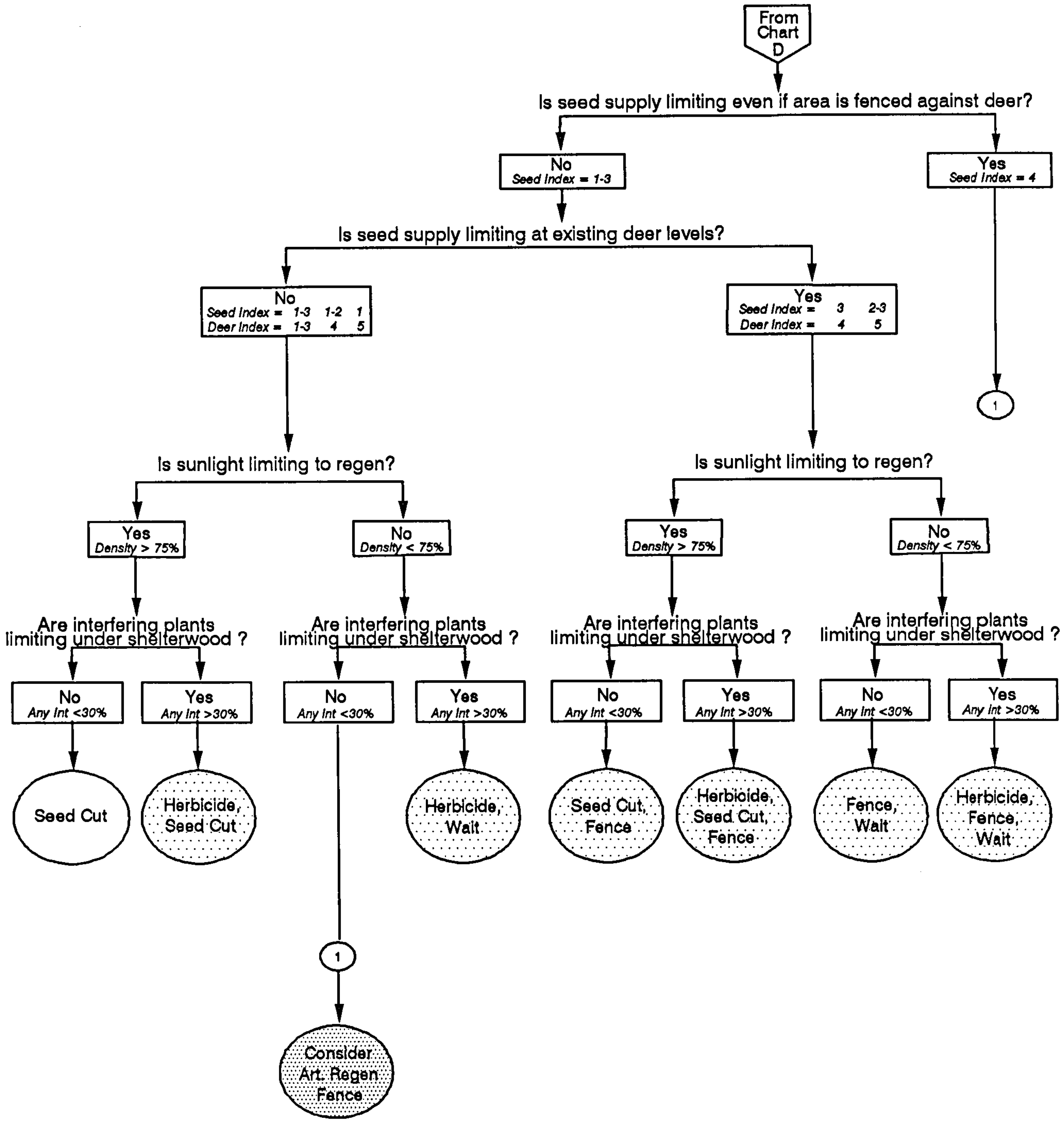
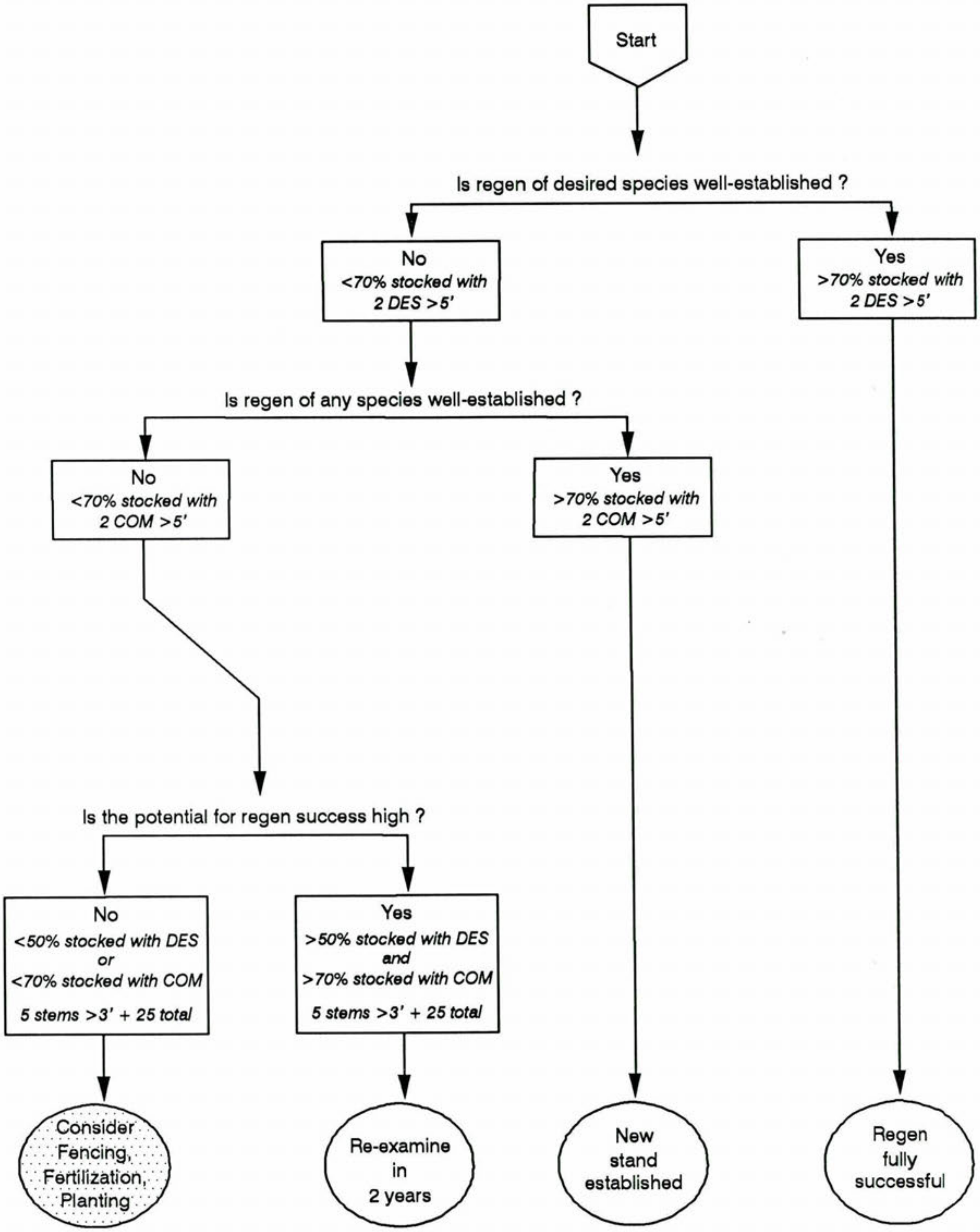


Chart F. Regeneration Follow-up



APPENDIX B

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			.20	
White ash				
Yellow poplar				
Red maple				
No. red oak				
Eastern hemlock				
All others				
Sugar maple			.15	
American beech				
Striped Maple				
Other oaks, hick.				
Total	▨	1	3/1 2	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

BA *f

Species	Size	BA	f	Sprouting stumps
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	46	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:

APPENDIX C

This exercise is designed to reenforce the concepts used in prescription writing. Table 1 contains data from a stand of 24 acres that was subdivided into 4 subplots, A through D, of about 6 acres each (Fig. 1). The data in this table are based on an inventory from the sub-plot, but a few of the values have been changed to better illustrate some regeneration principles. Stand T is the actual data for the entire 24-acre stand.

In this exercise, use the data from each "stand" to trace the proper prescription using charts A through E in Appendix A.

As you develop the prescriptions, be sure to consider these questions:

1. Is the stand mature?
2. Does it have adequate regen for clearcutting?
3. Is shelterwood cutting needed to develop advance seedlings?
4. Is an herbicide needed to eliminate interfering understory?
5. Are there factors that will prevent shelterwood from working?
6. Is an extended harvest needed to overcome site limits or visual restrictions?

Tracing the path through the charts should result in the following prescriptions.

Stand	Prescription
A.	FINAL REMOVAL CUT. This stand is mature, management goals permit even-age management, advance regen is adequate, and interfering plants are not limiting so a final removal cut or clearcut is possible.
B.	SEED CUT (Strictly a THIN-HARVEST). This stand is within 5 years of maturity--it could be considered mature. Following the charts strictly would result in a thin-harvest prescription; recognizing the understory conditions along with the effective age, will lead to the shelterwood sequence. This is a situation where strict adherence to the guideline can be relaxed. Management goals permit even-age management, but advance regeneration is inadequate. Interfering plants should not be a problem since they occur on less than 30 percent of the plots. Seed source, deer pressure, site limits, and present stocking do not prevent shelterwood.
C.	FIRST REMOVAL CUT AND FENCE. The stand is mature and there are no restrictions to even-age management. While the regeneration is inadequate in the presence of the large deer herd, it is adequate with a low deer impact. Fencing along with a clearcut would be adequate if it were not for the site limitations. The site limitations require the overstory to be removed over an extended period, thus, this is the first removal cut of a three-cut shelterwood. If fencing is not possible, then a do-nothing prescription may be appropriate.
D.	HERBICIDE, SEED CUT. This stand is mature, not because of age, but because of lack of quality. Management goals permit even-age management. The advance regen is inadequate, and interfering plants require herbicide. Notice that site limits will require the three-cut herbicide shelterwood sequence; that is, if the seed cut is successful in establishing regeneration, then site limits will require the overstory to be removed in two cuts.
T.	HERBICIDE, SEED CUT. This stand is mature and management goals permit even-age management. The advance regen is inadequate, and interfering plants require herbicide. The seed source, deer pressure, and overstory density allow the shelterwood sequence.

Notice that the prescription for the entire 25-acre area is an herbicide-shelterwood cut, while the prescription for the individual subplots varies from clearcut to shelterwood with fencing or herbicide to do nothing. Although a few of the numbers in the data set were altered for purposes of this exercise, the actual regeneration conditions <u>do</u> vary within this stand. There are some wet spots that total 5 or 6 acres. A small amount of advance regeneration that exists is confined to the northern subplot, and fern, which occurs throughout the area, is heaviest in the southern subplot. It is not at all unusual to find that understory conditions vary within a stand that is quite uniform throughout the overstory. Because of this variability, you must take twice as many understory plots .

In this particular stand, use of the overall herbicide-shelterwood cut prescription should produce satisfactory results in most of the area, but could easily be a problem in the wet spots. Five or six acres of regeneration failures in a 25-acre stand is not a very desirable result. How do you deal with these spatial variations in understory conditions within a single stand? For that matter, how do you even recognize the variation when data are only available for the entire stand?

It is a good practice to keep notes on your cruise map as the inventory is being made. When you find wet spots, islands of fern or seedlings, or other changing conditions, sketch them in as best you can as you traverse the stand. Do not hesitate to note important conditions even if they do not fall on one of your plots. The more information you have, the better. Figure 2 is an example of a working cruise map that was prepared while working through the stand.

If you have access to a computer, there are programs that can analyze your cruise data and map out areas of interest or concern. To use such programs, you need to keep track of your cruise line location and plot sequence so that you can determine X,Y coordinates for each plot. Figures 3 to 5 are examples of the output from such a program showing the location of the wet spots, the advance regen, and the fern in the stand.

Whether done by computer or via field notes on your cruising map, knowledge of the distribution of key understory parameters can be a big help in identifying the need to modify overall stand prescriptions to accommodate the variation in conditions.

In this stand, for example, there are several possible courses of action. The wet spots could be treated as inclusions, and left uncut or partially cut. Such islands of standing trees are often left intentionally in clearcuts for their visual or wildlife value--here is another reason for leaving them. They break up the appearance of the clearcut, and since the overstory has some hemlock and beech in the wet spots, they should have considerable value as mast production or winter cover habitat for wildlife.

Another option might be to harvest the entire stand and to fence the wet spots against deer browsing to ensure that regeneration will develop there.

In this stand, there are interfering plants throughout, but in many stands the interfering plants are confined to one part of the stand. In such cases, there is a big savings in applying the shelterwood to the entire stand and treating with herbicide only those areas that need it. Caution must be exercised here, though, not to miss areas needing treatment in an effort to save a little money on herbicide.

In some situations, the conditions may vary so much that there is no choice but to split the stand into several smaller stands, with separate prescriptions for each. For practical reasons though, stands less than 10 acres are difficult to deal with, and it is better to look for ways to treat the area so as to increase the uniformity rather than subdividing into smaller and smaller stands.

So, considerable judgment is necessary to ensure that the overall prescription arrived at through the SILVAH guidelines makes sense in all parts of the stand. But if used systematically, those procedures provide the basis for sound decisions.

Table 1. Exercise in Silvicultural Prescription Writing

	STAND CONDITIONS				
CRITERION	A	B	C	D	T
Management Goal	1	1	1	1	1
Deer Impact Index	4	4	4	3	4
Seed Source Index	1	1	1	3	1
Site Limits	0	15	40	30	20
Any Small Regen	70	5	30	20	14
Any Small Regen or Residuals	75	5	35	20	20
Any Small Regen NO DEER	70	5	73	20	14
Any Small Regen or Residuals NO DEER	75	5	76	20	20
Sapling Regen	0	0	0	0	0
Any Interference	45	25	45	50	45
Sapling BA	12	8	7	12	9
Shade Tolerant BA	15	20	55	30	35
Relative Density	105	94	93	88	95
AGS Density	90	80	70	20	65
Stand Diameter (MD)	17.9	17.1	18.0	15.5	17.3
Merchantable Stand Diameter (MDM)	18.6	17.7	18.8	16.1	18.1
Years to Maturity	0	2	0	11	0
Volume > Threshold	Y	Y	Y	Y	Y

Figure 1. -- Study Plot

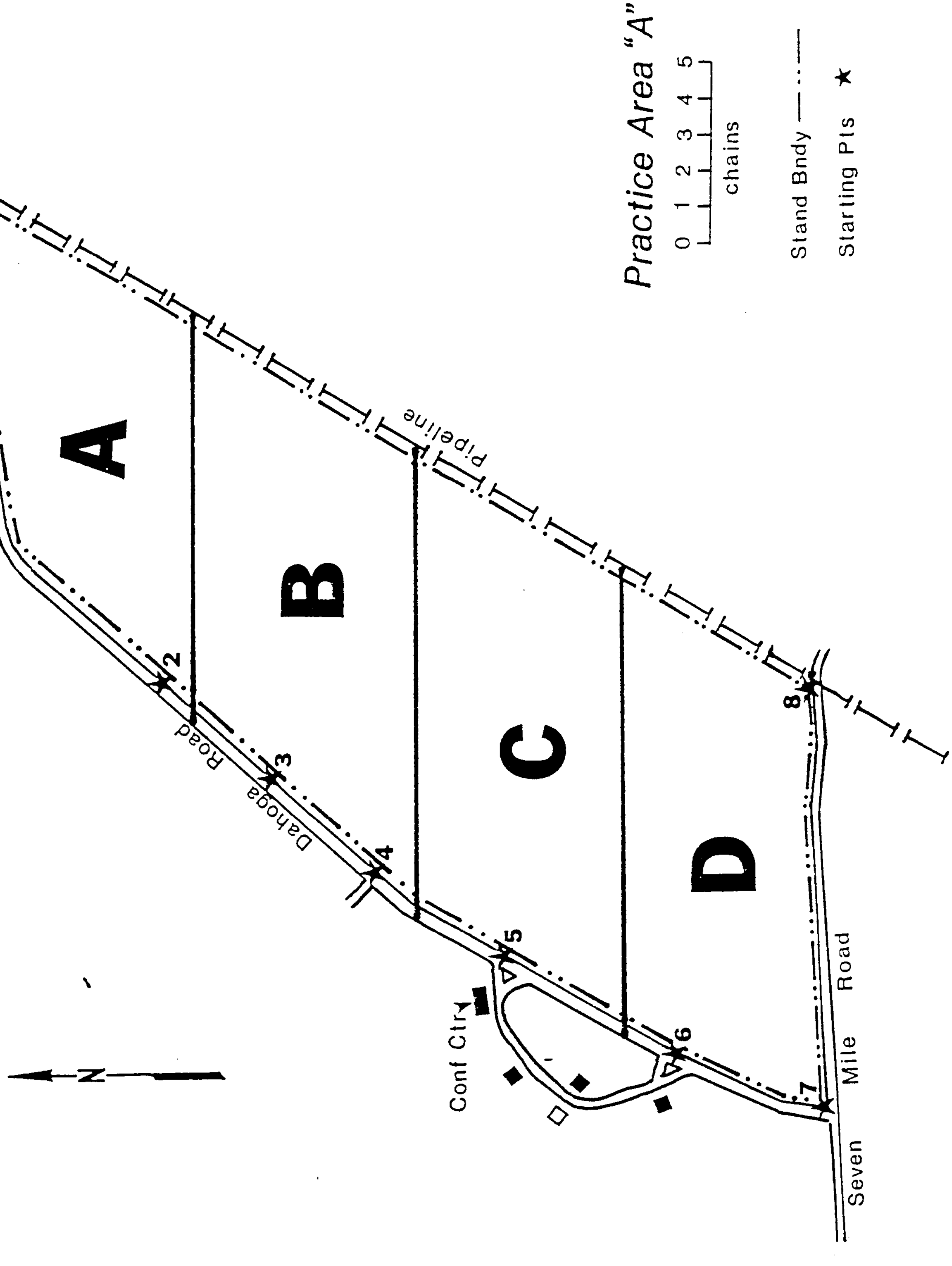


Figure 2. -- A Working Cruise Map

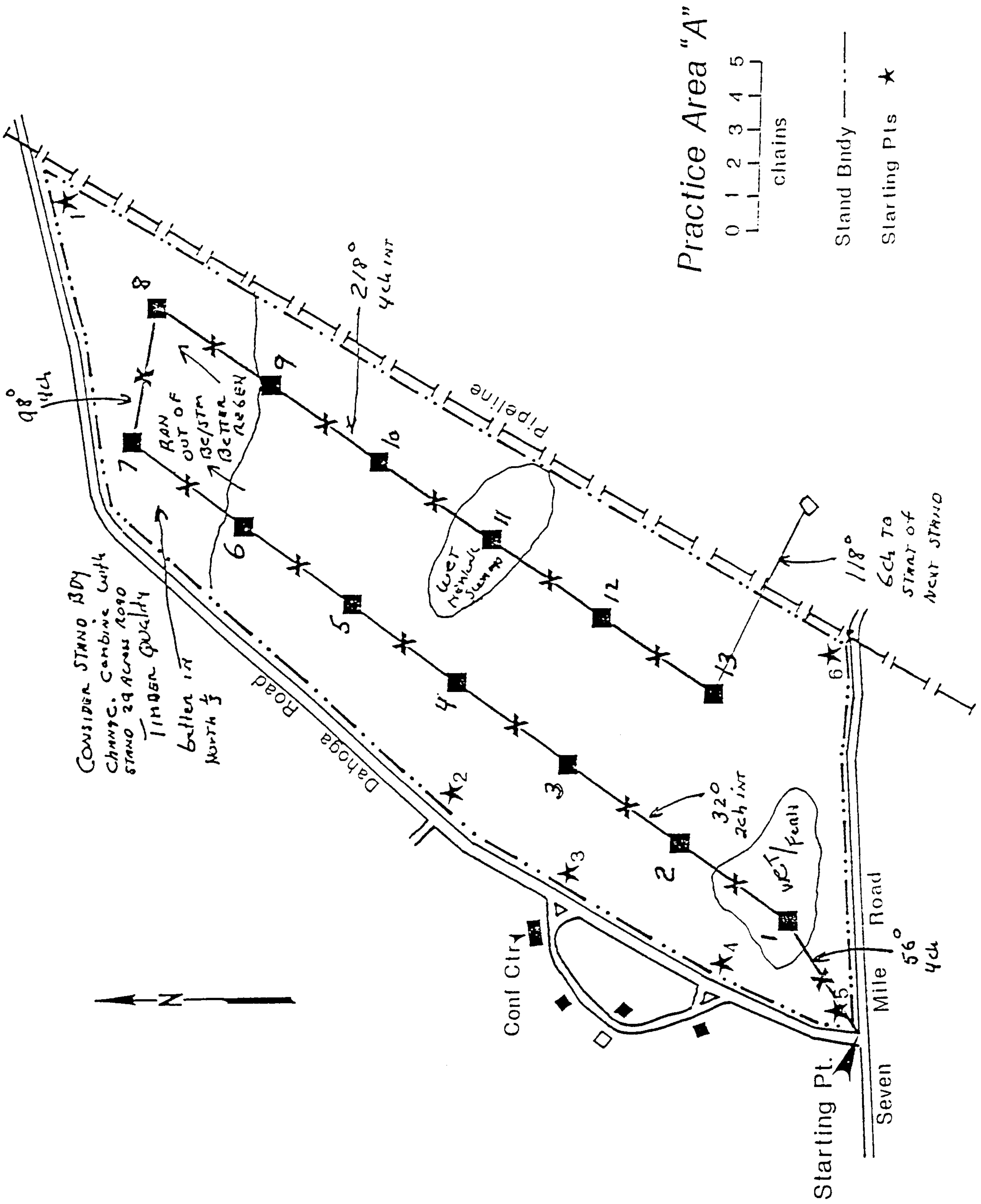


Figure 3. -- Site Limitations for Training Area A

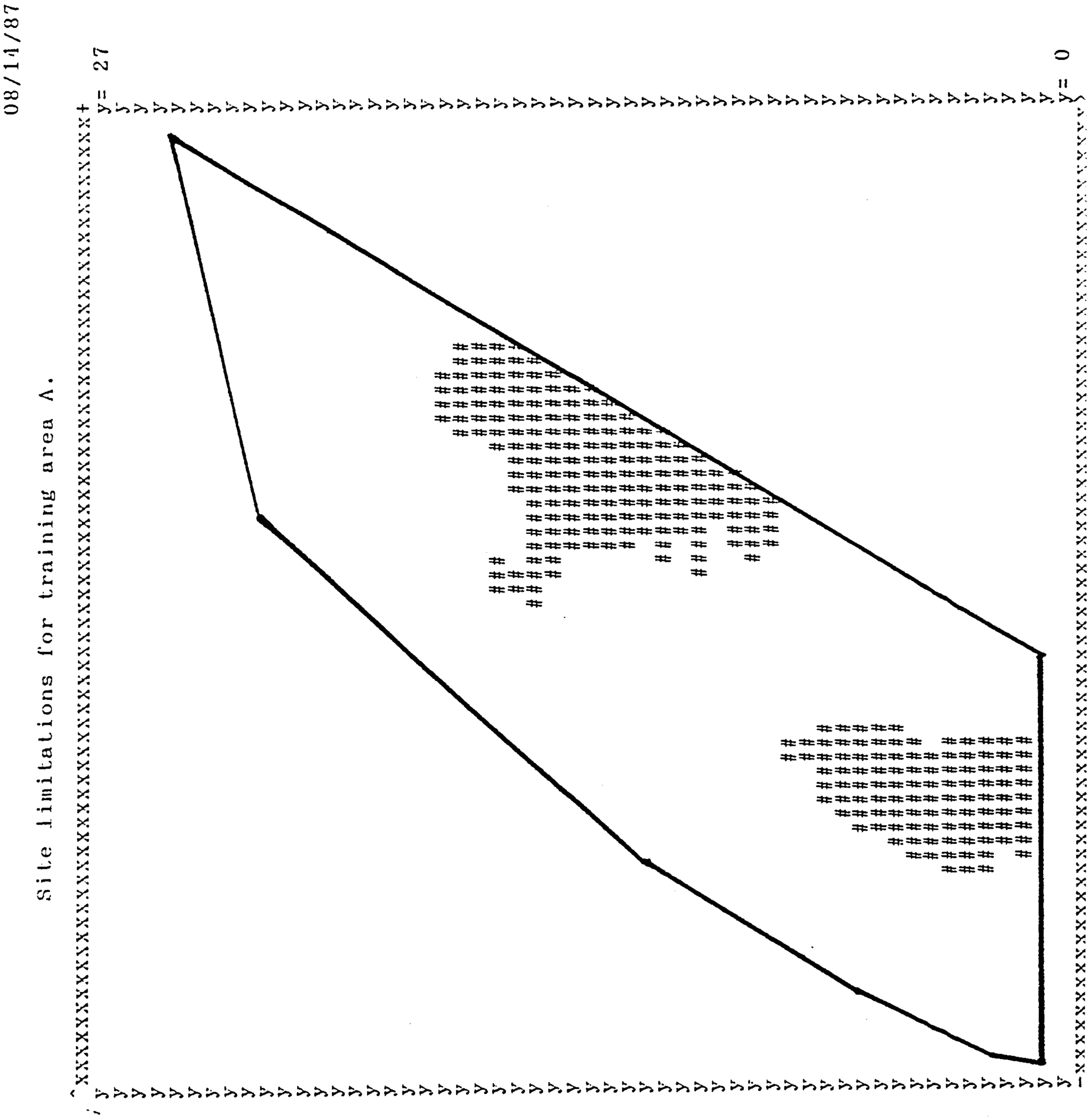


Figure 4. -- Black Cherry Regeneration Distribution for Training Area A

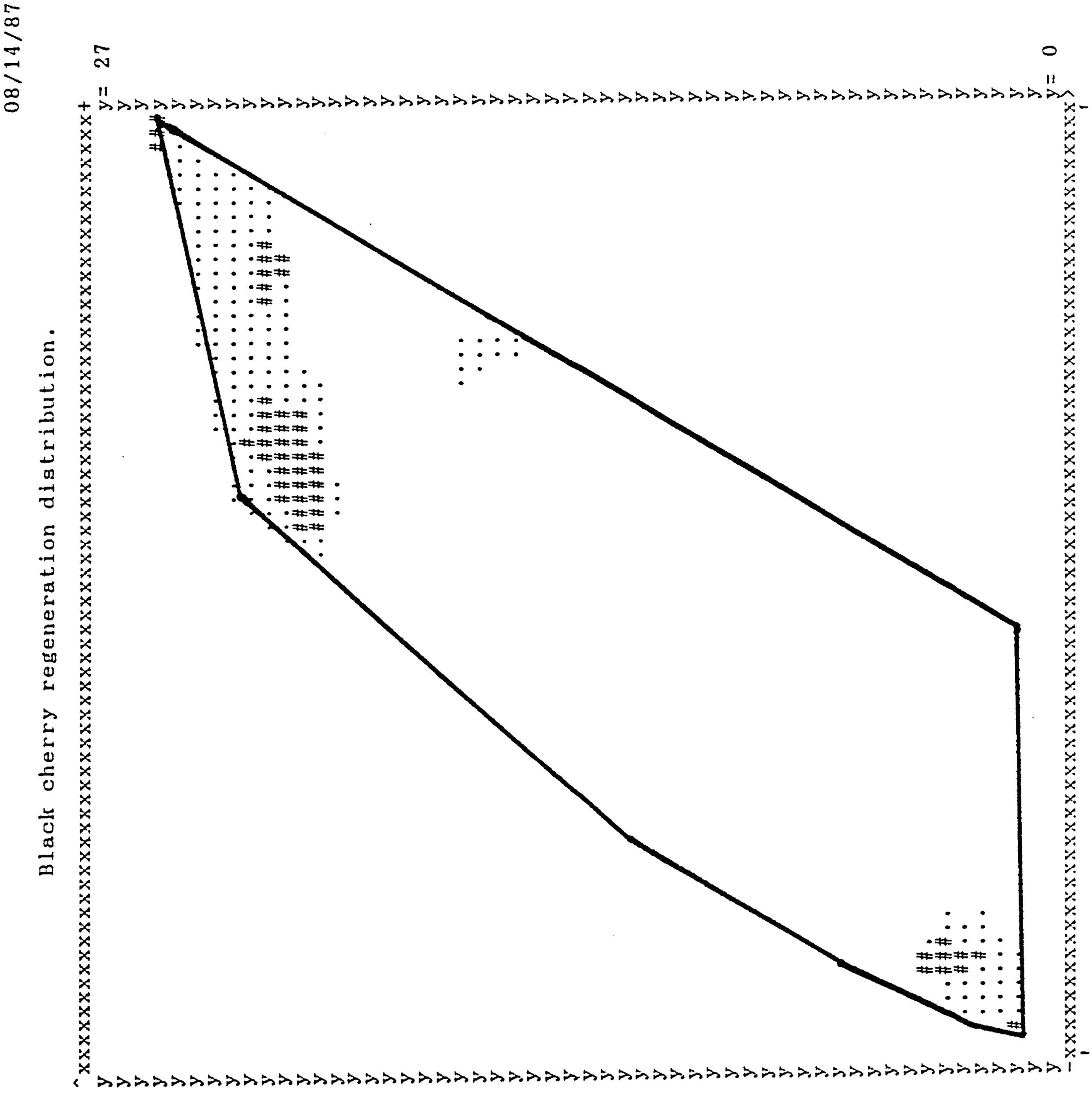
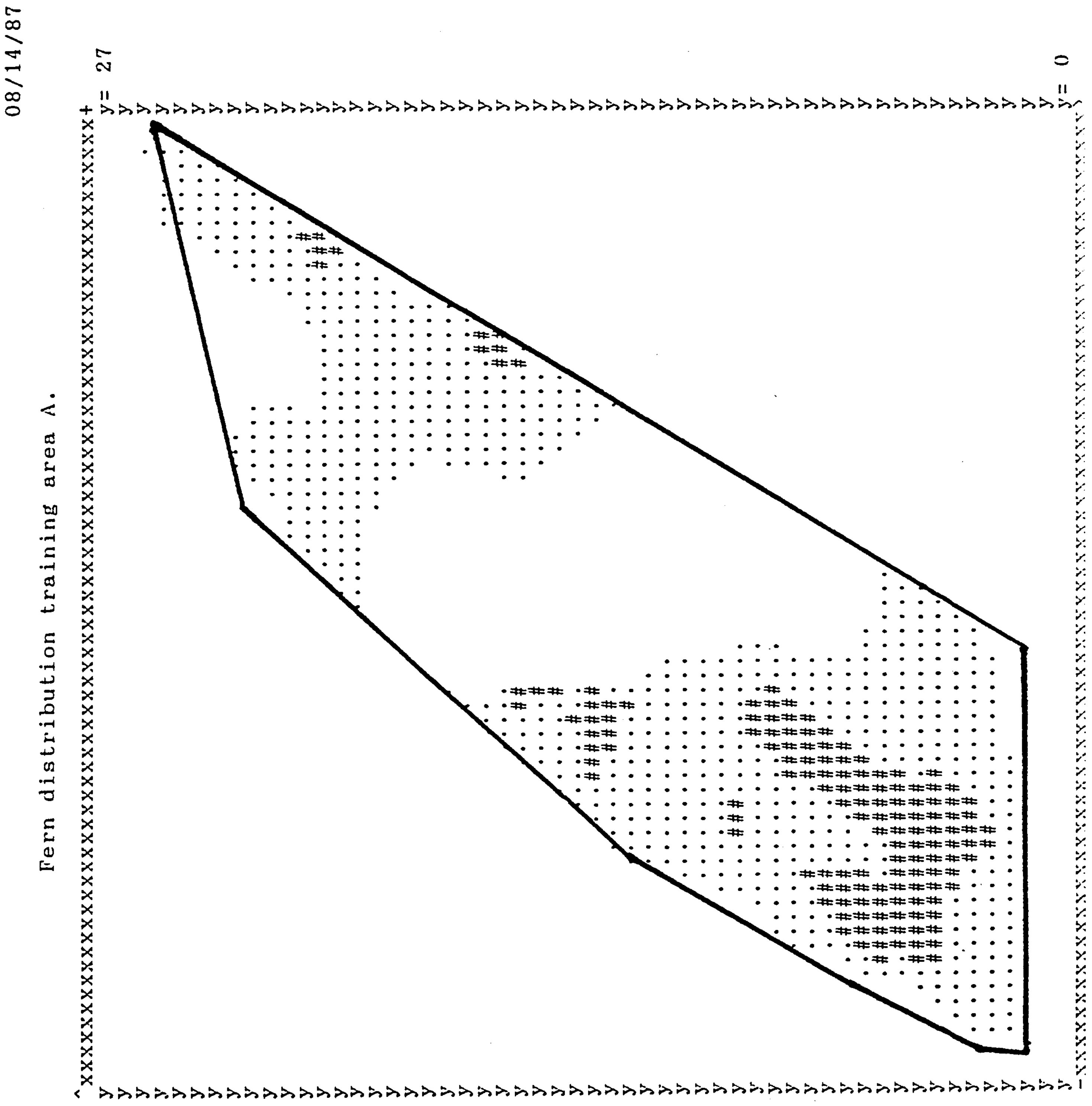
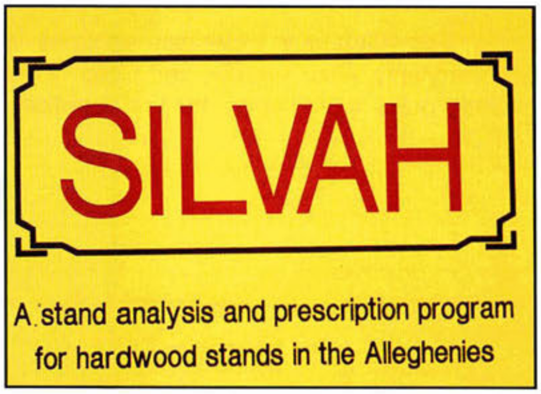


Figure 5. -- Fern Distribution for Training Area A



SILVAH Computer Analysis

David A. Marquis



SILVAH

A stand analysis and prescription program for hardwood stands in the Alleghenies

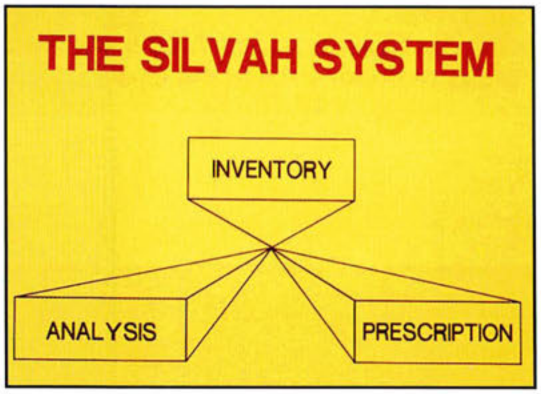
1. The SILVAH computer program integrates all of the many silvicultural guidelines that have been developed for hardwood forests of the Alleghenies into a complete stand analysis and prescription procedure.

SILVAH

SILVICULTURE

OF ALLEGHENY HARDWOODS

2. The acronym SILVAH stands for SILViculture of Allegheny Hardwoods.



THE SILVAH SYSTEM

INVENTORY

ANALYSIS

PRESCRIPTION

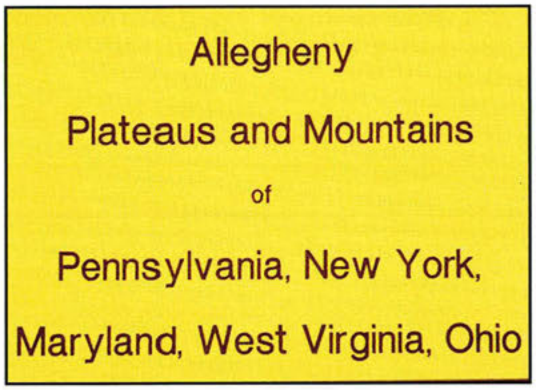
3. The SILVAH system involves an inventory of basic vegetation and site variables that is analyzed in specific ways to estimate the stand's potential for growth and regeneration. Then a prescription is determined based on critical levels of the stand variables.

Beech - birch - maple

Cherry - maple

Oak - hickory

4. SILVAH is applicable to the beech-birch-maple, cherry-maple, and oak-hickory forest types



Allegheny

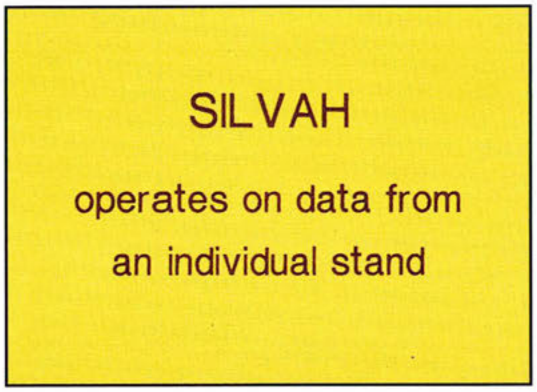
Plateaus and Mountains

of

Pennsylvania, New York,

Maryland, West Virginia, Ohio

5. in the Allegheny Plateau and Allegheny Mountain sections of Pennsylvania, New York, Maryland, West Virginia, and Ohio. Parts of the program may be used outside this range, but with caution.

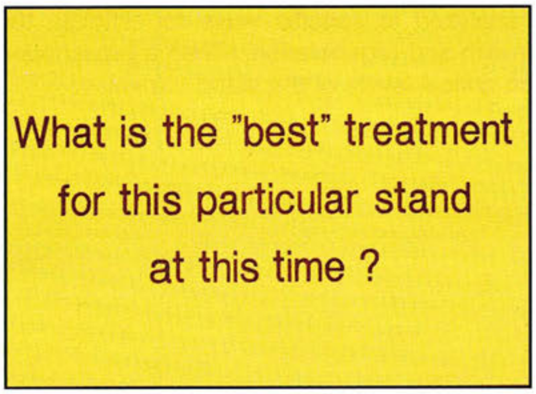


SILVAH

operates on data from

an individual stand

6. SILVAH operates on data from an individual stand

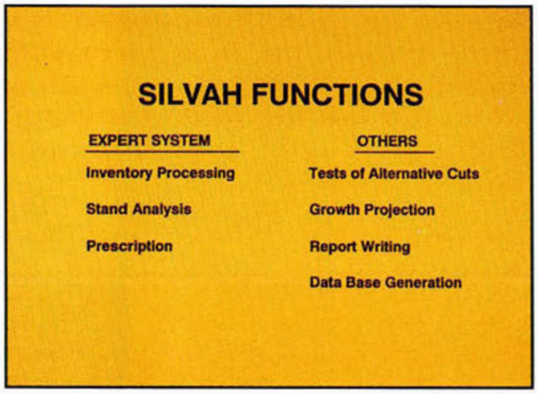


What is the "best" treatment

for this particular stand

at this time ?

7. and is designed to answer the basic question: "What is the 'best' silvicultural treatment for this particular stand at this time?"



SILVAH FUNCTIONS

EXPERT SYSTEM	OTHERS
Inventory Processing	Tests of Alternative Cuts
Stand Analysis	Growth Projection
Prescription	Report Writing
	Data Base Generation

8. As such, SILVAH is an "expert system". It automates the three basic functions of the silvicultural prescription procedure. In addition, SILVAH can perform the functions of report writing, data-base generation, comparison of alternative cuts, and stand growth simulation. We will look at each of these functions in detail.

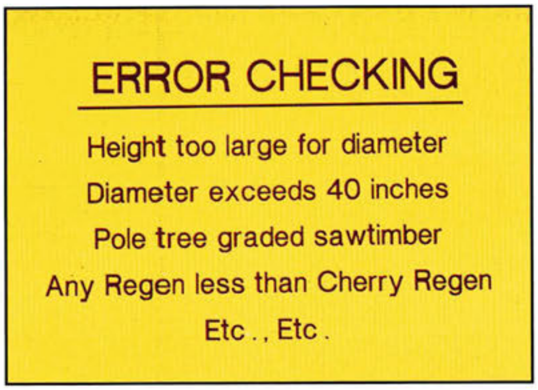
INVENTORY PROCESSING

9. Inventory processing is the first and most basic function of the SILVAH program.

10. Data on overstory, understory, and site variables are collected during the stand inventory

11. and entered into SILVAH along with general information on stand conditions and management objectives. The tally form is shown as Appendix A-1. The Appendix contains samples of the various SILVAH forms and printouts. Data entry may occur either through the computer keyboard, or

12. electronically from a field data recorder.



ERROR CHECKING

Height too large for diameter

Diameter exceeds 40 inches

Pole tree graded sawtimber

Any Regen less than Cherry Regen

Etc., Etc.

13. Data entered into SILVAH are error checked to ensure that values are within acceptable ranges and internally consistent (Appendix A-2). For example, it will inform you of an error if you classify a 6-inch tree as veneer, or enter a 90-inch d.b.h., or 20 log merchantable height.

14. SILVAH processes the information entered and outputs all of the usual tabular data that one expects from a forest inventory. The number and type of inventory printouts that can be obtained are very large, and the user is free to select all, none, or any combination of these outputs.

CRUISE INFORMATION

Overstory	Understory
Prism or Fixed	Standard or Detailed
Ind. Tree or Dot Tally	----
No. Plots	No. Plots
Factor or Plot Size	Plot Size
Standard Error	----
Additional Plots Needed	Additional Plots Needed

15. If desired, SILVAH will output a page of information on the type and accuracy of the cruise (Appendix A-3). This page describes the type of overstory cruise used (prism or fixed plot by individual trees or dot tally), standard or detailed understory data, number of plots of each type, standard error in overstory basal area, and number of additional plots (if any) required to estimate basal area within both 10 percent and 15 percent of the mean.

REGENERATION STATUS

% plots with Regeneration

% plots with interfering plants

Oak Stump Sprouting

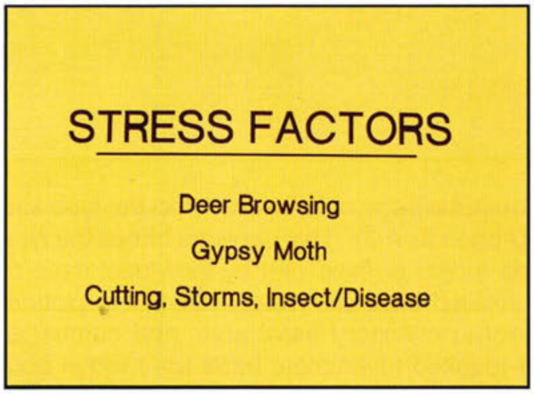
Regeneration Difficulty

16. If desired, SILVAH will output a page of information summarizing tree regeneration status (Appendix A-4). This includes a summary of the proportion of plots stocked with ten categories of desirable regeneration, and six categories of interfering understory plants. It also provides data on the proportion of oak stumps that are expected to sprout and the effect it will have on reducing the amount of advance oak regeneration needed. Estimates of factors that will affect the ease or difficulty of securing regeneration (such as deer impact, seed supply index, and site limitations) are given also. Where coded values are used, the printout provides a brief definition. More complete definitions are provided in the SILVAH user's guide.

SITE AND STAND INFO

Cover Type
Habitat Type
Soil Type
Site Class
Site Index
Site Species
Elevation
Aspect
Slope %
Topo. Position
Operability
Accessability
Relative Merchantable Height

17. If desired, SILVAH will output a page of site and general stand information (Appendix A-5). Site information is supplied by the user and includes: cover type, habitat type, soil type, site class, site species, site index, relative merchantable height (which can be used as an indicator of site quality if the stand has not been high-graded), elevation, aspect, percent slope, topographic position, operability, and accessibility.



STRESS FACTORS

Deer Browsing
Gypsy Moth
Cutting, Storms, Insect/Disease

18. Stress factors also may be supplied by the user and may include: deer impact, danger of gypsy moth defoliation, and stress created by recent cutting, storms, or insect and disease outbreaks.

MANAGEMENT GOALS

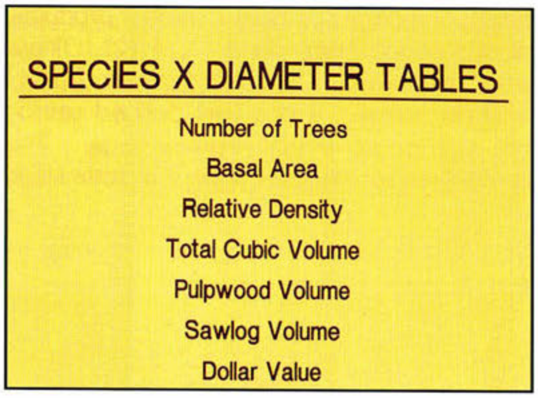
Visual
Wildlife

19. Management goals are stated in terms of the extent to which timber prescriptions may be (or must be) modified to accommodate visual or wildlife objectives (Appendix A-6).

WILDLIFE INFO

Den Trees & Snags
Water Habitats in this Stand
Habitat Conditions w/i 1 mile

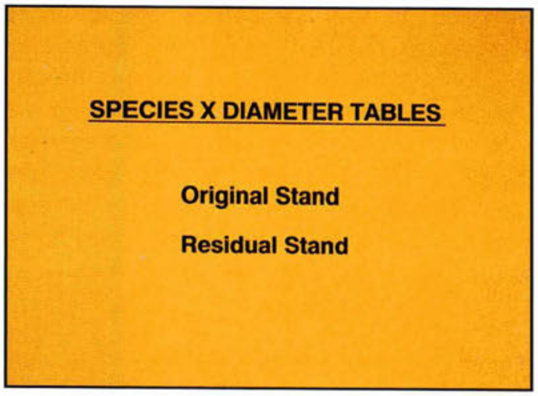
20. If desired, SILVAH will output information on wildlife variables (Appendix A-6). At present, this information is limited to number per acre of potential and existing den trees and snags, plus information on water habitat and vegetative conditions in areas surrounding the stand.



SPECIES X DIAMETER TABLES

Number of Trees
Basal Area
Relative Density
Total Cubic Volume
Pulpwood Volume
Sawlog Volume
Dollar Value

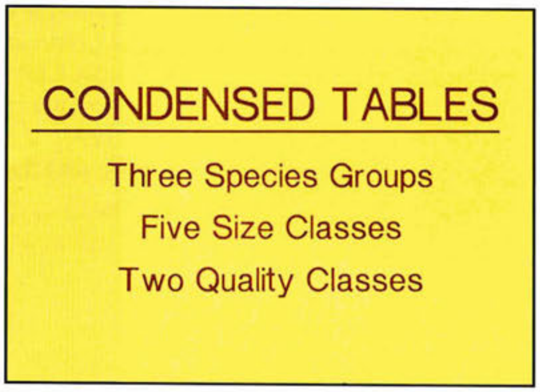
21. If desired, SILVAH will output overstory data by species and diameter (Appendix A-7, A-8). These tables also contain a summary by major size classes and quality classes. The tables can be generated showing per acre values for number of trees, basal area, relative density, net total cubic-foot volume, net pulpwood cubic-foot volume, net board-foot volume (using International 1/4", Doyle & Scribner log rule), and dollar value.



SPECIES X DIAMETER TABLES

Original Stand
Residual Stand

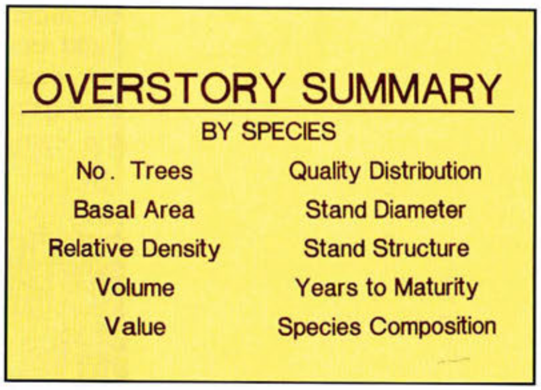
22. These tables can be printed for the original stand and for any residual stands generated in SILVAH.



CONDENSED TABLES

Three Species Groups
Five Size Classes
Two Quality Classes

23. If desired, a condensed version of these tables can be printed showing only three species groups, five size classes, and two quality classes (Appendix A-9). This format is identical to that on the Manual Tally and Summary Forms.



OVERSTORY SUMMARY

BY SPECIES

No. Trees
Basal Area
Relative Density
Volume
Value
Quality Distribution
Stand Diameter
Stand Structure
Years to Maturity
Species Composition

24. If desired, SILVAH will output a one-page summary of all overstory data (Appendix A-10), showing values by species for such variables as number of trees, basal area, relative density, percent species, total cubic-foot volume, total pulpwood volume, board-foot volume, and dollar value. This summary page also shows the distribution of acceptable quality trees by species and size class. In addition, several stand diameters, several measures of stand structure, estimates of effective stand age and years to maturity are presented.

PRODUCT SUMMARY

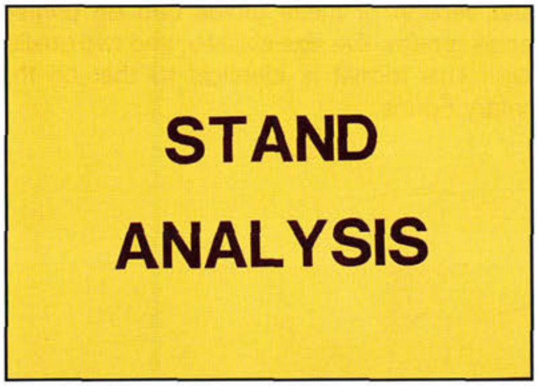
Firewood
Pulpwood
User-defined bulk product
Sawlogs
Veneer
User-defined sawlog product

25. If desired, SILVAH will print a one-page summary of timber products, by species, grade, and size class (Appendix A-11, A-12). These products include: firewood, pulpwood, a user-defined bulk product such as boltwood, sawtimber, veneer, and a user-defined sawlog product such as pallet logs or construction-grade logs. This product printout can be obtained on either a per acre or total stand basis.

USER SPECIFICATIONS

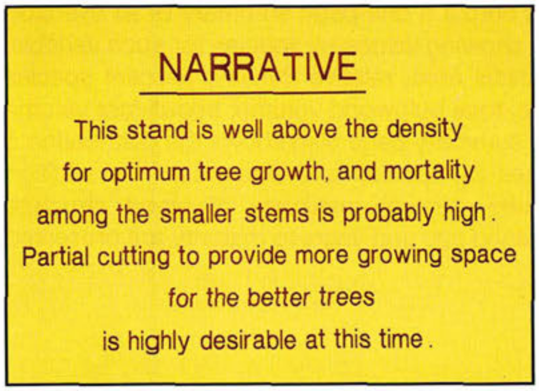
Log Rule (Int 1/4, Doyle, Scribner)
Form Class
Volume Correction Factors
Stumpage Prices
Local Bulk and Sawlog Products
Diameters for Size Classes
Species Codes

26. In all of these inventory printouts, the user can adapt SILVAH to meet the needs of the particular organization or geographic area (Appendix A-13, A-14). Users may specify: the log rule to use, stumpage prices for all products by species, diameters to be included in each product, form class to be used for each species, volume correction factors to be used for each species, and minimum volumes required for commercial sales. The user can also insert his or her own species codes into the system, and may name one bulk and one sawlog product other than the usual ones.



STAND ANALYSIS

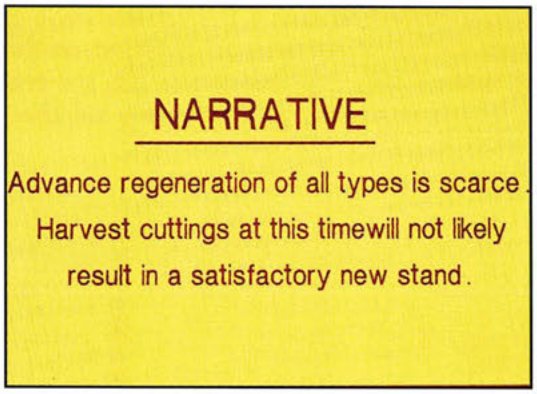
27. In the second step of the SILVAH process, all inventory data are then analyzed to provide an assessment of the silvicultural potential of the stand. The analysis includes categorization of the stand into type-size-density class, evaluation of the potential for regeneration, the status of this stand in approaching financial maturity, the potential of the stand for growth and accumulation of value, and the need for partial cutting.



NARRATIVE

This stand is well above the density
for optimum tree growth, and mortality
among the smaller stems is probably high.
Partial cutting to provide more growing space
for the better trees
is highly desirable at this time.

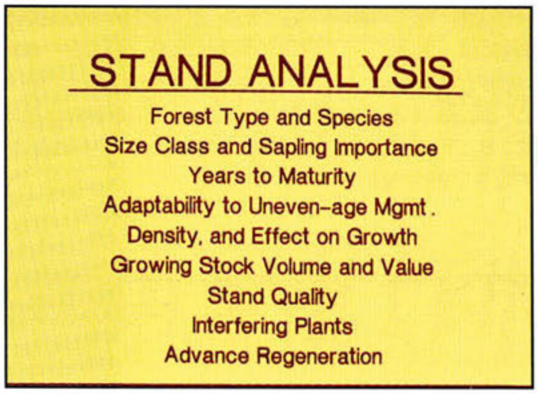
28. The analysis is presented in an easily read narrative report (Appendix A-15). For example, data on stand density and tree volume may be interpreted in the narrative as: "This stand is well above the density for optimum tree growth, and mortality among the smaller stems is probably high. A thinning to provide some intermediate yield is highly desirable at this time."



NARRATIVE

Advance regeneration of all types is scarce.
Harvest cuttings at this timewill not likely
result in a satisfactory new stand.

29. Or, data on overstory density and tree size combined with understory information may produce the message: "Advance regeneration of all types is scarce; harvest cuttings at this time probably will not result in a satisfactory new stand." Such evaluations, routinely printed for each stand, ensure that the user's attention is systematically focused on all of the characteristics of the stand.

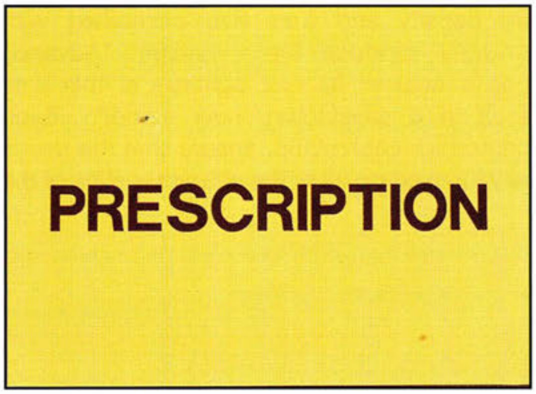


STAND ANALYSIS

Forest Type and Species
Size Class and Sapling Importance
Years to Maturity
Adaptability to Uneven-age Mgmt.
Density, and Effect on Growth
Growing Stock Volume and Value
Stand Quality
Interfering Plants
Advance Regeneration

30. The stand analysis narrative includes the following information:

- o Forest type and names of the dominant species.
- o Stand size class, and an indication of the importance of including noncommercial saplings in partial cutting considerations.
- o Expected time to financial maturity if the stand is managed under an even-age system, and the degree to which all species will mature at the same time.
- o Adaptability of the stand to uneven-age management, based upon "q" factor, proportion of sawtimber, and proportion of shade-tolerant species.
- o Relative stand density or stocking, and the expected effect of that density on individual tree growth and stand growth and mortality.
- o The desirability of partial cutting.
- o A statement of total growing stock, merchantable volumes, and dollar value.
- o Information on overall stand quality.
- o Evaluation of the impact that interfering plants and site limitations will have on seedling regeneration.
- o An evaluation of the amount of advance regeneration present, and the stand's ability to regenerate if harvested. Information on the dominant species in the next stand also may be provided.



PRESCRIPTION

31. The third step in the decisionmaking process is the determination of a management prescription. This determination is based on the goals of the landowner, and on the characteristics of the site and present vegetation. So, owner objectives must be clearly identified for the prescription function to work properly.

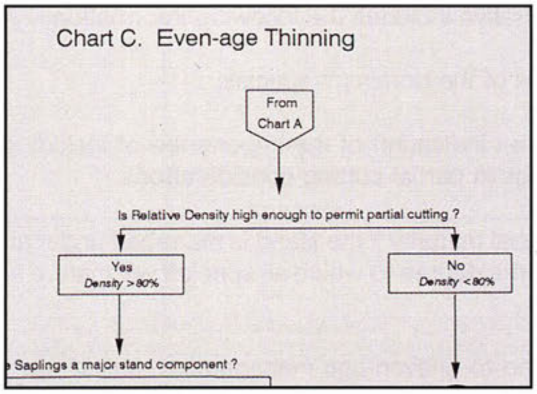


Chart C. Even-age Thinning

From Chart A

Is Relative Density high enough to permit partial cutting ?

Yes
Density >80%

No
Density <80%

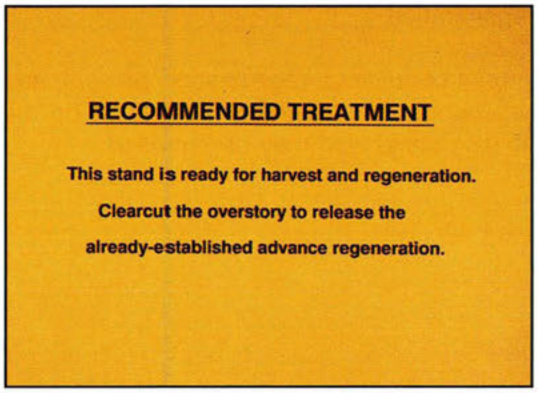
Saplings a major stand component ?

32. A series of decision charts is used to find a recommended treatment for the present stand. The decision charts are constructed in such a way that there is only one possible treatment for each combination of goals and stand conditions. The program scans through the charts using the data from the stand analysis and the owner's goals to find a treatment.

RECOMMENDED TREATMENT

Make a commercial thinning to provide additional growing space for the better trees, and to provide some intermediate yield.

33. The result is our recommendation on the silvicultural treatment that will best meet management objectives based upon current knowledge. SILVAH will print this recommended treatment (Appendix A-16). It may call for a commercial thinning,



RECOMMENDED TREATMENT

This stand is ready for harvest and regeneration.
Clearcut the overstory to release the
already-established advance regeneration.

34. a final harvest, or any of about 50 other silvicultural activities.

35. No system of this sort can substitute for professional judgment, nor is it intended to do so. The decision tables are based on average situations. Circumstances not evaluated or other considerations may dictate that the recommendations be modified. So, the procedure provides a starting point or standard that must be verified by professional judgment. Nevertheless, it removes much of the subjectivity formerly associated with silvicultural decisionmaking, and ensures that a wide range of factors are systematically considered in the process. It also provides for uniformity in prescriptions among stands and among individual prescribers.

BREAKPOINT WARNINGS

Relative density is just below the 80% breakpoint; a cutting prescription may also be appropriate.

Interfering plants are just below the 30% breakpoint; an herbicide treatment may also be appropriate.

36. SILVAH provides some help even on the use of professional judgment. When stand conditions fall very close to a decision point, SILVAH prints a warning to that effect (Appendix A-17). For example, if SILVAH recommends the use of an herbicide prior to shelterwood cutting because 31 percent of the plots have interfering plants (30 percent is the breaking point), SILVAH will alert you that herbicide may not be required. In such situations, you might get by without any herbicides; or you might treat only the portion of the stand where the interfering plants are dense.

MARKING INSTRUCTIONS

Residual density and basal area

Proportion of trees to cut from each size class

Proportion of trees to cut that are poor quality

37. If the recommended treatment includes a partial cutting of any type, a set of marking instructions is then generated. Desired residual stands are calculated using a stand structure model suitable for either even-age or all-age management, as appropriate. Then the number of trees to be removed to achieve that objective is calculated. The narrative indicates the residual density desired, and provides a series of ratios for each major size class, indicating the proportion of trees to be cut from each class (Appendix A-16).

COMPARISON TABLE

Overstory Summary Data Comparing
Original, Cut, and Residual
Stands

38. If desired, SILVAH will output a page of overstory summary data comparing the original, cut, and residual stands (Appendix A-18). This provides data on volumes and values available for cutting, and provides summary data on the effect of that cutting on the residual stand. One can evaluate the effects of the cut on such parameters as stand quality, stand diameter, years to maturity, species composition, stand structure, and so on.

More complete information on the residual stand is available if desired; any of the overstory tables previously described for the original stand also can be printed for the residual stand (Appendix A-19).

STAND ANALYSIS
AND PRESCRIPTION

OTHER SILVAH FEATURES

39. The computer program SILVAH does all of the described analyses and prescription writing automatically, once provided with inventory data and management goals. Regular use provides for data processing and decisionmaking on large numbers of individual stands without timeconsuming and costly testing of possible alternatives.

SILVAH also provides a number of other important features.

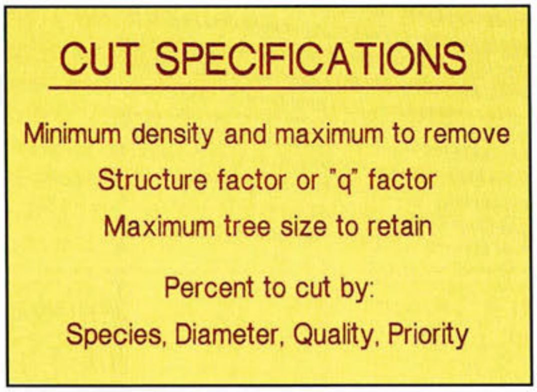
TESTING OF
ALTERNATIVE
CUTS

40. SILVAH provides the opportunity to test alternative cuts, if that is desired. The user can choose to ignore the recommended treatment and specify any other cutting treatment desired. The effect of that treatment on the residual stand that results will be assessed in the same way as for a SILVAH-recommended treatment. Thus, one can compare the effect of as many alternative treatments as desired.

ALTERNATIVES

Select Different Std. Treatment
Modify Standard Treatments
Build Your Own Treatments

41. There are three ways to specify other treatments. You can: a) select one of the other standard SILVAH treatments; b) select any of the standard SILVAH treatments but modify it by specifying your own residual density or structure; or c) specify the cut in detail, selecting individual species, diameter, and quality classes to cut.



CUT SPECIFICATIONS

Minimum density and maximum to remove
Structure factor or "q" factor
Maximum tree size to retain

Percent to cut by:
Species, Diameter, Quality, Priority

42. The printout of any user-specified treatment shows the specifications used (Appendix A-20, A-21). Any of the printouts described earlier showing the residual stand and cut volumes can be obtained for user-specified treatments, providing a means to compare the effects of any desired treatments.

STAND GROWTH SIMULATOR

43. In addition, SILVAH contains a stand growth simulator, so that one can project the stand into the future after any treatment. Stand analyses like those produced on the actual inventory data can be produced for any future date, permitting detailed comparisons of impacts of any number of possible treatments on future timber yields.

SIMULATOR OUTPUTS

All inventory tables
Product Yields at each cut
Stand Development Record:
No. trees, basal area, density, stand diameter, species composition, pulp and sawlog volumes, dollar values.

44. Summary pages from a typical simulation run include product yield and stand stocking and volume data over the entire projection period (Appendix A-22, A-23). Any of the tables printed on the original stand inventory also can be printed on the simulated stand, for any of the 5-year intervals projected (Appendix A-24).

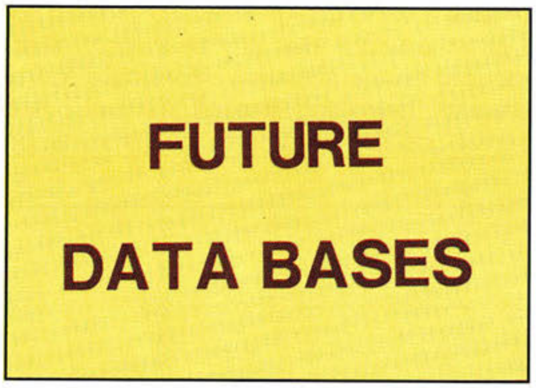
REPORT WRITING

45. SILVAH also serves as a report writer, in that the stand analysis and prescription printouts are in narrative form and can be sent to a computer file for use with a word processor. Thus, narrative information from these printouts can be combined with other text and graphics and incorporated into management plans and similar reports. Consultants and service foresters often do this for small properties, and we have seen several management plans where most of the material came directly from SILVAH printouts.

DATA BASE

OUTPUT

46. SILVAH also provides the option of writing the stand summary data to a computer file, from which it can be incorporated into a forest-wide data base for management planning. With such a data base, it is easy to obtain summaries of volumes and values across selected stands, compartments, properties, or ownerships. One can quickly determine how many acres (stands) are ready for harvest or thinning; how many need herbicide treatments, and so on. Unlike data bases generated by many other inventory systems, the data base generated from SILVAH summary records permits users to identify each of the stands included in any summaries generated.

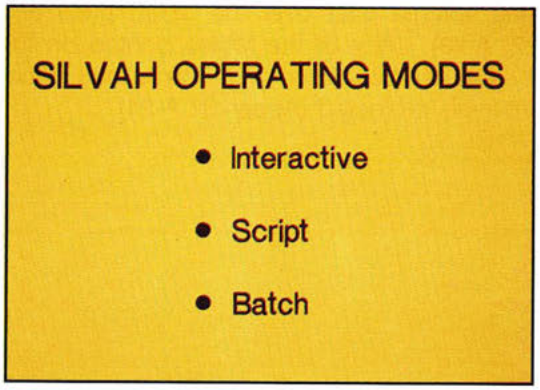


FUTURE

DATA BASES

47. Still another feature is the ability to combine the use of the data base output feature and the stand growth simulator to produce data bases for any future date. Thus, one could produce a data base for the year 2000 that could be used to estimate how many stands will be ready for harvest, thinning, and so on in that decade, and what volumes will be available for cutting.

By using these data bases of future forest conditions in combination with a program of retallying stands after treatment, it is possible to establish a continuous forest inventory process that will materially reduce the cost of traditional forest inventories.

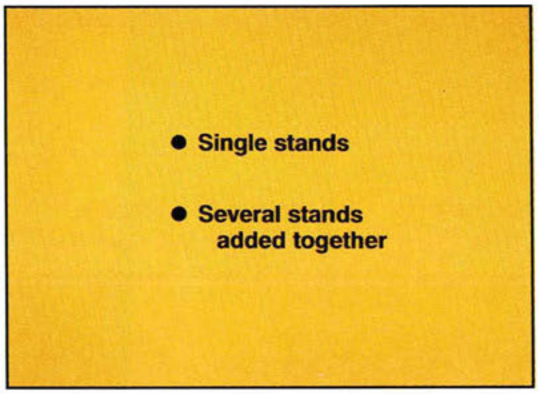


SILVAH OPERATING MODES

- Interactive
- Script
- Batch

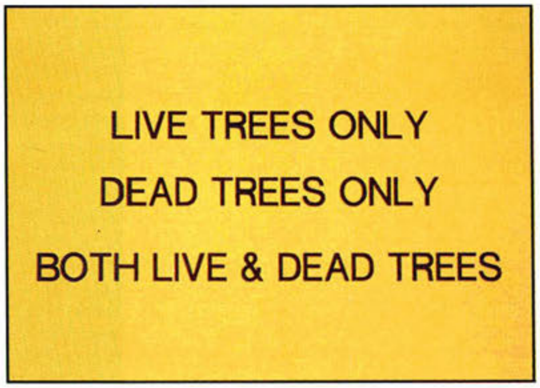
48. SILVAH is a very flexible program. It can be run in three different modes:

   - o Interactive mode allows the user to interact directly with the program, viewing the results of one step before deciding what to do next.
   - o Script mode allows the user to set up a file containing processing instructions. Since many users process their data in the same way, getting the same printouts each time, this script file enables the program to run without answering the same questions for each stand.
   - o Batch mode carries automatic processing a step further, allowing the user to create a file that lists a number of stands to be run at one time. Thus, it is possible to process data from a large number of stands without user intervention (overnight, for example).



- **Single stands**
- **Several stands added together**

49. SILVAH also permits data from several stands to be added together and treated as one stand. This is often convenient to get total volumes from a compartment or property, or to permit combining of data from adjacent stands.

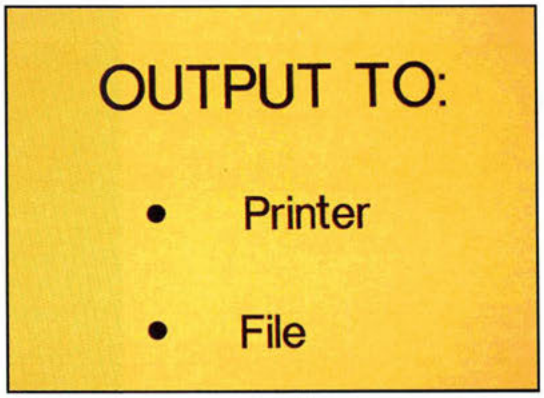


LIVE TREES ONLY

DEAD TREES ONLY

BOTH LIVE & DEAD TREES

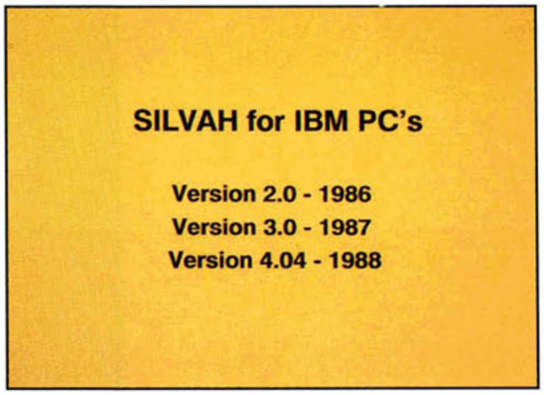
50. Another option is to include only live trees, only dead trees, or both live and dead trees. Inclusion of dead trees in volume estimates is occasionally useful for salvage timber sales and similar programs.



OUTPUT TO:

- Printer
- File

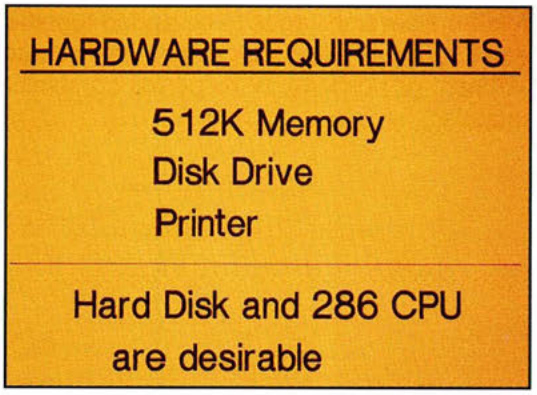
51. Finally, output is usually directed to a printer, but it can easily be redirected to a disk file. This enables printouts to be imported to a word processor and easily incorporated into reports and management plans. It also enables SILVAH to be run without a printer.



SILVAH for IBM PC's

Version 2.0 - 1986
Version 3.0 - 1987
Version 4.04 - 1988

52. The current version of SILVAH is version 4.04, released in October of 1988 for use on IBM compatible microcomputers. Minor revisions and updates are made as the need arises. An identical version is also available for Data General minicomputers.



HARDWARE REQUIREMENTS

512K Memory
Disk Drive
Printer

Hard Disk and 286 CPU
are desirable

53. Minimum hardware required to run SILVAH on a microcomputer consists of:

- 512K memory
- disk drive
- printer
- Hard disk and a 286 or faster CPU are highly desirable.

Selected References

Ernst, Richard L. 1982. Computerized prescription for Allegheny hardwoods. In: Microcomputers: a new tool for foresters - Conference Proceedings; 1982 May 18-20; West Lafayette, IN; SAF Pub. NO. SAF 82-05. West Lafayette, IN: Purdue University: 103-105.

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Marquis, David A.; Ernst, Richard L. 1992. User's Guide to SILVAH: Stand analysis prescription, and management simulator program for hardwood stands of the Alleghenies. Gen. Tech. Rep. NE-162. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 124 p.

Marquis, David.A.; Ernst, Richard.L.; Stout, Susan.L. 1992. Prescribing silvicultural treatment 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.

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

SILVAH V4 - Stand Analysis Tally Form

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

Identification Data

Sheet ____ of ____

Owner/Agency									
Forest/Property									
County/District									
Compartment/Uni		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	

Regeneration Data

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Black cherry														
Small oak														
Other desirables														
Large oak														
Residuals														
Sapling regen														
Woody interference														
Ferns														
Grasses														
Laurel & Rhod.														
Grapevines														
Site limitations														

Overstory Data

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

```
          SILVAH -- SILVICULTURE OF ALLEGHENY HARDWOODS - V4.5
     STAND SUMMARY, PRESCRIPTION, AND MANAGEMENT SIMULATOR PROGRAM
  DEVELOPED BY THE NORTHEASTERN FOREST EXPERIMENT STATION, WARREN, PA.

 OWNER/AGENCY     -- US Forest Serv.          DATE TALLIED:      AUG/1988
 FOREST/PROPERTY -- Allegheny NF              DATE PRINTED:   17/SEP/1988
 COUNTY/DISTRICT -- Ridgway                   FILE: A:\T1.SIL
 COMPT - STAND    -- 12      32               DEFAULT: SILVAH.DEF
 ACRES            --       .00                   TYPE:
 STAND AGE        -- UNKNOWN                     SIZE:
 SITE             --   70 FOR  BC                DENSITY:

This is a test of read time error messages.



 FILE = A:\T1.SIL
**WARNING** ONE OF THE ADVANCE REGEN VALUES IS LARGER THAN "ANY REGN"
**WARNING** THE "ANY REGN" VALUE IS LARGER THAN THE "ANY+RESD" VALUE
**WARNING** ONE OF THE INTERFERING PLANT VALUES IS LARGER THAN "ANY INTF"
**WARNING** NO MATCH FOR SPECIES CODE IN PLOT 1 TREE NO. 1;  CODED OHW
**WARNING** DBH NOT BY 2" CLASS IN PLOT 1 TREE NO. 2;  DBH RAISED 1"
**WARNING** DBH EXCEEDS 40" IN PLOT 1 TREE NO. 3; DBH CHANGED TO 40"
**WARNING** QUALITY CLASS OUT OF RANGE IN PLOT 1 TREE NO. 4;TREATED AS AGS
**WARNING** HEIGHT APPEARS HIGH IN  PLOT 1 TREE NO. 7
**WARNING** HEIGHT ON BULK PRODUCT IN PLOT 1 TREE NO. 8; HEIGHT IGNORED
**WARNING** HEIGHT ON SAPLING OR POLE IN PLOT 1 TREE NO. 11;HEIGHT IGNORED
**WARNING** SAP OR POLE GRADED SAW IN PLOT 1 TREE NO. 12; CHANGED TO PULP
```

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           SILVAH -- SILVICULTURE OF ALLEGHENY HARDWOODS - V4.5
        STAND SUMMARY, PRESCRIPTION, AND MANAGEMENT SIMULATOR PROGRAM
      DEVELOPED BY THE NORTHEASTERN FOREST EXPERIMENT STATION, WARREN, PA.

OWNER/AGENCY     -- US Forest Serv.         DATE TALLIED:       AUG/1988
FOREST/PROPERTY  -- Allegheny NF            DATE PRINTED:    17/SEP/1988
COUNTY/DISTRICT  -- Ridgway                 FILE: A:\T2.SIL
COMPT - STAND    -- 12      32              DEFAULT: SILVAH.DEF
ACRES            --    125.00                  TYPE:     TRANSITION HARDWOOD
STAND AGE        --    68                      SIZE:       SMALL SAW
SITE             --    70 FOR  BC              DENSITY:    GT 95 %
SAMPLE TRANSITION STAND




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, and heights in the HT/COUNT column.

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

Mean basal area is  116. plus or minus   16. square feet per acre
at 90 % confidence ( 13. % of mean).


UNDERSTORY CRUISE INFORMATION
-----------------------------

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

Understory data is based on  30. plots.

                          ****** WARNING ******
Regeneration data is not based on an adequate number of plots to give
reliable results.  At least  1. additional plots needed in this stand.
```

```
            SILVAH -- SILVICULTURE OF ALLEGHENY HARDWOODS - V4.5
       STAND SUMMARY, PRESCRIPTION, AND MANAGEMENT SIMULATOR PROGRAM
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FOREST/PROPERTY -- Allegheny NF           DATE PRINTED:   17/SEP/1988
COUNTY/DISTRICT -- Ridgway                FILE: A:\T2.SIL
COMPT - STAND    -- 12     32             DEFAULT: SILVAH.DEF
ACRES            --   125.00                 TYPE: TRANSITION HARDWOOD
STAND AGE        --   68                     SIZE:      SMALL SAW
SITE             --   70 FOR  BC             DENSITY:   GT 95 %
SAMPLE TRANSITION STAND



SPECIES OR             % OF PLOTS          VALUE
 CATEGORY               STOCKED
----------             ----------          -----

DESIRABLE TREE REGENERATION
---------------------------

BLACK CHERRY                73.
NORTHERN HDWD               77.
SMALL OAK                   27.
LARGE OAK                    3.
ANY REGEN                   83.
RESIDUAL TREES               7.
ANY REGEN + RESD            87.
SAPLING REGEN                0.
OAK SPROUT POTENTIAL        46.        352.   (OAKS/A EXPECTED TO SPROUT)
ANY REGEN + SPROUTS        100.

FACTORS AFFECTING REGENERATION DIFFICULTY
-----------------------------------------

DEER IMPACT                                   4   High
SEED SUPPLY                                   1   Abundant seeds
REGEN DIFFICULTY                              5   Somewhat difficult

INTERFERING UNDERSTORY
---------------------

WOODY INTERFRNCE            10.
LAUREL & RHOD                0.
FERN                        30.
GRASS                        0.
ANY INTERFERENCE            33.
GRAPEVINE                    0.

SITE LIMITATIONS FOR REGENERATION
---------------------------------

SITE LIMITATIONS             7.
```

```
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SITE             --   70 FOR  BC               DENSITY:   GT 95 %
SAMPLE TRANSITION STAND



SPECIES OR             % OF PLOTS         VALUE
 CATEGORY               STOCKED
----------             ----------         -----

SITE INFORMATION
----------------

COVER TYPE                                    1   Forest
HABITAT TYPE                                  9   Unknown
SOIL TYPE                                     9   Unknown
SITE CLASS                                    2   Medium site
SITE SPECIES                                 BC
SITE INDEX                                   70
REL MERCH HT                               1.26
ELEVATION                                  2000
ASPECT                                       25
SLOPE %                                       5
TOPO POSITION                                 6   Upper flat
OPERABILITY                                   1   No limitations
ACCESSABILITY                                 1   2-wh road at stand
STRESS FACTORS
--------------
DEER IMPACT                                   4   High
GYPSY MOTH                                    1   Unimportant
OTHER STRESS                                  2   Light cutting
```

```
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STAND AGE        --   68                       SIZE:      SMALL SAW
SITE             --   70 FOR  BC               DENSITY:   GT 95 %
SAMPLE TRANSITION STAND





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                           12.1
EXISTING DEN TREES                             5.1
SNAGS WITH POTENTIAL CAVITIES                   .0
SNAGS WITH EXISTING CAVITIES                  15.2
OTHER STANDING DEAD TREES (Not Snags)           .0


WATER HABITATS WITHIN THIS STAND INCLUDE:
-----------------------------------------
Spring seep
Stream < 15 ft wide


HABITAT CONDITIONS SURROUNDING THIS STAND
-----------------------------------------
CLEARCUT ACRES W/I 1 MILE                    56.00
CULTIVATED ACRES W/I 1 MILE                   6.00
OPEN ACRES W/I 1 MILE                        30.00
WATER HABITATS INCLUDE:                      Lake
```

```
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COUNTY/DISTRICT  -- Trng Area B             FILE: A:\4A.SIL
COMPT - STAND    -- 4       A               DEFAULT: SILVAH.DEF
ACRES            --     1.00                   TYPE: ALLEGHENY HARDWOOD
STAND AGE        -- UNKNOWN                    SIZE:        SMALL SAW
SITE             -- UNKNOWN                    DENSITY:    GT 95 %
SAMPLE CHERRY-MAPLE STAND

                              ORIGINAL STAND

                       BASAL AREA - SQ. FT. PER ACRE

SPECIES > ALL SP |   BC    AB    SM    RM    YP     B   CUC   STM
 DIA.
 1             .2 |   .0    .2    .0    .0    .0    .0    .0    .0
 2            1.6 |   .0   1.1    .4    .0    .0    .0    .0    .0
 3            3.2 |   .0   1.8   1.3    .0    .0    .0    .0    .0
 4            4.4 |   .0   1.7   2.4    .3    .0    .0    .0    .0
 5            6.5 |   .0   2.0   3.8    .5    .0    .1    .0    .0
 6            5.1 |   .0    .6   4.1    .4    .0    .0    .0    .0
 7            6.7 |   .3   2.1   3.2    .5    .0    .3    .3    .0
 8            5.6 |   .7   1.7   2.4    .3    .0    .3    .0    .0
 9            7.1 |  4.4    .4   1.8    .4    .0    .0    .0    .0
10           15.8 |  8.2   2.2   2.2   1.1    .0   2.2    .0    .0
11            9.2 |  5.9    .7    .0   2.6    .0    .0    .0    .0
12           18.8 |  8.6   4.7    .8   4.7    .0    .0    .0    .0
13           24.0 | 19.4   1.8    .0   1.8    .0    .9    .0    .0
14           15.0 | 12.8   2.1    .0    .0    .0    .0    .0    .0
15           12.3 |  8.6   2.5    .0    .0   1.2    .0    .0    .0
16           11.2 |  8.4    .0    .0   1.4    .0    .0   1.4    .0
17            9.5 |  7.9    .0    .0   1.6    .0    .0    .0    .0
18            3.5 |   .0    .0    .0    .0   3.5    .0    .0    .0

SAPS         15.9 |   .0   6.9   8.0    .9    .0    .1    .0    .0
POLES        49.5 | 19.5   7.8  13.7   5.4    .0   2.8    .3    .0
SM SAW       90.7 | 65.7  11.1    .8   9.5   1.2    .9   1.4    .0
MED SAW       3.5 |   .0    .0    .0    .0   3.5    .0    .0    .0
LG SAW         .0 |   .0    .0    .0    .0    .0    .0    .0    .0
TOTAL       159.6 | 85.2  25.8  22.5  15.8   4.8   3.9   1.7    .0

SPECIES%     100. |  53.   16.   14.   10.    3.    2.    1.    0.


ACCEPTABLE GROWING STOCK ONLY
SAPS         11.1 |   .0   4.7   5.7    .6    .0    .0    .0    .0
POLES        42.5 | 18.2   6.4  10.7   5.0    .0   2.0    .3    .0
SM SAW       80.1 | 56.8  11.1    .0   9.5   1.2    .0   1.4    .0
MED SAW       1.8 |   .0    .0    .0    .0   1.8    .0    .0    .0
LG SAW         .0 |   .0    .0    .0    .0    .0    .0    .0    .0
TOTAL       135.4 | 75.0  22.2  16.4  15.1   3.0   2.0   1.7    .0
```

```
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COMPT - STAND    -- 4       A              DEFAULT: SILVAH.DEF
ACRES            --      1.00                 TYPE: ALLEGHENY HARDWOOD
STAND AGE        -- UNKNOWN                   SIZE:       SMALL SAW
SITE             -- UNKNOWN                   DENSITY:    GT 95 %
SAMPLE CHERRY-MAPLE STAND

                                  ORIGINAL STAND

                   NET VOLUME: DOYLE     LOG RULE - BD. FT. PER ACRE

SPECIES > ALL SP |    BC     AB     SM     RM     YP      B    CUC    STM
 DIA.
 1            0. |    0.     0.     0.     0.     0.     0.     0.     0.
 2            0. |    0.     0.     0.     0.     0.     0.     0.     0.
 3            0. |    0.     0.     0.     0.     0.     0.     0.     0.
 4            0. |    0.     0.     0.     0.     0.     0.     0.     0.
 5            0. |    0.     0.     0.     0.     0.     0.     0.     0.
 6            0. |    0.     0.     0.     0.     0.     0.     0.     0.
 7            0. |    0.     0.     0.     0.     0.     0.     0.     0.
 8            0. |    0.     0.     0.     0.     0.     0.     0.     0.
 9            0. |    0.     0.     0.     0.     0.     0.     0.     0.
10            0. |    0.     0.     0.     0.     0.     0.     0.     0.
11          160. |  120.     4.     0.    35.     0.     0.     0.     0.
12          411. |  247.    52.    17.    96.     0.     0.     0.     0.
13          813. |  718.    29.     0.    51.     0.    15.     0.     0.
14          632. |  587.    45.     0.     0.     0.     0.     0.     0.
15          614. |  468.    64.     0.     0.    83.     0.     0.     0.
16          701. |  529.     0.     0.    71.     0.     0.   101.     0.
17          657. |  565.     0.     0.    92.     0.     0.     0.     0.
18          318. |    0.     0.     0.     0.   318.     0.     0.     0.

SAPS          0. |    0.     0.     0.     0.     0.     0.     0.     0.
POLES       160. |  120.     4.     0.    35.     0.     0.     0.     0.
SM SAW     3829. | 3113.   190.    17.   311.    83.    15.   101.     0.
MED SAW     318. |    0.     0.     0.     0.   318.     0.     0.     0.
LG SAW        0. |    0.     0.     0.     0.     0.     0.     0.     0.
TOTAL      4306. | 3232.   194.    17.   346.   401.    15.   101.     0.

SPECIES%    100. |   75.     5.     0.     8.     9.     0.     2.     0.


ACCEPTABLE GROWING STOCK ONLY
SAPS          0. |    0.     0.     0.     0.     0.     0.     0.     0.
POLES       160. |  120.     4.     0.    35.     0.     0.     0.     0.
SM SAW     3404. | 2719.   190.     0.   311.    83.     0.   101.     0.
MED SAW     159. |    0.     0.     0.     0.   159.     0.     0.     0.
LG SAW        0. |    0.     0.     0.     0.     0.     0.     0.     0.
TOTAL      3723. | 2839.   194.     0.   346.   242.     0.   101.     0.
```

```
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ACRES            --     1.00                    TYPE: ALLEGHENY HARDWOOD
STAND AGE        -- UNKNOWN                     SIZE:       SMALL SAW
SITE             -- UNKNOWN                     DENSITY:    GT 95 %
SAMPLE CHERRY-MAPLE STAND

                              ORIGINAL STAND

                           |              | SUGAR MAPLE        ||
             B. CHER.      | R. MAPLE     | BEECH              ||
             W. ASH        | RED OAK      | STR. MAP.          ||ALL
             Y. POP.       | OTHERS       | OTH. OAK           ||SPECIES

                         BASAL AREA - SQ. FT. PER ACRE

    AGS

SAPS                .0     |          .6  |         10.4       ||        11.1
POLE              18.2     |         7.2  |         17.1       ||        42.5
SSAW              58.0     |        10.9  |         11.1       ||        80.1
MSAW               1.8     |          .0  |           .0       ||         1.8
LSAW                .0     |          .0  |           .0       ||          .0

TOT               78.0     |        18.8  |         38.7       ||       135.4

    UGS

SAPS                .0     |          .4  |          4.4       ||         4.8
POLE               1.3     |         1.3  |          4.4       ||         7.0
SSAW               8.9     |          .9  |           .8       ||        10.6
MSAW               1.8     |          .0  |           .0       ||         1.8
LSAW                .0     |          .0  |           .0       ||          .0

TOT               12.0     |         2.6  |          9.6       ||        24.2

    ALL

SAPS                .0     |         1.0  |         14.8       ||        15.9
POLE              19.5     |         8.5  |         21.5       ||        49.5
SSAW              66.9     |        11.8  |         11.9       ||        90.7
MSAW               3.5     |          .0  |           .0       ||         3.5
LSAW                .0     |          .0  |           .0       ||          .0

TOT               89.9     |        21.4  |         48.3       ||       159.6
```

```
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ACRES            --     1.00                    TYPE: ALLEGHENY HARDWOOD
STAND AGE        -- UNKNOWN                     SIZE:        SMALL SAW
SITE             -- UNKNOWN                     DENSITY:     GT 95 %
SAMPLE CHERRY-MAPLE STAND

                                ORIGINAL STAND

SPECIES >   ALL SP ¦    BC     AB     SM     RM     YP      B    CUC    STM

                        COMPOSITION -- BA, % OF BA, TREES

TOT BA       159.6 ¦  85.2   25.8   22.5   15.8    4.8    3.9    1.7     .0
SPECIES%      100. ¦   53.    16.    14.    10.     3.     2.     1.     0.
# TREES       486. ¦   99.   187.   156.    30.     3.     8.     2.     1.

                           QUALITY -- % IN AGS

SAPS           70. ¦    0.    68.    72.    74.     0.     0.     0.     0.
POLES          86. ¦   93.    82.    78.    91.     0.    71.   100.     0.
SM SAW         88. ¦   86.   100.     0.   100.   100.     0.   100.     0.
MED SAW        50. ¦    0.     0.     0.     0.    50.     0.     0.     0.
LG SAW          0. ¦    0.     0.     0.     0.     0.     0.     0.     0.
ALL SIZE       85. ¦   88.    86.    73.    96.    63.    51.   100.     0.

                     DIAMETERS AND AGES -- INCHES, YEARS

DIAM          11.5 ¦  13.2    9.2    6.6   11.8   17.2   10.2   14.6    2.0
DIAM MER      12.4 ¦  13.2   11.3    7.8   12.2   17.2   10.3   14.6     .0
QUAD DIA       7.8 ¦  12.6    5.0    5.1    9.8   17.1    9.4   12.3    2.0

YRS MAT        31. ¦   24.    45.    68.    29.     4.    51.    17.   120.
EFCT AGE       67. ¦   66.    75.    52.    61.    86.    69.    73.     0.

                              STRUCTURE

Q FACTOR      1.35 ¦   .97   1.24   2.42    .85    .63    .00    .00    .00
WEIB C         .00 ¦   .00    .00    .00    .00    .00    .00    .00    .00

                         RELATIVE DENSITY -- %

REL DEN       101. ¦   36.    26.    23.    10.     2.     3.     1.     0.
AGS RDEN       84. ¦   32.    22.    17.    10.     1.     1.     1.     0.

                  VOLUMES AND VALUES - INT 1/4" LOG RULE

GTOT CDS      41.9 ¦  27.0    4.5    2.9    4.4    1.6     .9     .5     .0
NTOT CDS      33.5 ¦  21.6    3.6    2.4    3.5    1.3     .7     .4     .0
PULP CDS      23.2 ¦  13.7    3.1    2.3    2.7     .4     .7     .2     .0
GRS BDFT     9769. ¦ 6891.   889.    63.  1021.   652.    69.   184.     0.
NET BDFT     7072. ¦ 5354.   328.    32.   591.   585.    25.   156.     0.
DOLLARS       938. ¦  856.     8.     5.    25.    34.     2.     7.     0.
```

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ACRES            --      1.00                 TYPE: ALLEGHENY HARDWOOD
STAND AGE        -- UNKNOWN                   SIZE:        SMALL SAW
SITE             -- UNKNOWN                   DENSITY:     GT 95 %
SAMPLE CHERRY-MAPLE STAND

                                ORIGINAL STAND

                        PRODUCT LISTING    (per acre)


SPECIES >  ALL SP |    BC    AB    SM    RM    YP     B   CUC   STM

           NET LOG VOLUME (INT 1/4" LOG RULE) - MBF PER ACRE

VENEER         .3 |    .2    .0    .0    .0    .0    .0    .0    .0
GRADE 1       1.5 |   1.1    .0    .0    .2    .2    .0    .1    .0
GRADE 2       3.5 |   2.8    .2    .0    .1    .4    .0    .0    .0
GRADE 3       1.8 |   1.3    .2    .0    .3    .0    .0    .0    .0
PALLET         .0 |    .0    .0    .0    .0    .0    .0    .0    .0
TOTAL         7.1 |   5.4    .3    .0    .6    .6    .0    .2    .0

                   NET BULK VOLUME - CORDS PER ACRE

BOLTWOOD       .0 |    .0    .0    .0    .0    .0    .0    .0    .0
PULPWOOD     23.2 |  13.7   3.1   2.3   2.7    .4    .7    .2    .0
FIREWOOD       .0 |    .0    .0    .0    .0    .0    .0    .0    .0
TOTAL        23.2 |  13.7   3.1   2.3   2.7    .4    .7    .2    .0

                     VALUE - DOLLARS PER ACRE

VENEER        54. |   49.    0.    0.    2.    2.    0.    1.    0.
GRADE 1      303. |  277.    0.    0.   10.   12.    0.    4.    0.
GRADE 2      399. |  373.    1.    0.    4.   19.    0.    1.    0.
GRADE 3      136. |  130.    1.    0.    4.    0.    0.    1.    0.
PALLET         0. |    0.    0.    0.    0.    0.    0.    0.    0.
TOTAL        892. |  829.    2.    0.   20.   34.    1.    7.    0.

$/MBF        126. |  155.    6.    5.   34.   57.   20.   42.    0.

BOLTWOOD       0. |    0.    0.    0.    0.    0.    0.    0.    0.
PULPWOOD      46. |   27.    6.    5.    5.    1.    1.    0.    0.
FIREWOOD       0. |    0.    0.    0.    0.    0.    0.    0.    0.
TOTAL         46. |   27.    6.    5.    5.    1.    1.    0.    0.

$/CORD         2. |    2.    2.    2.    2.    2.    2.    2.    0.

GR.TOTAL     938. |  856.    8.    5.   25.   34.    2.    7.    0.
```

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FOREST/PROPERTY -- Allegheny NF           DATE PRINTED:   17/SEP/1988
COUNTY/DISTRICT -- Ridgway                FILE: A:\T2.SIL
COMPT - STAND    -- 12     32              DEFAULT: SILVAH.DEF
ACRES            --   125.00                  TYPE: TRANSITION HARDWOOD
STAND AGE        --   68                      SIZE:       SMALL SAW
SITE             --   70 FOR  BC              DENSITY:    GT 95 %
SAMPLE TRANSITION STAND

                                ORIGINAL STAND

                         PRODUCT LISTING (total stand)

SPECIES >   ALL SP |    SM    NRO     CO     BC     WO     AB     RM

              NET LOG VOLUME (INT 1/4" LOG RULE) - MBF /      1

VENEER          .0 |    .0     .0     .0     .0     .0     .0     .0
GRADE 1      353.3 |    .0   50.7     .0  302.6     .0     .0     .0
GRADE 2      102.4 |    .0  102.4     .0     .0     .0     .0     .0
GRADE 3      317.8 |    .0     .0  145.0     .0   58.8  107.0    7.0
PALLET          .0 |    .0     .0     .0     .0     .0     .0     .0
TOTAL        773.5 |    .0  153.1  145.0  302.6   58.8  107.0    7.0

                     NET BULK VOLUME - CORDS /     10

BOLTWOOD        .0 |    .0     .0     .0     .0     .0     .0     .0
PULPWOOD     131.1 |  32.5   15.4   31.8   18.4   26.1    6.0     .9
FIREWOOD        .0 |    .0     .0     .0     .0     .0     .0     .0
TOTAL        131.1 |  32.5   15.4   31.8   18.4   26.1    6.0     .9

                        VALUE - DOLLARS /    100

VENEER          .0 |    .0     .0     .0     .0     .0     .0     .0
GRADE 1      766.4 |    .0   76.8     .0  689.6     .0     .0     .0
GRADE 2      137.3 |    .0  137.3     .0     .0     .0     .0     .0
GRADE 3       68.2 |    .0     .0   18.6     .0   31.6   17.3     .8
PALLET          .0 |    .0     .0     .0     .0     .0     .0     .0
TOTAL        971.9 |    .0  214.0   18.6  689.6   31.6   17.3     .8

$/MBF         126. |    0.   140.    13.   228.    54.    16.    11.

BOLTWOOD        .0 |    .0     .0     .0     .0     .0     .0     .0
PULPWOOD      26.2 |   6.5    3.1    6.4    3.7    5.2    1.2     .2
FIREWOOD        .0 |    .0     .0     .0     .0     .0     .0     .0
TOTAL         26.2 |   6.5    3.1    6.4    3.7    5.2    1.2     .2

$/CORD          2. |    2.     2.     2.     2.     2.     2.     2.

GR.TOTAL     998.1 |   6.5  217.1   25.0  693.3   36.8   18.4    1.0
```

```
                          SILVAH V4.5 -- SYSTEM DEFAULTS


For default file: SILVAH.DEF


Owner/Agency:                                 US Forest Serv.
Species codes:                                1
Dbh classes:                                  2
Overstory cruise type:                        7
BAF/Plot size:                                    10
Regen cruise type:                            1
Plot size:                                    1
Management goal:                              1
Management value:                             2
Deer pressure:                                4
Log Rule:                                     1
Name of local boltwood product:               BOLTWOOD
Name of local log product:                    PALLET
Data drive & path: A:\
List drive & path: C:\SCRATCH\
Script drive & path: C:\FORESTRY\SILVAH\
How SILVAH interacts:                         2
Trees included (1=live, 2=dead, 3=both):      1
Output list dev. (1=printer, 2=file):         1


                 COMMERCIAL SALE BREAKPOINTS

                      Board Feet     Cords
                      ----------     -----
Sawtimber sale          2000.          0.
Integrated sale         1500.          5.
Cordwood sale              0.          7.


            MINIMUM DIAMETERS FOR VOLUME CALCULATIONS

                      Hardwoods      Softwoods
                      ---------      ---------
Pulp                     5.5            5.5
Sawtimber               10.5            8.5
```

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                              SILVAH V4.5 -- SPECIES DEFAULTS

For default file: SILVAH.DEF

-- SPECIES --  FC   PCF   SCF  $/MBF    $/VEN   $/CD   $/BOLT.  $/CONST.
-------------  ---  ----  ---- -------  ------  -----  -------  --------

 OSW   0   1   82.  1.00  1.00    12.      0.   2.00      .00        0.
 OHW  88   4   82.  1.00  1.00    20.      0.   2.00      .00        0.
  BF   0  12   82.  1.00  1.00    12.      0.   2.00      .00        0.
 ERC   0  68   82.  1.00  1.00    12.      0.   2.00      .00        0.
   L   0  70   82.  1.00  1.00    12.      0.   2.00      .00        0.
 TAM   0  71   82.  1.00  1.00    12.      0.   2.00      .00        0.
   S   0  90   82.  1.00  1.00    12.      0.   2.00      .00        0.
  NS   0  91   82.  1.00  1.00    12.      0.   2.00      .00        0.
  WS   0  94   82.  1.00  1.00    12.      0.   2.00      .00        0.
  BS   0  95   82.  1.00  1.00    12.      0.   2.00      .00        0.
  RS   0  97   82.  1.00  1.00    12.      0.   2.00      .00        0.
   P   0 100   82.  1.00  1.00    12.      0.   2.00      .00        0.
  JP   0 105   82.  1.00  1.00    12.      0.   2.00      .00        0.
  RP   0 125   82.  1.00  1.00    12.      0.   2.00      .00        0.
  PP   0 126   82.  1.00  1.00    12.      0.   2.00      .00        0.
  WP   1 129   82.  1.00  1.00    80.      0.   2.00      .00        0.
  VP   0 132   82.  1.00  1.00    12.      0.   2.00      .00        0.
  SP   0 170   82.  1.00  1.00    12.      0.   2.00      .00        0.
 NWC   0 241   82.  1.00  1.00    12.      0.   2.00      .00        0.
  EH   6 261   82.  1.00  1.00    20.      0.   2.00      .00        0.
   M   0 310   82.  1.00  1.00    12.      0.   2.00      .00        0.
  RM  21 316   82.  1.00  1.00    54.    100.   2.00      .00        0.
 SVM   0 317   82.  1.00  1.00    12.      0.   2.00      .00        0.
  SM  20 318   82.  1.00  1.00    55.    150.   2.00      .00        0.
 BUC   0 330   82.  1.00  1.00    12.      0.   2.00      .00        0.
   B  50 370   82.  1.00  1.00    36.      0.   2.00      .00        0.
  YB   0 371   82.  1.00  1.00    36.    150.   2.00      .00        0.
  SB   0 372   82.  1.00  1.00    12.      0.   2.00      .00        0.
  PB   0 375   82.  1.00  1.00    12.      0.   2.00      .00        0.
   H  60 400   82.  1.00  1.00    12.      0.   2.00      .00        0.
  BH   0 402   82.  1.00  1.00    12.      0.   2.00      .00        0.
  PH   0 403   82.  1.00  1.00    12.      0.   2.00      .00        0.
 PCN   0 404   82.  1.00  1.00    12.      0.   2.00      .00        0.
 SLH   0 405   82.  1.00  1.00    12.      0.   2.00      .00        0.
 SGH   0 407   82.  1.00  1.00    12.      0.   2.00      .00        0.
  MH   0 409   82.  1.00  1.00    12.      0.   2.00      .00        0.
 HAC   0 460   82.  1.00  1.00    12.      0.   2.00      .00        0.
  YW   0 481   82.  1.00  1.00    12.      0.   2.00      .00        0.
 PER   0 521   82.  1.00  1.00    12.      0.   2.00      .00        0.
  AB  54 531   82.  1.00  1.00    19.      0.   2.00      .00        0.
   A   0 540   82.  1.00  1.00    12.      0.   2.00      .00        0.
  WA  55 541   82.  1.00  1.00   118.    400.   2.00      .00        0.
  BA   0 543   82.  1.00  1.00    12.      0.   2.00      .00        0.
  GA   0 544   82.  1.00  1.00    12.      0.   2.00      .00        0.
  HL   0 552   82.  1.00  1.00    12.      0.   2.00      .00        0.
 BUT  71 601   82.  1.00  1.00    12.      0.   2.00      .00        0.
  BW   0 602   82.  1.00  1.00    12.      0.   2.00      .00        0.
  SG   0 611   82.  1.00  1.00    12.      0.   2.00      .00        0.
  YP  59 621   82.  1.00  1.00    53.      0.   2.00      .00        0.
 CUC  84 651   82.  1.00  1.00    44.      0.   2.00      .00        0.
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            SILVAH -- SILVICULTURE OF ALLEGHENY HARDWOODS - V4.5
       STAND SUMMARY, PRESCRIPTION, AND MANAGEMENT SIMULATOR PROGRAM
    DEVELOPED BY THE NORTHEASTERN FOREST EXPERIMENT STATION, WARREN, PA.

OWNER/AGENCY     -- US Forest Serv.          DATE TALLIED:      AUG/1988
FOREST/PROPERTY -- Allegheny NF              DATE PRINTED:   17/SEP/1988
COUNTY/DISTRICT -- Ridgway                   FILE: A:\T2.SIL
COMPT - STAND    -- 12      32               DEFAULT: SILVAH.DEF
ACRES            --   125.00                    TYPE: TRANSITION HARDWOOD
STAND AGE        --   68                        SIZE:      SMALL SAW
SITE             --   70 FOR  BC                DENSITY:   GT 95 %
SAMPLE TRANSITION STAND


This transition stand is dominated by
Sugar Maple, Red Oak, Chestnut Oak, Black Cherry, White Oak, and  Beech,
which together comprise  92. % of the basal area.

This is a small sawtimber stand, with average diameter of 12.1 inches.
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.

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   24.
Effective stand age is about  81. years.

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.

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 the better stems is
highly desirable at this time.

Total growing stock amounts to 116. sq. ft. of basal area per acre.
Gross total volume in all trees, to a 4-inch top, is    18. cords per acre;
if divided into pulpwood and sawtimber, the net merchantable volume
is   10. cords of pulp wood and   6188. board feet of
sawtimber Int 1/4"log rule.
The total stand value is estimated to be about    798. dollars per acre.

Trees of acceptable quality for future growing stock
provide a fully stocked stand by themselves.

Undesirable understory plants may interfere with regeneration.
Dense fern understory may limit regeneration.

Advance seedlings are abundant and should provide the basis
for successful natural regeneration if the overstory is harvested.
The next stand will be dominated by Black Cherry
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          SILVAH -- SILVICULTURE OF ALLEGHENY HARDWOODS - V4.5
      STAND SUMMARY, PRESCRIPTION, AND MANAGEMENT SIMULATOR PROGRAM
   DEVELOPED BY THE NORTHEASTERN FOREST EXPERIMENT STATION, WARREN, PA.

OWNER/AGENCY     -- US FOREST SERV.          DATE TALLIED:      JUL/  88
FOREST/PROPERTY  -- KEF                      DATE PRINTED:   17/SEP/1988
COUNTY/DISTRICT  -- Trng Area B              FILE: A:\4A.SIL
COMPT - STAND    -- 4        A               DEFAULT: SILVAH.DEF
ACRES            --     1.00                    TYPE: ALLEGHENY HARDWOOD
STAND AGE        -- UNKNOWN                     SIZE:      SMALL SAW
SITE             -- UNKNOWN                     DENSITY:   GT 95 %
SAMPLE CHERRY-MAPLE STAND




******RECOMMENDED TREATMENT:******


Make a COMMERCIAL THINNING (INTEGRATED)
to provide additional growing space for the better trees,
and to provide some intermediate yield.
The volumes to be removed are:
 1704. bd ft (Int 1/4" log rule) and  9.0 cords.



MARKING INSTRUCTIONS


Reduce relative stand density to  66. %
leaving  106. sq. ft. of basal area per acre.
Remove trees in the size and quality classes shown below.

Cut  2. out of  3. trees from the pole size class.

Cut  1. out of  5. trees from the ssaw size class.

Cut  3. out of  5. trees from the msaw size class.


About  36 % of the trees cut will be UGS.
This will result in removal of about  80 % of the UGS in this stand,
and about 100 % of the merchantable-size 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.
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            SILVAH -- SILVICULTURE OF ALLEGHENY HARDWOODS - V4.5
       STAND SUMMARY, PRESCRIPTION, AND MANAGEMENT SIMULATOR PROGRAM
    DEVELOPED BY THE NORTHEASTERN FOREST EXPERIMENT STATION, WARREN, PA.

OWNER/AGENCY    -- US Forest Serv.        DATE TALLIED:      AUG/1988
FOREST/PROPERTY -- Allegheny NF           DATE PRINTED:   17/SEP/1988
COUNTY/DISTRICT -- Ridgway                FILE: A:\T2.SIL
COMPT - STAND   -- 12     32              DEFAULT: SILVAH.DEF
ACRES           --   125.00                  TYPE: TRANSITION HARDWOOD
STAND AGE       --   68                      SIZE:      SMALL SAW
SITE            --   70 FOR  BC              DENSITY:   GT 95 %
SAMPLE TRANSITION STAND



******RECOMMENDED TREATMENT:******


NOTE: A COMMERCIAL THINNING (INTEGRATED)
would normally be recommended for this stand,
but there is insufficient volume available for such a cutting.  Therefore:

Defer any cutting now and re-examine the stand in about 10 years.


** WARNING ** Relative density is just above the 35% decision point;
              A harvest cutting may also be appropriate.
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            SILVAH -- SILVICULTURE OF ALLEGHENY HARDWOODS - V4.5
       STAND SUMMARY, PRESCRIPTION, AND MANAGEMENT SIMULATOR PROGRAM
    DEVELOPED BY THE NORTHEASTERN FOREST EXPERIMENT STATION, WARREN, PA.

OWNER/AGENCY     -- US FOREST SERV.          DATE TALLIED:      JUL/ 88
FOREST/PROPERTY  -- KEF                      DATE PRINTED:   17/SEP/1988
COUNTY/DISTRICT  -- Trng Area B              FILE: A:\4A.SIL
COMPT - STAND    -- 4      A                 DEFAULT: SILVAH.DEF
ACRES            --     1.00                    TYPE: ALLEGHENY HARDWOOD
STAND AGE        -- UNKNOWN                     SIZE:      SMALL SAW
SITE             -- UNKNOWN                     DENSITY:   GT 95 %
SAMPLE CHERRY-MAPLE STAND

            ORIGINAL   CUT   RESIDUAL  |      ORIGINAL   CUT   RESIDUAL

            BASAL AREA - SQ FT/A       |        SPECIES COMPOSITION - %

  SAPS        15.9      .0     15.9    | % BC       53.               55.
  POLES       49.5    33.8     15.7    | % YP        3.                2.
  SM SAW      90.7    17.8     72.9    | % CUC       1.                1.
  MED SAW      3.5     2.2      1.4    | % SM       14.               11.
  LG SAW        .0      .0       .0    | % RM       10.               11.
  TOTAL      159.6    53.7    105.8    | % AB       16.               18.
            NUMBER OF TREES - #/A      |          QUALITY -- % IN AGS

  # TREES     486.    107.     379.    | % AGS      85.               95.

               DIAMETERS - IN.         |               AGES - YRS.

  DIAM        11.5             11.9    | YRS MAT    31.               26.
  DIAM MER    12.4             13.3    | EFCT AGE   67.               72.
  QUAD DIA     7.8              7.2    |

            RELATIVE DENSITY - %       |                STRUCTURE

  REL DEN     101.              66.    | Q FACTOR   1.4               1.0
  AGS RDEN     84.              60.    | WEIB C      .0                .0

         BD FT INT 1/4", VALUE/A       |             CORD VOLUME/A

  GR. BDFT   9769.   2373.    7396.    | TOT CDS   41.9     14.4     27.5
  NET BDFT   7072.   1704.    5368.    | NET CDS   33.5     11.5     22.0
  DOLLARS     938.    220.     718.    | PULP CDS  23.2      9.0     14.1

  -------------------------- TOTAL STAND -----------------------------
          BD FT INT 1/4", VALUE        |              CORD VOLUME

  GR. MBF      9.8     2.4      7.4    | TOT CDS    42.      14.      27.
  NET MBF      7.1     1.7      5.4    | NET CDS    33.      12.      22.
  M DOLLAR      .9      .2       .7    | PULP CDS   23.       9.      14.
```

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          SILVAH -- SILVICULTURE OF ALLEGHENY HARDWOODS - V4.5
     STAND SUMMARY, PRESCRIPTION, AND MANAGEMENT SIMULATOR PROGRAM
  DEVELOPED BY THE NORTHEASTERN FOREST EXPERIMENT STATION, WARREN, PA.

OWNER/AGENCY     -- US FOREST SERV.         DATE TALLIED:       JUL/  88
FOREST/PROPERTY  -- KEF                     DATE PRINTED:    17/SEP/1988
COUNTY/DISTRICT  -- Trng Area B             FILE: A:\4A.SIL
COMPT - STAND    -- 4        A              DEFAULT: SILVAH.DEF
ACRES            --      1.00                  TYPE: ALLEGHENY HARDWOOD
STAND AGE        -- UNKNOWN                    SIZE:       SMALL SAW
SITE             -- UNKNOWN                    DENSITY:    50 TO 80 %
SAMPLE CHERRY-MAPLE STAND

                                RESIDUAL STAND

                          BASAL AREA - SQ. FT. PER ACRE

SPECIES > ALL SP |    BC     AB     SM     RM     YP      B    CUC    STM
 DIA.
 1             .2 |    .0     .2     .0     .0     .0     .0     .0     .0
 2            1.6 |    .0    1.1     .4     .0     .0     .0     .0     .0
 3            3.2 |    .0    1.8    1.3     .0     .0     .0     .0     .0
 4            4.4 |    .0    1.7    2.4     .3     .0     .0     .0     .0
 5            6.5 |    .0    2.0    3.8     .5     .0     .1     .0     .0
 6            1.3 |    .0     .1    1.1     .1     .0     .0     .0     .0
 7            2.0 |    .1     .7    1.0     .1     .0     .0     .1     .0
 8            1.8 |    .3     .5     .8     .1     .0     .1     .0     .0
 9            2.0 |   1.1     .2     .5     .2     .0     .0     .0     .0
10            5.2 |   3.0     .6     .6     .4     .0     .6     .0     .0
11            3.4 |   2.2     .2     .0    1.0     .0     .0     .0     .0
12           13.6 |   5.0    4.3     .0    4.3     .0     .0     .0     .0
13           18.5 |  15.1    1.7     .0    1.7     .0     .0     .0     .0
14           13.6 |  11.7    1.9     .0     .0     .0     .0     .0     .0
15           11.2 |   7.8    2.2     .0     .0    1.1     .0     .0     .0
16            8.9 |   6.4     .0     .0    1.3     .0     .0    1.3     .0
17            7.2 |   5.7     .0     .0    1.4     .0     .0     .0     .0
18            1.4 |    .0     .0     .0     .0    1.4     .0     .0     .0

SAPS         15.9 |    .0    6.9    8.0     .9     .0     .1     .0     .0
POLES        15.7 |   6.7    2.4    3.9    1.8     .0     .7     .1     .0
SM SAW       72.9 |  51.7   10.1     .0    8.7    1.1     .0    1.3     .0
MED SAW       1.4 |    .0     .0     .0     .0    1.4     .0     .0     .0
LG SAW         .0 |    .0     .0     .0     .0     .0     .0     .0     .0
TOTAL       105.8 |  58.4   19.4   11.9   11.4    2.5     .9    1.4     .0

SPECIES%     100. |   55.    18.    11.    11.     2.     1.     1.     0.


ACCEPTABLE GROWING STOCK ONLY
SAPS         11.1 |    .0    4.7    5.7     .6     .0     .0     .0     .0
POLES        15.7 |   6.7    2.4    3.9    1.8     .0     .7     .1     .0
SM SAW       72.9 |  51.7   10.1     .0    8.7    1.1     .0    1.3     .0
MED SAW       1.4 |    .0     .0     .0     .0    1.4     .0     .0     .0
LG SAW         .0 |    .0     .0     .0     .0     .0     .0     .0     .0
TOTAL       101.0 |  58.4   17.2    9.7   11.1    2.5     .7    1.4     .0
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          SILVAH -- SILVICULTURE OF ALLEGHENY HARDWOODS - V4.5
     STAND SUMMARY, PRESCRIPTION, AND MANAGEMENT SIMULATOR PROGRAM
   DEVELOPED BY THE NORTHEASTERN FOREST EXPERIMENT STATION, WARREN, PA.

OWNER/AGENCY     -- US Forest Serv.         DATE TALLIED:      AUG/1988
FOREST/PROPERTY  -- Allegheny NF            DATE PRINTED:   17/SEP/1988
COUNTY/DISTRICT  -- Ridgway                 FILE: A:\T2.SIL
COMPT - STAND    -- 12      32              DEFAULT: SILVAH.DEF
ACRES            --   125.00                   TYPE: TRANSITION HARDWOOD
STAND AGE        --   68                       SIZE:      SMALL SAW
SITE             --   70 FOR  BC               DENSITY:   GT 95 %
SAMPLE TRANSITION STAND


******TREATMENT SPECIFIED BY USER:******


The volumes to be removed are:
 1560. bd ft (Int 1/4" log rule) and  4.0 cords if an integrated sale
or  4.3 cords if a pulpwood only sale.



MARKING INSTRUCTIONS


Reduce relative stand density to  60. %,
leaving   75. sq. ft. of basal area per acre.
Remove trees in the size classes shown below.

Cut  1. out of  2. trees from the pole size class.

Cut  1. out of  2. trees from the ssaw size class.

Cut  1. out of  6. trees from the msaw size class.

Cut  5. out of  6. trees from the lsaw size class.

About 100 % of the trees cut will be UGS.
This will result in removal of about  89 % of the UGS in this stand,
and about  89 % of the merchantable-size UGS.


SPECIFICATIONS USED FOR THIS CUT ARE BASED ON
A SELECTION CUT

   MINIMUM      MAXIMUM     STRUCTURE     MAXIMUM        Q
   DENSITY      REMOVED      FACTOR      DIAMETER     FACTOR

     60           45                        26          1.2

   SPECIES      DIA TO DIA   QUAL TO QUAL    % CUT     PRIORITY

     ALL         6     11     2      2        100          2
     ALL        12     17     2      2         83          2
     ALL        18     23     2      2         83          2
     ALL        24     40     2      2         83          2
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          SILVAH -- SILVICULTURE OF ALLEGHENY HARDWOODS - V4.5
     STAND SUMMARY, PRESCRIPTION, AND MANAGEMENT SIMULATOR PROGRAM
  DEVELOPED BY THE NORTHEASTERN FOREST EXPERIMENT STATION, WARREN, PA.

OWNER/AGENCY     -- US Forest Serv.          DATE TALLIED:      AUG/1988
FOREST/PROPERTY  -- Allegheny NF             DATE PRINTED:   17/SEP/1988
COUNTY/DISTRICT  -- Ridgway                  FILE: A:\T2.SIL
COMPT - STAND    -- 12      32               DEFAULT: SILVAH.DEF
ACRES            --   125.00                    TYPE: TRANSITION HARDWOOD
STAND AGE        --   68                        SIZE:      SMALL SAW
SITE             --   70 FOR  BC                DENSITY:   GT 95 %
SAMPLE TRANSITION STAND


******TREATMENT SPECIFIED BY USER:******


The volumes to be removed are:
 2966. bd ft (Int 1/4" log rule) and  4.1 cords if an integrated sale
or  6.6 cords if a pulpwood only sale.



MARKING INSTRUCTIONS


Reduce relative stand density to  60. %,
leaving   70. sq. ft. of basal area per acre.
Remove trees in the size classes shown below.

Cut  1. out of  3. trees from the pole size class.

Cut  2. out of  5. trees from the ssaw size class.

Cut  3. out of  5. trees from the msaw size class.

Cut all of the trees from the lsaw size class.

About  77 % of the trees cut will be UGS.
This will result in removal of about  76 % of the UGS in this stand,
and about  76 % of the merchantable-size UGS.



SPECIFICATIONS USED FOR THIS USER-DEFINED CUT:

   MINIMUM      MAXIMUM      STRUCTURE     MAXIMUM         Q
   DENSITY      REMOVED       FACTOR       DIAMETER      FACTOR

     60           45           0/ 0

   SPECIES      DIA TO DIA   QUAL TO QUAL   % CUT        PRIORITY

     AB          6     40     1       2      100            1
    ALL         20     40     1       2       71            2
    ALL          6     18     2       2       71            2
    ALL          6     40     1       1        0            3
```

```
            SILVAH -- SILVICULTURE OF ALLEGHENY HARDWOODS - V4.5
        STAND SUMMARY, PRESCRIPTION, AND MANAGEMENT SIMULATOR PROGRAM
    DEVELOPED BY THE NORTHEASTERN FOREST EXPERIMENT STATION, WARREN, PA.

OWNER/AGENCY     -- US FOREST SERV.          DATE TALLIED:       JUL/  88
FOREST/PROPERTY  -- KEF                      DATE PRINTED:    17/SEP/1988
COUNTY/DISTRICT  -- Trng Area B              FILE: A:\4A.SIL
COMPT - STAND    -- 4       A                DEFAULT: SILVAH.DEF
ACRES            --      1.00                   TYPE:
STAND AGE        -- VARIOUS                     SIZE:
SITE             -- UNKNOWN                     DENSITY:
SAMPLE CHERRY-MAPLE STAND

                          SIMULATED STAND DEVELOPMENT
                          ---------------------------


YRS  NO.    BASAL REL   DIA    %   %     %    TOT PULP MBF    $     NET   MORT
    TREES   AREA  DEN   MER   CAP M&B   OAK   CDS CDS              GROWTH
 --------------------------------------------------------------------------------
-------------------

  0  486    160   101  12.4   56   30     0    33  23   7.1   938
CUT  107     54    35                          12   9   1.7   220
RES  379    106    66  13.3   58   30     0    22  14   5.4   718
                                                                     2.49   .05
  5  375    118    71  14.0   59   28     0    26  15   7.0  1097
                                                                     2.55   .05
 10  370    131    76  14.8   60   27     0    29  17   8.7  1611
                                                                     2.59   .06
 15  364    144    80  15.6   61   26     0    33  18  10.6  2248
CUT   58     33    20                           7   5   2.0   461
RES  307    111    60  16.2   64   23     0    26  14   8.6  1787
                                                                     2.46   .04
 20  302    124    64  17.1   66   22     0    30  15  10.4  2398
                                                                     2.49   .04
 25  297    136    69  17.9   67   21     0    33  16  12.3  3037
                                                                     2.49   .04
 30  293    149    73  18.7   67   20     0    37  18  14.2  3713
CUT  293    149    73                          37  18  14.2  3713
RES    0      0     0    .0    0    0     0     0   0    .0     0
```

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          SILVAH -- SILVICULTURE OF ALLEGHENY HARDWOODS - V4.5
      STAND SUMMARY, PRESCRIPTION, AND MANAGEMENT SIMULATOR PRARREN, PA.

OWNER/AGENCY      -- US FOREST SERV.         DATE TALLIED:      JUL/  88
FOREST/PROPERTY -- KEF                       DATE PRINTED:   17/SEP/1988
COUNTY/DISTRICT -- Trng Area B               FILE: A:\4A.SIL
COMPT - STAND     -- 4       A               DEFAULT: SILVAH.DEF
ACRES             --      1.00                  TYPE:
STAND AGE         -- VARIOUS                    SIZE:
SITE              -- UNKNOWN                    DENSITY:
SAMPLE CHERRY-MAPLE STAND

                                 SIMULATED PRODUCT YIELD
                                 -----------------------


YRS      DATE                  TOTAL       PULP        MBF          $
                               CORDS       CORDS       SAW        TOTAL
------------------------------------------------------------------------
----------------


INITIAL STAND

   0       88                  22.0        14.1        5.4         718.

CUTTING YIELDS

   0       88                  11.5         9.0        1.7         220.
  15      103                   7.4         4.6        2.0         461.
  30      118                  37.3        17.6       14.2        3713.

FINAL STAND

  30      118                    .0          .0         .0           0.

------------------------------------------------------------------------
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TOTAL YIELD                    56.2        31.3       17.9        4394.
```

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          SILVAH -- SILVICULTURE OF ALLEGHENY HARDWOODS - V4.5
     STAND SUMMARY, PRESCRIPTION, AND MANAGEMENT SIMULATOR PROGRAM
  DEVELOPED BY THE NORTHEASTERN FOREST EXPERIMENT STATION, WARREN, PA.

 OWNER/AGENCY     -- US FOREST SERV.       YEAR SIMULATED:  10   (  98)
 FOREST/PROPERTY  -- KEF                   DATE PRINTED:    17/SEP/1988
 COUNTY/DISTRICT  -- Trng Area B           FILE: A:\4A.SIL
 COMPT - STAND    -- 4       A             DEFAULT: SILVAH.DEF
 ACRES            --      1.00                TYPE: ALLEGHENY HARDWOOD
 STAND AGE        -- UNKNOWN                  SIZE:       MEDIUM SAW
 SITE             -- UNKNOWN                  DENSITY:    50 TO 80 %
 SAMPLE CHERRY-MAPLE STAND

                                  SIMULATED STAND

 SPECIES >  ALL SP |    BC     AB     SM     RM     YP      B    CUC    STM

                      COMPOSITION -- BA, % OF BA, TREES

 TOT BA      131.0 |  75.6   22.1   13.4   13.8    3.2    1.0    1.7     .0
 SPECIES%     100. |   58.    17.    10.    11.     2.     1.     1.     0.
 # TREES      370. |   61.   166.   116.    20.     2.     2.     1.     1.

                         QUALITY -- % IN AGS

 SAPS          68. |    0.    66.    71.    73.     0.     0.     0.     0.
 POLES         96. |  100.    95.    94.    95.     0.    92.   100.     0.
 SM SAW       100. |  100.   100.   100.   100.   100.   100.   100.     0.
 MED SAW      100. |  100.     0.     0.   100.   100.     0.   100.     0.
 LG SAW         0. |    0.     0.     0.     0.     0.     0.     0.     0.
 ALL SIZE      96. |  100.    89.    82.    98.   100.    86.   100.     0.

                   DIAMETERS AND AGES -- INCHES, YEARS

DIAM          13.6 |   15.7   10.0    5.9   13.9   19.0   10.0   17.2    2.0
DIAM MER      14.8 |   15.7   12.8    7.7   14.3   19.0   10.5   17.2     .0
QUAD DIA       8.1 |   15.1    4.9    4.6   11.2   18.7    8.9   15.6    2.0

YRS MAT        17. |    11.    35.    69.    18.     0.    50.     4.   120.
EFCT AGE       80. |    79.    85.    51.    72.    95.    70.    86.     0.

                                STRUCTURE

Q FACTOR      1.09 |   1.03   1.12   3.12    .80    .00    .00    .00    .00
WEIB C         .00 |    .00    .00    .00    .00    .00    .00    .00    .00

                          RELATIVE DENSITY -- %

REL DEN        76. |    28.    22.    14.     8.     1.     1.     1.     0.
AGS RDEN       70. |    28.    20.    11.     8.     1.     1.     1.     8.

                  VOLUMES AND VALUES - INT 1/4" LOG RULE

GTOT CDS      36.7 |   25.5    3.9    1.3    4.1    1.1     .2     .6     .0
NTOT CDS      29.4 |   20.4    3.1    1.0    3.3     .9     .2     .4     .0
PULP CDS      16.9 |   10.6    2.5    1.0    2.2     .3     .2     .2     .0
GRS BDFT    11029. |  8090.   998.    41.  1175.   466.    38.   221.     0.
NET BDFT     8703. |  6838.   420.    18.   790.   427.    10.   200.     0.
DOLLARS      1611. |  1516.     9.     2.    44.    29.     0.    11.     0.
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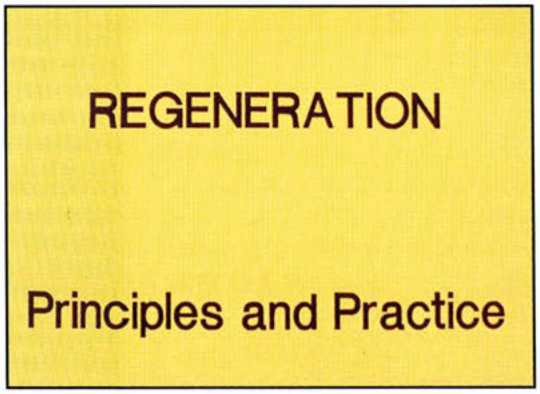
Regeneration Principles and Practices

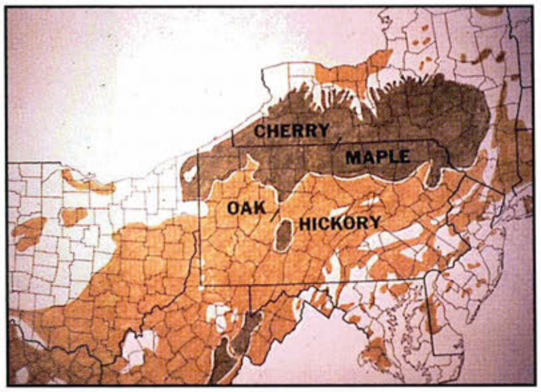
Stephen B. Horsley, L. R. Auchmoody, Russell S. Walters



REGENERATION

Principles and Practice

1. The SILVAH stand analysis and prescription system provides a systematic procedure for analyzing data from forest stands in order to choose a silvicultural prescription. In stands being managed under an even-age system, regeneration cuttings will be prescribed by the SILVAH system when the stand has reached maturity. This paper describes the underlying principles behind even-age regeneration practices recommended by the SILVAH system, and gives guidance on the proper application of these regeneration practices.

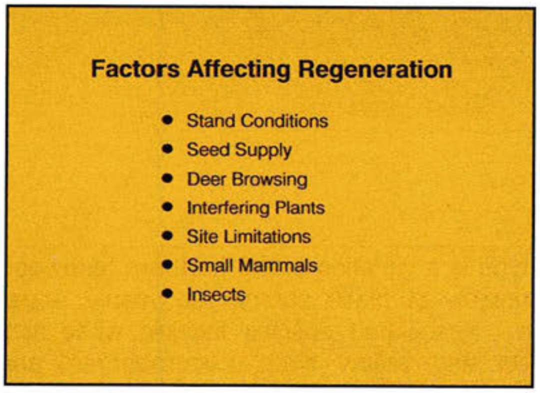


2. The principles and practices presented here apply to the cherry-maple, northern hardwood, and oak-hickory forests that occur on the Allegheny Plateau and Allegheny Mountain sections of New York, Pennsylvania, Maryland, and West Virginia.

3. The cherry-maple type is a variation of the northern hardwood type consisting primarily of black cherry, red maple, sugar maple, and beech. Associated species include white ash, yellow-poplar, sweet and yellow birch, cucumbertree, and hemlock. Cherry and the maples usually dominate stands in Pennsylvania and southward; white ash and sugar maple tend to be more important, and red maple less important, in the New York portion of the range. Stands with less than 25 percent basal area in black cherry are considered part of the northern hardwood type. The small proportion of cherry affects ease of regeneration, however, the two types are at opposite ends of a continuum.

4. Oak types predominate in the eastern and southern parts of Pennsylvania, as well as in adjacent Maryland and West Virginia. To the north in New York, an important oak region is the south-central highlands. Red, black, white, and chestnut oaks are the main species. Oaks are warm climate types and relatively pure oak stands are found on ridgetops and southfacing slopes. Mixtures of oak with northern hardwoods occupy the moist, cooler sites.

5. Oak regeneration is characteristically scarce in Allegheny oak stands. Where advance regeneration exists in these oak stands, it is often black cherry and red maple. Oak stands in other parts of the Allegheny region have numerous, but small oak seedlings along with red maple and other species.

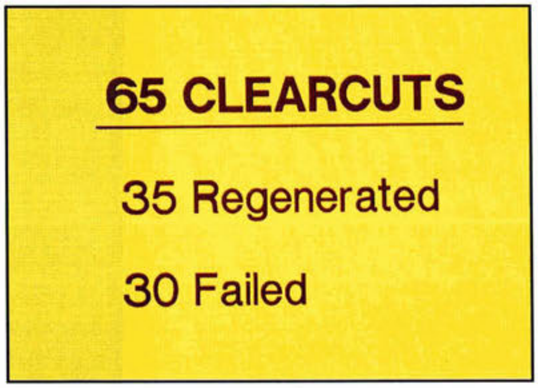


Factors Affecting Regeneration

- Stand Conditions
- Seed Supply
- Deer Browsing
- Interfering Plants
- Site Limitations
- Small Mammals
- Insects

6. Regeneration is affected by a variety of factors. These include stand conditions, seed supply, deer browsing, interfering plants, small mammal predation, insects, and site limitations. Small mammals and insects are particularly important acorn predators and are capable of destroying entire acorn crops.

7. The present Allegheny forests are second- and third-growth stands that developed after extensive commercial clearcutting between 1890 and 1930. Although generally even-aged, many stands contain scattered residuals from the previous stand, and others contain two to four age classes. Ecologically, the cherry-maple and northern hardwood types represent early- to mid-successional stages; if left undisturbed for a long period they tend to evolve toward a climax forest dominated by beech, hemlock, and sugar maple. Oak forests in northwestern Pennsylvania are transitory. When cut, they often regenerate to cherry-maple or northern hardwood. Elsewhere in the Allegheny oak range, other species often replace oak after cutting. For example, in the central Appalachians, yellow-poplar and red maple often regenerate in oak stands.



65 CLEARCUTS

35 Regenerated

30 Failed

8. Despite the presence of valuable species in the overstory, regeneration is difficult in the Allegheny region. A survey of 65 timber cuttings made in the early 1970's revealed that satisfactory natural regeneration was developing in only 54 percent of them. Subsequent studies have shown that the presence of abundant advance regeneration before the final harvest cut was the most important factor determining whether satisfactory regeneration occurred.

SOURCES OF REGENERATION

- Advance Seedlings
- Seed Stored in Forest Floor
- New Seed
- Sprouts and Suckers

9. Regeneration originates from advance seedlings, seed stored in the forest floor, recently dispersed seed, stump sprouts, and root suckers.

NORTHERN HARDWOOD SEED SUPPLY

Species	Periodicity (yrs)
Black Cherry	2 - 3
Red Maple	2 - 3
White Ash	3 - 5
Sugar Maple	3 - 5
Yellow-Poplar	1
Beech	6

10. Black cherry and red maple produce abundant seed, with good crops occurring every 2 or 3 years. White ash and sugar maple have good seed crops much less frequently approximately every 3 to 5 years. Yellow-poplar may produce a good seed crop almost every year; crop failures as well as bumper crops, only occur infrequently. Although yellow-poplar produces a lot of seed, viability is extremely low, seldom more than 5 percent. Beech produces a good seed crop at approximately 6-year intervals.

OAK SEED SUPPLY

Species	Periodicity (yrs)
Northern Red Oak	4 - 5
White Oak	4 - 5
Scarlet Oak	4 - 5
Chestnut Oak	4 - 5
Black Oak	3

11. In general, oak acorn production is very erratic. Black oak may produce a good acorn crop approximately every 3 years, whereas red, white, chestnut, and scarlet oaks may only have a good crop every 4 or 5 years. Bumper crops occur irregularly and may be as infrequent as 10 years apart. It is believed that significant quantities of oak seedlings originate only in years of a bumper seed crop, when quantities in excess of those consumed by mammals and insect predators are produced. These seedlings are generally from acorns cached but not retrieved by small mammals.

SEED STORAGE IN FOREST FLOOR

Northern Hardwoods	Years
Black Cherry	3 - 5
White Ash	3 - 5
Yellow-Poplar	3 - 5
Red Maple	1 - 2
Birch	1 - 2
Hemlock	1 - 2
Sugar Maple	0
Beech	0

12. Buried seed is an important source of regeneration in Allegheny stands. Seeds of some species remain viable for several years. Among the northern hardwoods, black cherry, white ash, and yellow-poplar seeds may remain dormant and viable in the forest floor for 3 to 5 years. This helps ensure a relatively constant seed supply for these species. Red maple, birch, and hemlock seeds seldom remain viable in the forest floor for more than a year or two. But, these species have frequent seed crops, so their seed supply is also relatively constant. Sugar maple and beech seeds commonly germinate following dispersal, and do not store in the forest floor.

SEED STORAGE IN FOREST FLOOR

Oaks	Years
Northern Red Oak	0
White Oak	0
Scarlet Oak	0
Chestnut Oak	0
Black Oak	0

13. Lack of seed storage in the forest floor also is common to the northeastern oaks.

14. Some species, notably beech and aspen, also reproduce abundantly from root suckers.

15. Striped maple, an undesirable species, produces seeds almost every year, but the seeds do not remain viable for more than a year or so. However, striped maple seedlings can persist in the shade of a closed canopy, growing very slowly for up to about 40 years.

SEED STORAGE IN FOREST FLOOR

Noncommercial Species

Species	Years
Striped Maple	1 - 2
Pin Cherry	30+
Rubus spp.	30+
Grass	Many
Sassafras	5
Grapevine	11+
Rhododendron	5
Dogwood	0
Sourwood	0
Blackgum	0
Laurel	?

16. Buried seeds of non-commercial and undesirable species also are important in revegetation of disturbed stands. These include pin cherry, blackberry, raspberry, grass, other herbaceous plants, sassafras, grapevine, and rhododendron. Seeds of dogwood, sourwood, blackgum, and mountain laurel have little or no storage life.

17. Seedbed requirements vary among species. Birches regenerate more abundantly on scarified seedbeds, but scarification is not required. Red maple, white ash, and hemlock germinate better where the surface organic layers have been disturbed or mixed with mineral soil.

18. Sugar maple, beech, and black cherry germinate as well on undisturbed forest floor as on disturbed sites. High surface moisture is necessary for good germination of all species.

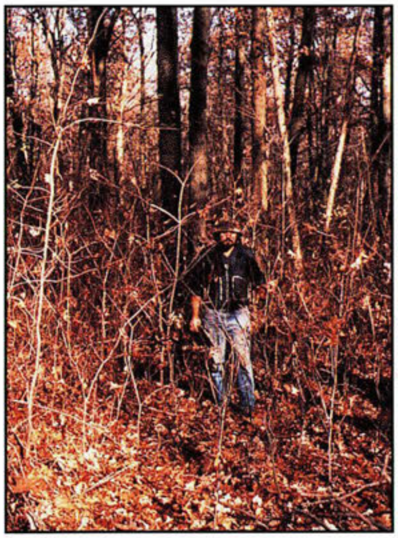
19. Advance reproduction of sugar maple, beech, and hemlock is very shade-tolerant and can survive and grow in uncut or lightly cut stands for many years.

20. Even the less tolerant cherry, ash, most oaks, and red maple can germinate and survive for 3 to 5 years under a moderately heavy canopy. These seedlings will die, if the overstory is not reduced, but new seedlings are constantly germinating to replace them.

21. In addition, all of the hardwood species can also reproduce from sprouts. Red maple is well known as a prolific sprouter. Black cherry, white ash, sugar maple, beech, birch, and the oaks sprout readily from dormant buds around the base of stumps. Stumps of small trees less than 4 inches in diameter sprout more frequently than stumps of larger diameter trees.

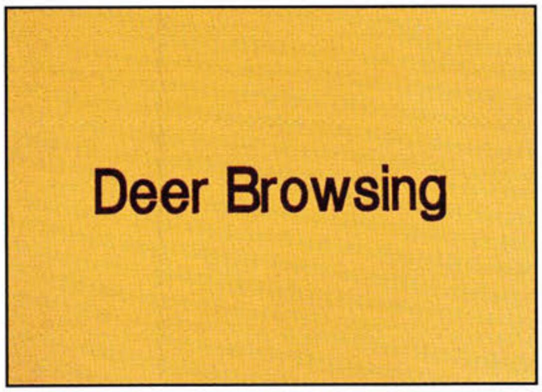
22. Because of its strong sprouting ability, oak regeneration can survive browsing, breakage, drought, and fire. Top dieback and resprouting of seedlings usually occurs a number of times. Each successive shoot is taller and the root system is stronger. These shoots are called seedling sprouts.

23. Where oak regeneration is obtained, seedling sprouts and stump sprouts usually form much of the new stand. Thus, oak stands are regenerated before, not after, the harvest cut.



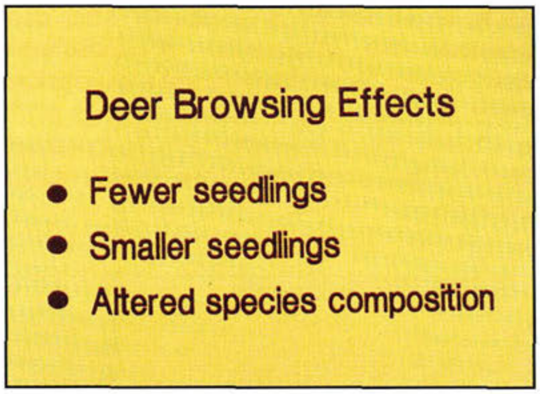
24. Many oak stands are transitory on sites where shade-tolerant hardwoods are the climax. The trend toward this climax is very strong. Without adequate large oak advance regeneration, a new oak forest will not regenerate. Small oak seedlings, if present, cannot grow fast enough to compete with faster growing species, such as black cherry, red maple, and yellow-poplar.

25. Stand density controls the quantity of light available to advance regeneration, and is an important environmental factor affecting seedling development. Reducing stand density to 60 percent of full stocking improves conditions for seed germination and seedling survival, but permits only a small amount of growth. Thus, the number of small advance seedlings increases gradually over a 5- to 10-year period.



Deer Browsing

26. Even in the presence of adequate light, the understory of hardwood stands in Pennsylvania lacks the waist-high regeneration commonly found in other eastern hardwood types. When desirable seedlings are present, they are normally only a few inches tall. The dramatic difference in regeneration between hardwood stands in Pennsylvania and similar stands elsewhere has been brought about by long-term browsing from a large herd of white-tailed deer. Deer browsing has caused continuous damage to forest vegetation since the 1920's.

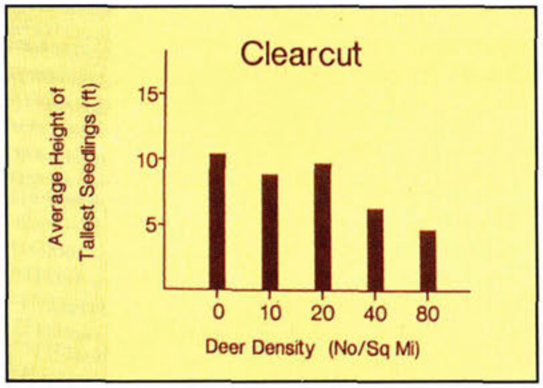


Deer Browsing Effects

- Fewer seedlings
- Smaller seedlings
- Altered species composition

27. Deer browsing has several effects on regeneration. The number of seedlings is reduced, surviving seedlings are smaller, and the species composition is altered.

28. Deer dramatically affect regeneration stocking. Where deer were excluded by fencing (right). regeneration was successful; but where they were not (left). regeneration failed. Browsing by white-tailed deer is presently recognized as the most important cause of regeneration failure in the forests of Pennsylvania.



29. Deer browsing also has strong effects on seedling height. This chart shows the average height of the tallest seedling in 5-year-old clearcuts where different deer densities were maintained. Seedling height is reduced dramatically at higher deer densities. At 40 and 80 deer per square mile, seedlings were only half as tall as those at 10 and 20 deer per square mile. Thus, the amount of time required to establish a new stand increases with increasing deer densities.

30. Deer browsing effects the species composition of regeneration. Desirable timber species, such as the maples, ash, and yellow-poplar, are highly preferred by deer and tend to be eliminated when they are small seedlings. Since black cherry is very abundant and is intermediate in food preference, it is browsed to a lesser extent. Thus, with the higher deer populations found on the Allegheny Plateau, if any desirable regeneration is present it tends to be black cherry, as shown here. Stands composed mostly of black cherry have shortcomings for timber production and deer habitat. Monotypic stands are vulnerable to insect and disease attacks and they lack the diversity needed for high-quality wildlife habitat.

Interfering Plants

31. In addition to causing fewer seedlings of smaller size, deer browsing also increases the abundance of undesirable herbaceous and woody plants. Such changes are most obvious in stands that have had thinnings or shelterwood cuttings in the past 25 years or so. These cuttings have dramatically increased hayscented fern, New York fern, short husk grass, striped maple, and beech in the understory.

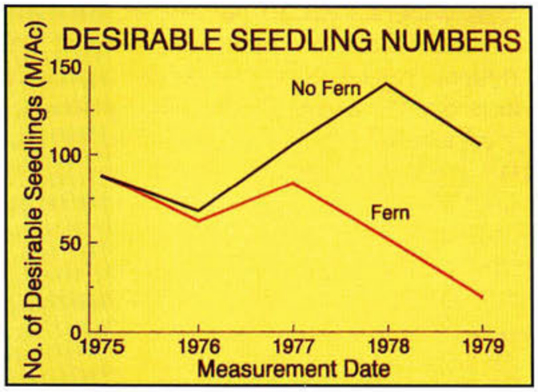
32. Increases in the amounts of these plants seem to have occurred for several reasons. First, they are either low on the food preference list of deer, or they tolerate browsing, or they resprout readily. Ferns and grass form a very small portion of the deer's diet and are not browsed extensively. Striped maple and beech are browsed to some extent, but they are not killed and are able to respond with vigorous new growth.

33. Second, all of these species are tolerant of understory shade. Beech is one of the most shade-tolerant species in the eastern hardwood forest. And, the ferns and striped maple actually grow better in partial shade than when fully exposed in a clearcut.

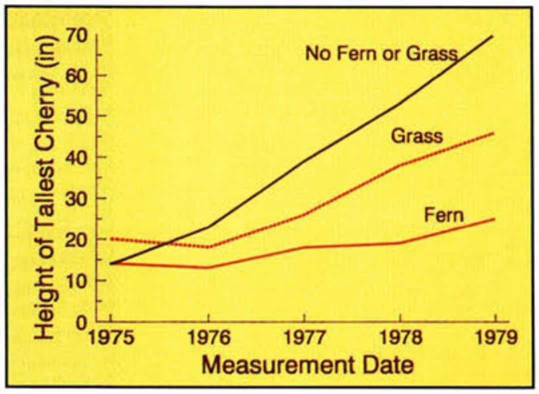
34. Lacking competition from the more palatable species, undesirable species are able to thrive in the understory. Understanding how these plants regenerate and become established is an important first step in learning how to control them.

35. Hayscented and New York fern regenerate from spores where bare mineral soil is present, but they spread primarily from a perennial underground stem or rhizome. The ferns spread by repeated forking and extension of the rhizome. In stands where a portion of the overstory has been removed, the rhizome not only grows faster and forks more frequently than in uncut stands, but it also forms many new rhizome buds. These buds grow out rapidly and greatly expand the area covered by the fern plant.

36. Short husk grass has a rhizome system similar to that of the ferns, but this species also produces large quantities of seed that fall to the ground and are stored in the forest floor. The forest floor also contains seeds of other grasses and sedges that germinate after logging disturbance.



37. These plants interfere with the development of advance regeneration of Allegheny hardwoods. We found that ferns have a major effect on the buildup of desirable seedlings. After 5 years, where seedlings were fenced and weeded of ferns, there were 106,000 desirable seedlings per acre. But where seedlings were fenced, and ferns were not removed, there were only 19,000 desirable seedlings per acre.



38. After a shelterwood removal cut, desirable seedlings, such as black cherry, grow less in the presence of fern and grass. Both fern and grass reduce seedling height growth, but ferns have a greater effect than grass. Hardwood seedlings are inhibited by fern and grass, and with the present high deer population few are able to grow above the reach of deer.

39. Dense understories of tolerant hardwoods also have undesirable effects on hardwood advance regeneration. Even small stems of tolerant species can be troublesome in partially cut stands because they often develop faster than the less tolerant regeneration of desirable species.

INTERFERENCE IN OTHER FOREST TYPES

- Fern and Grass
- Rhododendron and Mountain Laurel
- Undesirable Hardwood Understories
- Grapevine

40. In addition to fern, grass, striped maple, and beech, many oak stands contain dense understories of rhododendron and mountain laurel or understories of tolerant species, such as dogwood, sourwood, sassafras, red maple, and black gum. When these species are present in dense stands, oaks either fail to become established or are not able to outgrow these competitors. Climbing grapevines can also physically damage or kill large saplings or small poles by breaking tops and branches, twisting and bending stems and uprooting trees. Grapevines are an important problem in northern hardwood stands where deer populations are low.

INTERFERENCE

›30% of Plots

Stocked with

Interfering Plants

41. Our studies show that if more than 30 percent of the 6-foot radius regeneration sample plots in a stand are stocked with interfering plants, adequate regeneration of desirable species is not likely to develop under the partial shade of a shelterwood seed cut. A plot is considered stocked with interfering plants if it contains at least 12 stems (weighted by size) of any woody interfering plant, at least 30 percent ground cover by fern on the 1/20-acre area surrounding the plot center, or at least 30 percent ground cover by grass on the 1/20-acre plot surrounding the plot center. Any plot with at least 1 grapevine is considered stocked with grapevines.

SITE LIMITATIONS

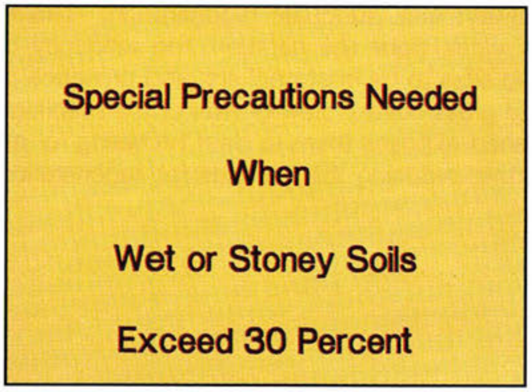
- Wet Soils
- Droughty Soils
- Stony Soils
- Logging Damage

42. The last major factor that can affect regeneration is limitations imposed by site conditions. In northwestern Pennsylvania, the most important site limitations are wet, droughty, and stony soils. Soil type also affects the amount of damage to advance regeneration that can occur during logging.

43. Wet soils almost always lack adequate regeneration. This is caused by excess water, poor soil aeration, the tendency of these poorly drained sites to be frost pockets, and presence of undesirable fern and grass cover. Slow growth of the seedlings that do get established exposes them to deer browsing for an extended time, further reducing the chances for regeneration success.

44. Droughty soils affect regeneration, not only because they cause seedlings to desiccate and die, but also because they affect species composition of the overstory and, hence, the seed supply to the site.

45. Very rocky surface soils also present difficulties for regeneration. Such sites are characterized by a thin forest floor that covers the underlying rocks over a high percentage of the area. In uncut stands, seedlings may be present, but they are often rooted only in the forest floor and humus covering the rocks. When the overstory is removed, the thin forest floor dries out rapidly and the seedlings die. Rocky surface soil usually can be identified before cutting by its hard uneven surface and scattered areas of exposed rock.


Special Precautions Needed

When

Wet or Stoney Soils

Exceed 30 Percent

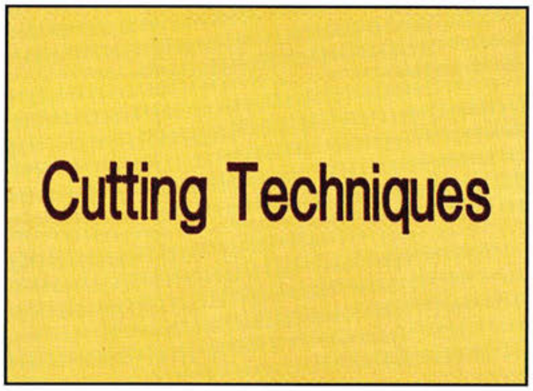
46. We recommend that limiting site factors be recorded during the advance regeneration survey. If 30 percent or more of the 1/20-acre area around regeneration plot centers have limitations from wet or stony soils, then special cutting measures must be used to regenerate the stand.

47. One last point about soils concerns the survival of advance regeneration during and after logging. Logging disturbance and soil compaction can eliminate many of the advance seedlings in areas used by skidders, resulting in patchy regeneration. Destruction of seedlings from uncontrolled skidding on vulnerable soils can easily account for failure of regeneration on 30 percent of an area. Disturbance stimulates development of grass ground cover from seed buried in the forest floor. And deer further compound the problem because severe browsing eliminates the few seedlings that remain. Generally, the wetter the soil, the greater the number of seedlings that will be destroyed.


Obtaining Successful Regeneration

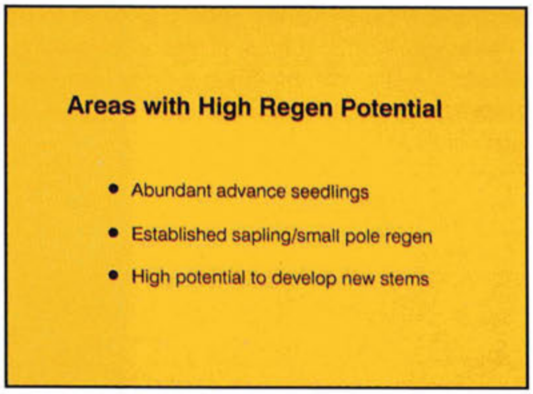
- Cutting Techniques
- Increase Seed Supply
- Reduce Deer Browsing
- Control Logging Damage to Seedlings
- Special Measures

48. Despite barriers to obtaining reproduction, it is possible to regenerate most stands. By evaluating the amounts of advance regeneration and the barriers to obtaining it, we can recognize the treatments necessary to successfully reproduce the stand. Regeneration success can be improved by using proper cutting techniques, increasing the seed supply, reducing deer browsing, controlling logging damage, and by using special measures that include herbicides, fertilization, and fencing.


Cutting Techniques

49. Using proper cutting techniques is the primary way we establish desirable regeneration.

50. In areas of high regeneration potential, simple overstory removal, or clearcutting, will usually provide satisfactory regeneration.



Areas with High Regen Potential

- Abundant advance seedlings
- Established sapling/small pole regen
- High potential to develop new stems

51. The key is to recognize these areas of high regeneration potential before prescribing a cut. These are stands with abundant advance seedlings, established sapling or small pole regeneration, or high potential to develop new stems from stump sprouts, buried seed, or seeds produced on site.

52. Advance seedlings are the primary source of reproduction in all forest types in the Allegheny region. The number of advance seedlings required varies, depending upon species, seedling size, and the amount of deer browsing expected.

53. In areas of high deer population, deer will consume many seedlings after cutting. So, large numbers are required to provide more than deer can eat. This situation is made worse by the fact that advance seedlings tend to be small from constant browsing in these areas. Since survival after cutting is relatively low for small seedlings, even larger numbers are required.

54. In areas of high deer population in northwestern Pennsylvania, no stands with less than 20,000 seedlings per acre have qualified for harvesting under our advance regeneration guidelines, and stands that do qualify average more than 50,000 advance seedlings per acre. Obviously, very large numbers of small advance seedlings are required to provide regrowth dense enough to overwhelm the deer.

FEWER DEER

FEWER SEEDLINGS REQUIRED

55. In areas of lower deer population, advance seedlings tend to be larger. Not only do the larger stems survive better after cutting, but also it is not necessary to provide excess quantities for deer consumption. So, fewer advance seedlings are required to assure successful regeneration.

Advance Regen Stocking

Weighted Number per Plot

Deer Index	Black Cherry	Small Oak	Other Des.	All Des.	Large Oak
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

56. Our guides to advance regeneration reflect these factors. For a 6-foot-radius regeneration sample plot to be adequately stocked in areas of high deer population, (Deer Impact Index = 4) we require 25 black cherry, 40 small oaks, or 100 other desirable seedlings assuming all are less than 1 foot tall. A single oak seedling greater than 4.5 feet tall will do. In areas of low deer population (Deer Impact Index = 2), fewer seedlings are required: 15 black cherry, 20 small oaks, or 30 other desirable seedlings are adequate if all are less than 1 foot tall. Since advance seedlings tend to be larger than (over 1 foot) in areas of low deer, the required number of seedlings may be even less. For example, 100 other desirable seedlings are required when deer population is high and seedlings are small, but only 15 other desirable seedlings are required when deer population is low and seedlings are large.

CLEARCUTTING GUIDES

Advance Seedlings > 70%

57. The number of advance seedlings present can be used to determine whether a single 6-foot-radius regeneration plot is adequately stocked. To ensure that an entire stand will regenerate satisfactorily, a large proportion of the stand area must have adequate regeneration. Any stand with less than 70 percent of the area stocked when it reaches merchantable size is unsatisfactory; so, 70 percent of the regeneration plots must be adequately stocked with advance seedlings before there is assurance that overstory removal or clearcutting is warranted.

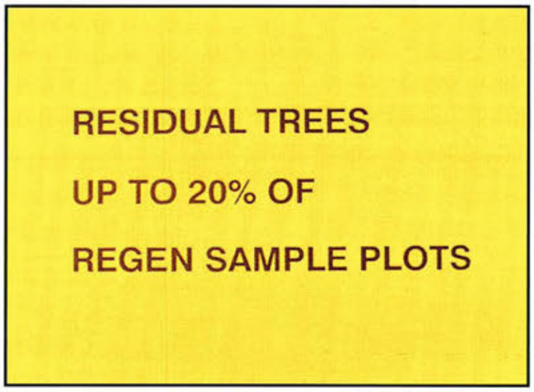
58. In some situations, regeneration may come from sources other than advance seedlings. Oak stump sprouts are an important source of oak regeneration, and it is possible to predict their potential numbers from data on overstory species and size. Potential stump sprouts can thus be substituted for advance seedlings in determining regeneration potential.

Expected percentage of oak stumps that will sprout after cutting

Size	CO	SO	RO	BO	WO
Saps	100	100	100	85	80
Poles	90	85	60	65	50
SSaw	75	50	45	20	15
Larger	50	20	30	5	0

59. This table shows that the expected percentage of oak stumps that will sprout after cutting varies with oak species and stump size. Chestnut oak is the most prolific sprouter, while white oak is the least prolific sprouter. Moving down the chart, notice that as stump size gets larger, the percentage of sprouting stumps gets smaller. Oak stump-sprouting ability is not influenced by site quality and season of cutting has very little effect. Stumps cut at the time of full leaf development may sprout slightly less than stumps cut at other times. SILVAH estimates the potential contribution of oak stump sprouts to regeneration stocking by multiplying the overstory tally of oaks by species and diameter times the factors shown in this table.

60. Pole size trees of shade-tolerant species in existing stands can also be retained as sources of regeneration. Only trees with good crowns and clear straight boles that are free of epicormic branches are suitable. We suggest leaving 30 to 80 trees per acre that are 3 to 10 inches in diameter as shown here. The goal is to leave up to 10 square feet of basal area in tolerant residuals. The present value of these small trees is low, but they respond rapidly and some can be harvested in the first thinning, helping to defray costs. And they also serve as a seed source of tolerant species when the stand is regenerated at the end of the next rotation. With a head start, these trees will mature at about the same time as the faster growing black cherry. Each 6-foot-radius regeneration plot containing at least one acceptable residual tree can be used as a substitute for advance seedlings.



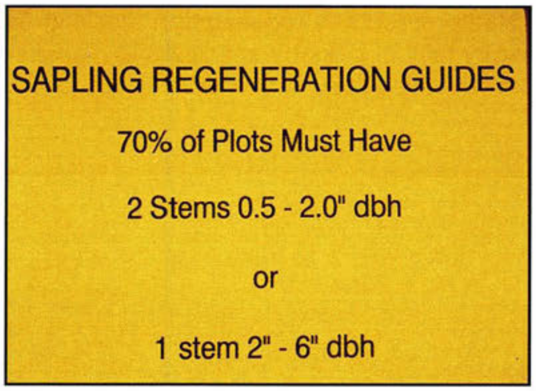
RESIDUAL TREES

UP TO 20% OF

REGEN SAMPLE PLOTS

61. However, if too many plots are stocked with residual tolerant trees, their crowns will quickly close, reducing the amount of light reaching the forest floor. Intolerant species, such as black cherry, white ash and yellow-poplar, which require high levels of light to survive and grow, will not form a significant part of the new stand. So, at least half of the plots must be stocked with small advance regeneration; residuals may be used for the rest to reach 70 percent stocking.

62. Sapling-size trees in the understory of existing stands are still another source of regeneration. These are usually the result of past cutting, either a shelterwood seed cut or a high-grading of some sort. The dense sapling understory usually precludes small advance regeneration, but will form the next stand by itself if released from the remaining overstory trees.



SAPLING REGENERATION GUIDES

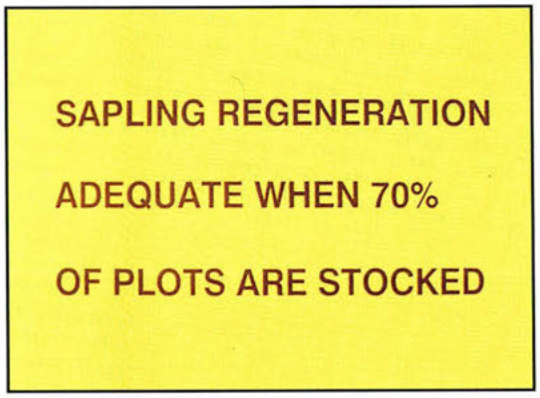
70% of Plots Must Have

2 Stems 0.5 - 2.0" dbh

or

1 stem 2" - 6" dbh

63. To be stocked with sapling regeneration, a 6-foot-radius plot must contain two stems 1/2 to 2 inches in diameter, or one stem 2 to 6 inches in diameter. The saplings must be commercial species of acceptable quality and vigor.



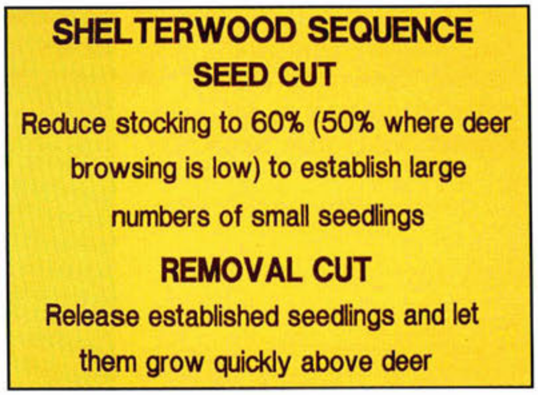
SAPLING REGENERATION

ADEQUATE WHEN 70%

OF PLOTS ARE STOCKED

64. With sapling regeneration, we do not substitute plots stocked with sapling regeneration for plots stocked with advance seedlings. Instead, the entire stand must have adequate sapling regeneration over 70 percent of the area before overstory removal is recommended. Thus, the overstory removal is essentially a release cut for the large advance reproduction resulting from some prior cutting operation.

65. Buried and wind blown seed are also sources of regeneration. For black cherry, the presence of advance seedlings is usually an indicator that there is seed stored in the forest floor seed bank. Some of this seed germinates each year and tends to compensate in years with small seed crops. Only two species, birch and yellow-poplar, often regenerate in large numbers from buried seed when there is no advance regeneration. In the Alleghenies, birch is not considered a desirable species, so we do not count birch seed sources in our assessments of regeneration potential. Yellow-poplar is different. In areas of low deer population, when seed sources are present, significant yellow-poplar regeneration may arise from seed stored in the forest floor.



SHELTERWOOD SEQUENCE

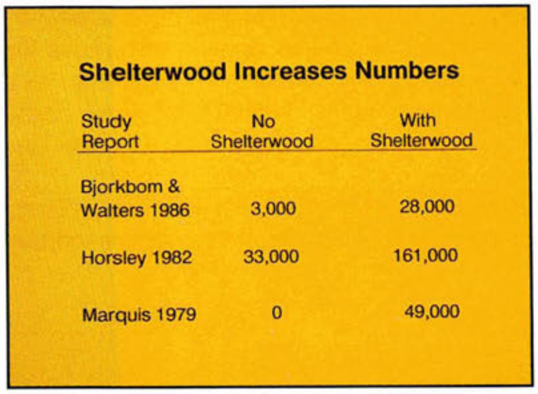
SEED CUT

Reduce stocking to 60% (50% where deer browsing is low) to establish large numbers of small seedlings

REMOVAL CUT

Release established seedlings and let them grow quickly above deer

66. If advance seedlings are scarce before the final harvest, seedling numbers usually can be increased by a sequence of shelterwood cuts. The seed cut should reduce the overstory to 60 percent of full stocking, where deer browsing is high, and to 50 percent where deer browsing is low. This makes additional sunlight, moisture, and nutrients available for the establishment of new seedlings.



Shelterwood Increases Numbers

Study Report	No Shelterwood	With Shelterwood
Bjorkbom & Walters 1986	3,000	28,000
Horsley 1982	33,000	161,000
Marquis 1979	0	49,000

67. The 60 percent shelterwood in high deer areas greatly increases the number of advance seedlings, but permits only small increases in seedling growth. This is an advantage in areas of high deer population, because the small understory seedlings are browsed only lightly, making it easier to build up the large numbers of stems required. In low deer areas, the 50 percent shelterwood provides for both increases in seedling numbers and moderate growth.

68. Once an adequate number of seedlings has become established, the remaining overstory can be removed. This usually requires 3 to 10 years. The overstory removal in this two-cut shelterwood sequence is essentially identical to the clearcutting recommended when advance seedlings are naturally abundant.

DO NOTHING

Where Shelterwood Needed

but

Overstory Density <70%
Deer Impact - High
Seed Production - Low

69. There are several situations where shelterwood cutting probably will not work without combining it with other remedial measures. Shelterwood cutting probably will not work when the overstory density is already below 70 percent. At these densities, overstory density is already low enough to provide adequate light, water, and nutrients for seedling establishment. Further overstory reduction will do no good and may stimulate the spread of undesirable plants. Shelterwood cutting also may not work where there is a combination of high deer browsing and low seed production.

70. Shelterwood cutting usually will not work where undesirable understory plants, such as beech root suckers, striped maple seedlings, and herbaceous fern and grass, are present in moderate amounts because these plants are stimulated so much by the increased resources created by the cutting that they interfere with establishment of desirable seedlings.

INTERFERING PLANT GUIDE
UNCUT STANDS

> 30% of plots stocked
with interfering plants and
regeneration stocking < 70%

Apply Herbicide
Make Shelterwood Cut

71. In stands where a shelterwood seed cut is proposed to increase advance regeneration, but where interfering plants are already moderately dense, herbicides should be applied to remove the interfering plants before making the shelterwood seed cut. As a guide to levels of interfering plant density that may cause problems during the shelterwood seed cut, we use the proportion of plots stocked with any interfering plant. If 30 percent of all plots examined are stocked with interfering plants, an herbicide is recommended before the shelterwood seed cut.

72. If oak advance regeneration already is adequate, shelterwood cutting may actually be detrimental to establishment of a new oak stand. The oaks grow more slowly than many desirable and undesirable species with which they compete, so providing partial sunlight for faster growing species may give quick-starting competitors an advantage over oak. If adequate large oak advance reproduction is present, clearcuttings usually will reproduce rapidly growing new stands containing oaks, other light-demanding species, and a few shade-tolerant species, especially on site index 60 and below.

Shelterwood Cutting Alone Won't Regenerate Oaks

Determine Problem
Take Remedial Action

73. In the absence of adequate oak advance regeneration, clearcutting eliminates oaks from the site, except for a few stump sprouts. On good sites, the stand will be converted to other fast growing, shade-intolerant species, such as yellow-poplar, black cherry, and red maple. Shelterwood cutting provides a starting point for increasing the numbers of oak seedlings in the stand. But best results have been obtained with very light cutting, even non-commercial timber stand improvement. Shelterwood cutting may need to be combined with measures to control competitors. These techniques are still under study.

74. Removal cuts in the shelterwood sequence in all forest types can begin as soon as the amount of advance regeneration meets the guidelines described earlier for removal cuts. This will usually take 3 to 10 years. The removal cut may be made in either one or two stand entries. In most situations, a single removal cut produces the best regeneration with the least damage to advance seedlings and is the most efficient procedure.

USE A 3-CUT SHELTERWOOD WHERE THERE ARE

- **Site limitations**
- **Management goal restrictions**

75. Site limitations may make a three-cut shelterwood necessary in some stands. The purpose is to allow seedlings to reach large size and ensure their establishment under the difficult environmental conditions that follow complete overstory removal. This three-cut sequence also can be used when management goals make it desirable to have the new stand tall enough to avoid the undesirable appearance of a fresh clearcut.

Increase Seed Supply

76. Seed supply is a major factor influencing regeneration. If there is not an adequate seed supply, you cannot expect to have seedlings in the understory.

SEED SOURCE INDEX

Estimates seed supply using basal area of overstory Black Cherry, Sugar Maple, Red Maple, White Ash and Oaks > 8" dbh.

77. The amount of seed produced in a stand is related to basal area of the species in the overstory. A helpful parameter to estimate whether seed sources are limiting natural regeneration is the seed source index. The determination is made using the basal area of overstory black cherry, white ash, red maple, sugar maple, and oaks of any species 8 inches d.b.h. and larger.

SEED SOURCE INDEX CALCULATION

Multiply the BA by species times the appropriate coefficient and sum.

BC = 4.0 * BC ba
SM in PA = 1.2 * SM ba
SM elsewhere = 2.4 * SM ba
RM, WA = 1.5 * RM + WA ba
Oaks = 1.0 * OAK ba

78. Sugar maple is the only tolerant among these species and is often overtopped by faster growing species such as black cherry. Furthermore, sugar maple flowers and leaves have been damaged repeatedly by the insect pear thrips in many northern Pennsylvania areas. When either of these situations occur, sugar maple seed production is very limited. Calculation of the seed source index for sugar maple requires a subjective judgment of ability to produce seed. A small seed production coefficient is used when sugar maple are overtopped and thrip-infested, whereas the normal coefficient is used when sugar maple are in the dominant or co-dominant crown position, without thrip infestation.

SEED SOURCE INDEX

Index Value	Desirable Seedlings (M/a)
4 very low	0 - 32
3	33 - 83
2	84 - 134
1 excellent	135 +

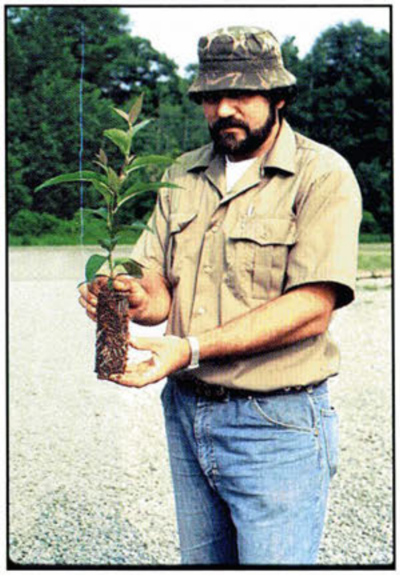
79. Basal area of each species 8 inches and larger is multiplied by a coefficient and the products totaled. This represents the total number of seedlings likely to originate over a 5-year period from available seed. A seed source index of 1 represents excellent seed production potential, while a value of 4 represents very low seed production potential.

80. Seed production for regeneration of the next stand is an important consideration during the intermediate stage of stand culture. Thinnings should attempt to encourage the species desired in the next stand to assume and maintain dominant and codominant crown positions and remove undesirable species from these positions. Such a program will maximize the stand's potential for natural seed production. Once a stand has reached the stage when it is ready to regenerate, there is little that one can do to increase natural seed production.

LOW SEED SUPPLY

- Determine cause
- Take remedial action

81. Insects may limit the seed supply of some species. This happens with oaks and sugar maple seed supplies. Fire and insecticides may be appropriate remedial treatments, depending upon the life cycle of the insect. Unfortunately, these are current research topics and clear treatments have not yet emerged.



82. The only way to deal with inadequate natural seed supplies at the end of the rotation is artificial regeneration (to avoid the need for natural seed supplies entirely) or fencing in areas of high deer population (to reduce the numbers of seeds required to establish adequate numbers of seedlings).

83. Excessive deer browsing is the most important single factor limiting regeneration success in Allegheny hardwood stands in Pennsylvania.

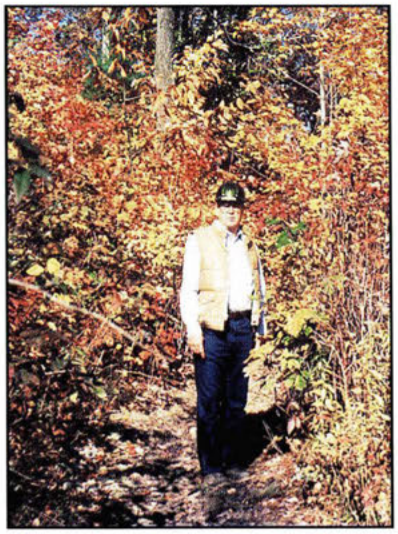
Reduce Deer Browsing

84. The most serious situation occurs when deer populations are high and available deer food is low. So, this means that any reduction in browsing pressure should result in a corresponding increase in successful regeneration. Browsing can be reduced by increasing the amount of available deer food or by decreasing the number of deer, or both.

Key to Success

overwhelm the critters
with abundant food

85. Our strategy for securing successful regeneration is to overwhelm the deer with more seedlings than they can eat, so some seedlings can escape to form the next stand. This can be done by selecting areas with abundant advance regeneration,



86. by increasing the number and size of advance seedlings through shelterwood cutting and herbicide control of interfering plants,

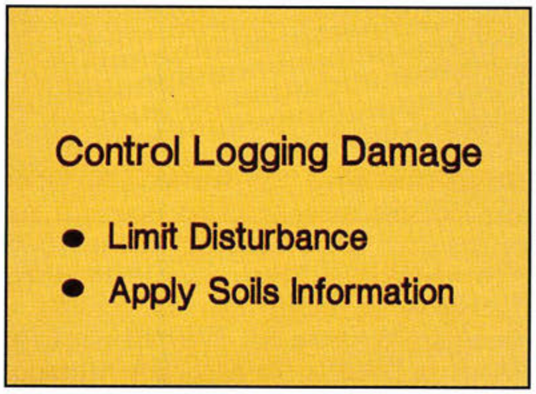
87. and by maximizing the area that is in a high deer-food producing condition. The larger the area in regeneration openings and thinnings, the greater the deer food production, and the lower the browsing impact on regeneration. Thus, to reduce browsing, it is important to schedule as much area as possible in clearcuttings and thinnings, and ensure that clearcuts contain as many advance seedlings as possible. In Allegheny hardwood stands it is possible to regenerate large amounts of black cherry and small amounts of species such as red maple, birch, and cucumber with deer populations as high as 32 deer per square mile, if 10 percent of the area is clearcut and 30 percent of the area is thinned every 10 years.

Control Logging Damage

To Seedlings

88. Logging damage to advance seedlings limits successful regeneration after overstory removal, and must be controlled.

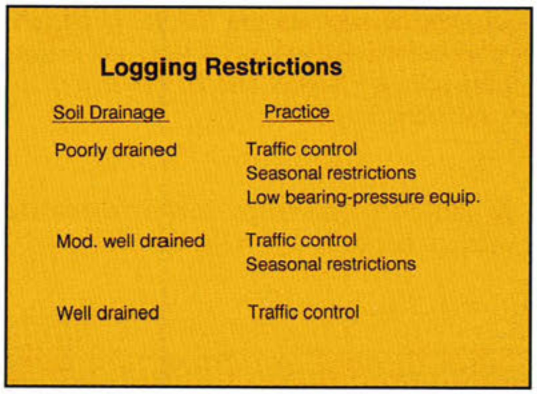
89. Destruction of advance seedlings from uncontrolled logging operations on sensitive soils can easily cause regeneration failure on 30 percent or more of clearcut areas, and result in patchy regeneration as shown in this 3-year-old sale area. The problem usually increases with closeness to the landing because the areas are the most heavily traveled. In areas of high deer population, the seedlings that escape damage, as well as those that may seed in afterwards, are heavily browsed and eventually die leaving logging corridors treeless and covered with grass.



Control Logging Damage

- Limit Disturbance
- Apply Soils Information

90. Logging damage to advance seedlings and soil compaction can be minimized by placing restrictions on the surface area that can be disturbed during the harvest operation, and by prescribing logging practices that are compatible with the soils in the sale area.



Logging Restrictions

Soil Drainage	Practice
Poorly drained	Traffic control Seasonal restrictions Low bearing-pressure equip.
Mod. well drained	Traffic control Seasonal restrictions
Well drained	Traffic control

91. The correct logging practice varies with soil drainage. The wetter the soil, the more vulnerable it is to compaction and the greater the need to prevent damage to advance regeneration. Logging damage can be minimized by controlling traffic patterns, by imposing seasonal restrictions on logging, and by requiring the use of low bearing-pressure equipment.

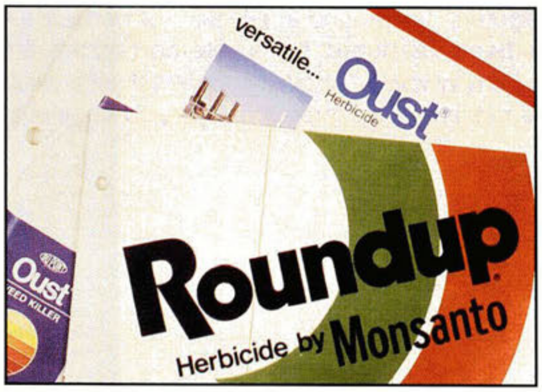
On poorly drained soils, which are the most sensitive, traffic should be confined to a few primary skid trails and logging restricted to the summer when the soils are driest. Low bearing-pressure equipment also should be used. On moderately well-drained soils, traffic also should be confined to a few primary skid trails and logging should be done only when the soils are dry. On well-drained soils, traffic should be dispersed as much as possible. And logging disturbance should be restricted so that less than 15 percent of the sale area is disturbed, even on well-drained soils where skidding traffic is dispersed.

Special Measures

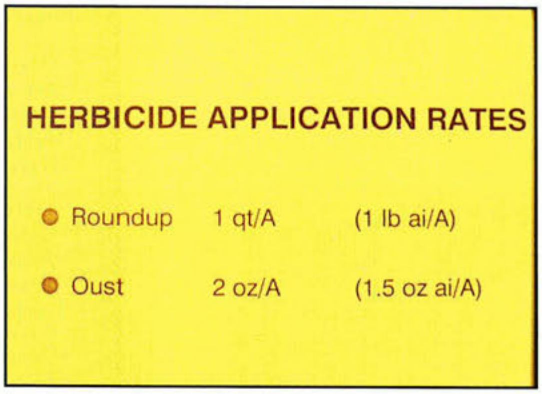
- Herbicides
- Fertilization
- Area Fencing

92. Herbicide application, fertilization, and area fencing have been identified as special remedial measures used to increase regeneration success in conjunction with cutting techniques.

93. Herbicides provide a practical way of removing unwanted vegetation in forest stands. Extensive research and commercial application experience has resulted in herbicide and cutting prescriptions for controlling ferns, grasses and sedges, striped maple, and beech in Allegheny hardwood stands. These prescriptions also may be a starting point for vegetation management in other forest types, but caution is advised in applying them where species or forest conditions differ from those in the Allegheny hardwood type.



94. Two herbicides are used in Allegheny hardwoods: Roundup® herbicide, manufactured by Monsanto and Oust® herbicide, manufactured by DuPont. Roundup is applied to foliage of actively growing plants. It is absorbed through the foliage and translocated throughout the plant. Roundup has no residual herbicidal activity in the soil. Oust is also applied to foliage, but it is absorbed by both plant foliage and roots and has residual herbicidal activity in the soil.



HERBICIDE APPLICATION RATES

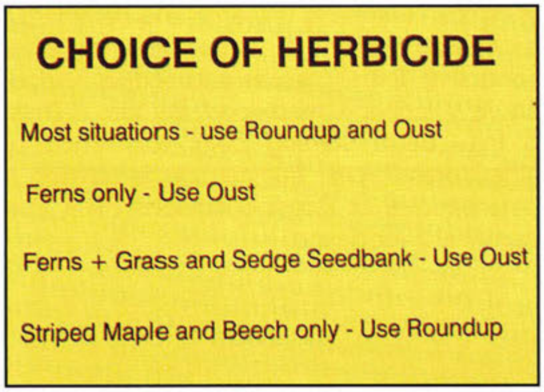
● Roundup	1 qt/A	(1 lb ai/A)
● Oust	2 oz/A	(1.5 oz ai/A)

95. Roundup is applied at the rate of 1 quart per acre (1 lb. ai/A) and Oust is applied at the rate of 2 ounces per acre (1.5 oz. ai/A). When Roundup and Oust are tank mixed together 0.5 percent (1 qt/100 gal of herbicide solution) of a non-ionic surfactant such as X-77 (Valant) or Frigate (Fermenta) should be added too. The herbicide mix is diluted to 20 to 25 gallons per acre with water.

OPTIMUM DATES OF APPLICATION

Roundup	
Short Husk Grass	June 1 to mid-September
Hayscented and New York Fern	July 1 to mid-September
Striped Maple	August 1 to mid-September
Beech	August 1 to mid-September
Oust	
Hayscented and New York Fern	July 1 to early October
Seedbank Grasses and Sedges	July 1 to early October

96. At the 1 quart per acre rate, Roundup effectively controls short husk grass when applied between early June and leaf yellowing in mid-September, and it controls hayscented or New York fern between early July and mid-September. Striped maple and beech are controlled by early August to mid-September applications. Oust also controls the ferns and its residual soil activity reduces the emergence and growth of grass and sedge originating in the forest floor seed bank after soil disturbance, when applied between early July and early October. Where important amounts of regeneration are present with ferns, grasses, and sedges, restricting Oust application to early August to early October will save much of this regeneration. Oust has no herbicidal effect on striped maple or beech.



CHOICE OF HERBICIDE

Most situations - use Roundup and Oust

Ferns only - Use Oust

Ferns + Grass and Sedge Seedbank - Use Oust

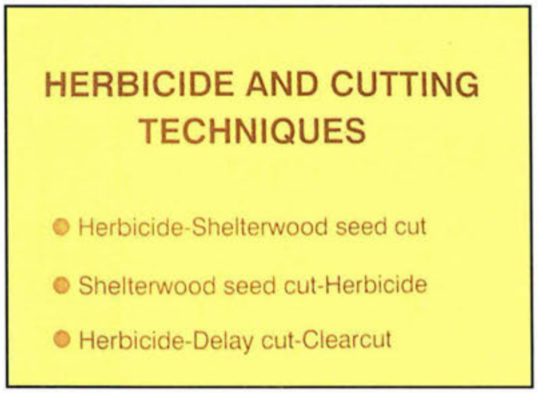
Striped Maple and Beech only - Use Roundup

97. Most Allegheny hardwood stands contain a mixture of interfering plants, so a Roundup-Oust tank mix usually should be applied. However, there are several situations when costs can be reduced by applying either Oust or Roundup alone. For example, where ferns or ferns and a grass and sedge seed bank are the only target species, Oust alone gives weed control as good as the Roundup-Oust tank mix. Where striped maple and beech are the only target species, Roundup alone should be applied.

98. Airblast spray equipment, for ground application of herbicide in forest stands, has been developed by private companies and public agencies in Pennsylvania. Airblast sprayers treat a swath of 35 to 75 feet, depending upon sprayer design and vegetation conditions.

99. This Friend air blast sprayer, manufactured by Friend and currently in use by International Paper Company at Coudersport, Pennsylvania, is designed to spray both ground vegetation and understory trees up to about 20 feet tall, simultaneously.

100. Both tracked vehicles and rubber-tired skidders or prehaulers are used to move the sprayer through the woods. Rubber-tired vehicles work best on flat to gently sloping terrain, as long as it is not rocky. Tracked vehicles can negotiate steeper slopes.



HERBICIDE AND CUTTING TECHNIQUES

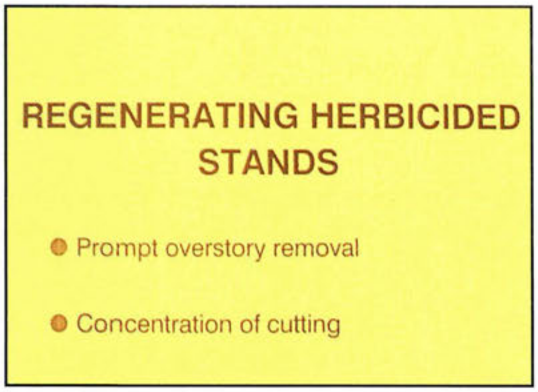
- Herbicide-Shelterwood seed cut
- Shelterwood seed cut-Herbicide
- Herbicide-Delay cut-Clearcut

101. Application of herbicide is usually followed within a year or so by a shelterwood seed cut to establish regeneration. Where the forest floor seed bank contains large amounts of grass and sedge or striped maple, other cutting strategies may also be considered. One option is to make the shelterwood seed cut first, then apply herbicide after cutting. Another option, in stands where overstory density is already low to moderate, is to apply an herbicide without any immediate cutting, then clearcut the overstory after regeneration becomes established. Both of these alternative procedures reduce soil disturbance after the herbicide treatment that stimulated grass and sedge seed in the forest floor seed bank to germinate.

DON'T MAKE A REMOVAL CUT WHERE

- Interfering plants stocking $\geq$ 70%
- Regen Stocking < 70%

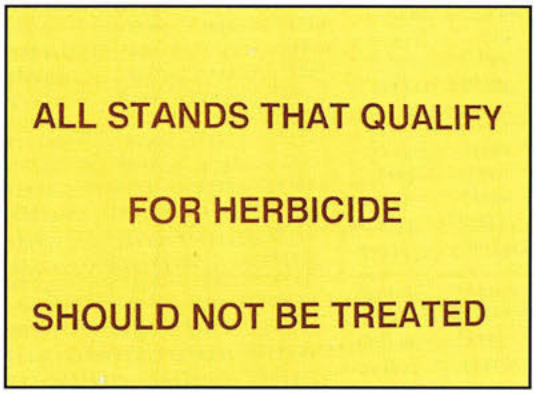
102. Also note that the final removal cut should not be made if greater than 70 percent of the regeneration sample plots are stocked with interfering plants or regeneration stocking is less than 70 percent. It will be necessary to remove the interfering plants with herbicides and develop adequate regeneration before making the final removal cut.



REGENERATING HERBICIDED STANDS

- Prompt overstory removal
- Concentration of cutting

103. Two key factors in regenerating stands were herbicide has been used are: prompt overstory removal after regeneration has become established, and concentration of cutting activity in a management area. The first reinvasion of the stand by interfering plants, and the second minimizes the impact of deer in areas of high deer population by increasing the food supply.



ALL STANDS THAT QUALIFY

FOR HERBICIDE

SHOULD NOT BE TREATED

104. Every stand that contains an undesirable understory is not a candidate for herbicide treatment. Stands that have a combination of limiting factors such as excessively wet or rocky soil, a long history of understocking, lack of adequate seed sources, or high deer browsing pressure may not regenerate satisfactorily when the interfering understory is removed. Nevertheless, the herbicide and cutting procedures described here are useful for regenerating other hardwood stands, where interfering plants inhibit regeneration.

FERTILIZATION

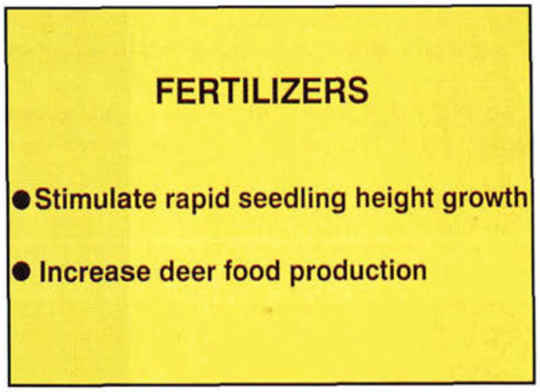
OF

REGENERATION

105. Another special method to increase regeneration success is aerial fertilization of the emerging young stand in clearcuts.

106. The technique was developed in the 1970's to help avoid regeneration failures caused by a combination of severe deer browsing, too few advance seedlings, and severe deficiencies of soil nitrogen and phosphorus. It has been used successfully on more than 12,000 acres of the Allegheny National Forest.

107. The growth responses that can be obtained with young black cherry are dramatic, as shown here. The tree on the left is from a fertilized clearcut and grew 6 to 7 feet during the year that fertilizer was applied. The tree on the right is an unfertilized seedling from the same stand; it grew only about 1 foot during the same time period. Both trees are of seedling origin and show the response after two growing seasons.



FERTILIZERS

- Stimulate rapid seedling height growth
- Increase deer food production

108. The basic principle of this strategy is to stimulate enough seedlings to grow rapidly out of reach of deer to produce a new stand and to produce more food than deer can consume.

109. When young clearcuts are fertilized, the tree seedlings, as well as the herbaceous plants, respond vigorously. The increased food supply reduces browsing pressure and allows many seedlings to grow rapidly and attain heights above the reach of deer in a year or so.

FERTILIZER PRESCRIPTION

Nutrient	Source	Rate
Nitrogen	Ammonium Nitrate	200# N/Ac
Phosphorus	Triple Super Phosphate	43# P/Ac

110. If you plan to fertilize, follow these simple guides: First, select the proper fertilizer. We recommend ammonium nitrate and triple superphosphate. Ammonium nitrate is preferred because it provides an immediate supply of nitrate that can be absorbed by the vegetation in large quantities, as well as providing a longer lasting supply of ammonium. Further, it is not subject to volatilization and it seems to stimulate growth more than other nitrogenous materials. Triple superphosphate is commonly used to supply phosphorus.

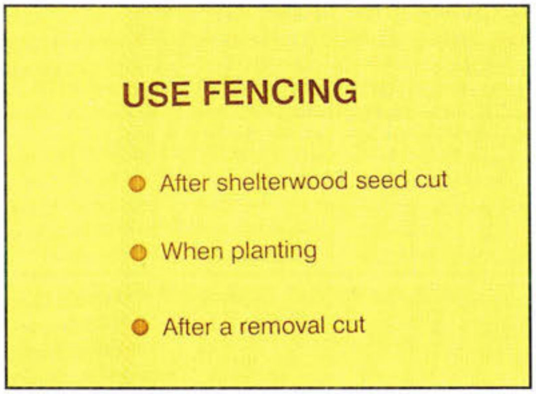
Second, fertilize at the appropriate rates. We recommend 200 pounds of nitrogen per acre and 43 pounds of phosphorus per acre.

Third, apply nitrogen only in the spring, when leaves are emerging and nutrient demands are high. Earlier applications when the vegetation is dormant are subject to leaching losses. Applications late in the growing season may not provide the nitrogen when needed. Phosphorus is not subject to leaching and can be applied before or simultaneously with the nitrogen.

Area Fencing

111. Fencing is another special measure for deterring deer damage to hardwood regeneration in areas of extremely high deer concentration.

112. In fenced areas, not only are fewer seedlings required to meet regeneration guidelines, but also there is greater species diversity due to reduction in deer browsing. The same species present before cutting are present after cutting, even if only as stump sprouts.



USE FENCING

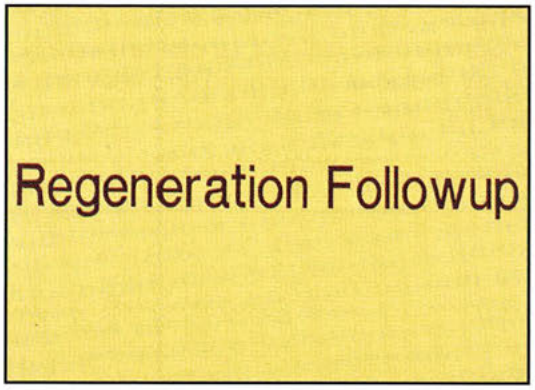
- After shelterwood seed cut
- When planting
- After a removal cut

113. Fencing immediately after a shelterwood seed cut can shorten the time required to build up enough regeneration to qualify for removal cutting. And it is required if planting is used to augment seed supply. Fencing may be the only way to salvage declining numbers of seedlings after a removal cut in areas of high deer population.

114. There are two major types of fencing materials, woven wire fence and electric fence. Standard woven wire fences are usually 8 feet tall. When properly sealed at the ground line, they can be very effective in excluding deer.

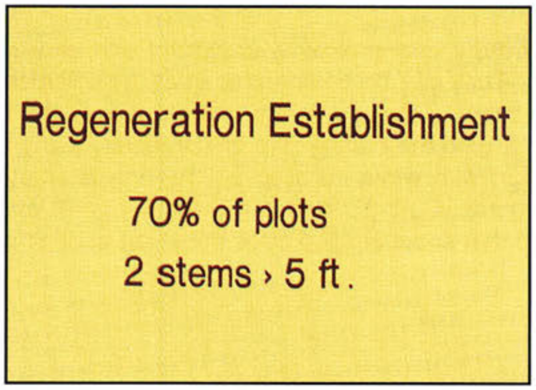
115. Electric fences are more economical to construct and can be salvaged for reuse. They can be constructed in either a vertical or a slant configuration. This is a 5-wire vertical fence with a solar panel for recharging the battery. We are presently using a 6-wire vertical design with wires installed so that the alternate wires serve as a ground. During the winter, the lower wires can be disconnected so that snow buildup does not short circuit the fence.

116. Although electric fences are considerably cheaper to construct than woven wire fences, they require a 5- to 10-year maintenance commitment to charge batteries, check for electrical continuity, and so on. Selecting the appropriate size solar collector and locating it properly can greatly reduce battery maintenance.



Regeneration Followup

117. Once a regeneration prescription is made and actually applied, it is important not to assume that satisfactory regeneration will develop automatically. Periodic checks are needed to monitor the progress of regeneration.

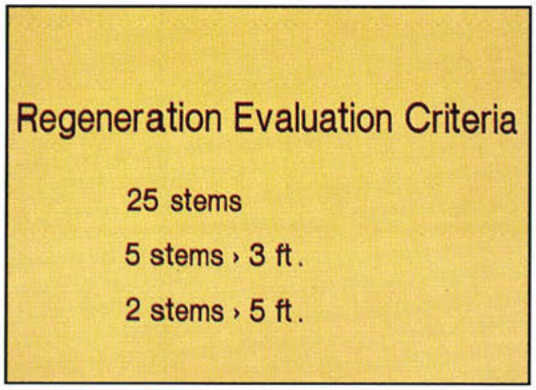


Regeneration Establishment

70% of plots

2 stems › 5 ft.

118. We usually do not consider regeneration successful until we have at least two stems greater than 5 feet tall on at least 70 percent of the area. This assures that the seedlings are well established and tall enough to escape further browsing. It may require anywhere from 2 or 3 years up to 10 to 15 years for regeneration to meet these criteria.



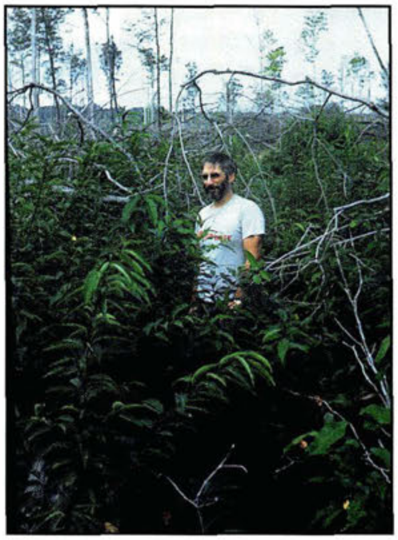
Regeneration Evaluation Criteria

25 stems

5 stems › 3 ft.

2 stems › 5 ft.

119. We use three criteria for evaluating progress of regeneration toward this goal: proportion of regeneration plots containing at least 25 small stems, the proportion of plots with at least five stems greater than 3 feet tall and the proportion of plots with at least two stems over 5 feet tall. All three stocking criteria should be determined both for desirable species alone and for all commercial species. This permits the probable success to be specified in terms of these two species groups.



120. Progress of regeneration development can be estimated at any time after final harvest from the proper combination of stocking criteria. Delays in this process will indicate the need for special measures. If the stand is progressing in the expected time with at least 70 percent stocking, the probability of regeneration success is high and no special treatments are needed. If the stems are not developing in height, deer browsing is probably hindering them: fertilization or fencing should be considered. If none of the stocking criteria exceed 30 percent, fencing, planting, fertilization, and weed control may all be required. When 70 percent or more of the plots are stocked with two stems greater than 5 feet tall, the stand should be considered established, even though it may not be with the most desirable species. Further change in stocking of desirable species is unlikely after the site is occupied by other stems of large size.

SILVAH PRESCRIPTION SUMMARY

121. The SILVAH system uses the principles and guidelines we have just discussed to determine which actions may be necessary to successfully regenerate a stand. The next few slides summarize the conditions under which each prescription is reached.

FINAL REMOVAL CUT

- Advance regeneration adequate
- Interfering plants not extremely heavy

122. A Final Removal Cut is prescribed in mature stands if advance regeneration and expected sprouts or sapling regeneration are adequate and interfering plants are not extremely heavy. All trees 2 inches d.b.h. and larger, including culls and non-merchantable trees should be removed or killed so that they do not interfere with developing regeneration. This may be a clearcut, the second cut in a two-cut shelterwood sequence, or the third cut in a three-cut shelterwood sequence when the advance regeneration is sapling size (as in a three-cut shelterwood or where sapling regen follows any heavy cut). Special care is required to protect saplings from damage during logging.

FINAL REMOVAL CUT WITH RESIDUALS

- Advance seedlings at least 50% of regeneration stocking
- There are enough well-formed poles of tolerant species to make 70% total stocking
- Interfering plants not extremely heavy

123. A Final Removal Cut with Residuals prescription is the same except that seedling regeneration provides at least 50 percent of the stocking and enough additional plots are stocked with well-formed poles of tolerant species to make 70 percent total stocking. The stand should be cut just as in the final removal cut prescription, but 30 to 80 good quality 3- to 10-inch trees per acre should be retained. Interfering plant stocking should be less that 70 percent.

FINAL REMOVAL CUT, FENCE

- Advance regeneration adequate only with low deer pressure
- Interfering plants not extremely heavy

124. The Final Removal Cut, Fence prescription is appropriate under the same conditions as the Final Removal Cut prescription, except that advance regeneration is only adequate under conditions of very low deer pressure. Erecting a fence at the time of the removal cut reduces deer pressure and the number of advance seedlings needed to successfully regenerate the stand. Interfering plant stocking should be less than 70 percent.

FINAL REMOVAL CUT WITH RESIDUALS, FENCE

- Advance seedlings at least 50% of regeneration stocking only with low deer pressure
- There are enough well-formed poles of tolerant species to make 70% total stocking
- Interfering plants not extremely heavy

125. A Final Removal Cut with Residuals, Fence prescription is used under the same conditions as the Final Removal Cut, Fence prescription, except that advance regeneration will be supplemented with residuals. Interfering plant stocking should be less than 70 percent.

FIRST REMOVAL CUT

- Stand mature
- Advance regeneration adequate
- Interfering plants not heavy
- Visual or site limitations present

126. The First Removal Cut prescription is part of a three-cut shelterwood prescription. It is appropriate in stands that are mature, have adequate small advance regeneration to ensure success after overstory removal, that do not have heavy interfering plant problems, but do have visual or site limitations. In these stands spreading the overstory removal over two cuts will retain some overstory shelter while providing enough additional sunlight to allow the small seedlings that are already established to grow to sapling size of 10 or 15 feet tall. These saplings not only improve the visual appearance of the site, but also since they are rooted in mineral soil, will maintain the transpiration pump established by the overstory trees and thus be able to withstand high early season water tables and late season soil drying.

FIRST REMOVAL CUT WITH RESIDUALS

- Stand mature
- Advance seedlings at least 50% of regeneration stocking
- There are enough well-formed poles of tolerant species to make 70% total stocking
- Interfering plants not heavy
- Visual or site limitations present

127. The First Removal Cut with Residuals prescription is used under the same conditions as the previous prescription, except that advance seedlings are supplemented with residual trees. Thus, retention of 30 to 80 good quality trees as described previously is a requirement, not an option.

FIRST REMOVAL CUT, FENCE

- Stand mature
- Advance regeneration adequate only with low deer pressure
- Interfering plants not heavy
- Visual or site limitations present

128. The First Removal Cut, Fence prescription is appropriate in mature stands under the same conditions of visual or site limitation as its unfenced counterpart. In this situation, however, advance regeneration is only adequate under very low deer pressure. A fence is used to exclude deer, thus reducing the number of seedlings required for adequate advance seedling regeneration.

FIRST REMOVAL CUT WITH RESIDUALS, FENCE

- Stand mature
- Advance seedlings at least 50% of regeneration stocking only with low deer pressure
- There are enough well-formed poles of tolerant species to make 70% total stocking
- Interfering plants not heavy
- Visual or site limitations present

129. The First Removal Cut with Residuals, Fence prescription is identical to the First Removal Cut, Fence prescription, but residual trees are required to supplement small advance seedlings in the regeneration counts.

SEED CUT

- Stand mature
- Advance regeneration inadequate
- Seed supply and deer will permit seedling establishment
- Interfering plants not abundant

130. A Seed Cut prescription is made in stands that are mature, but advance regeneration is not adequate to permit a final removal cut; seed supply and deer pressure will permit seedling establishment, and interfering plants are not currently abundant. In these stands, a shelterwood sequence will usually provide the best way to establish new seedlings and harvest the overstory. The first cut should reduce overstory relative density to 60 percent to allow establishment of additional seedlings, but not let them grow rapidly enough that they become attractive to deer. Where deer pressure is low, overstory relative density can be reduced to 50 percent to provide slightly larger seedlings. After 3 to 10 years, when adequate seedlings have become established, the overstory can be removed in one cut if there are no visual or site limitations or in two cuts if there are visual or site limitations. If overstory density is already below 75 percent, making a seed cut alone will probably not develop the desired regeneration. It is important in this situation to determine what other limitations may exist and remedy them before proceeding with any cutting.

HERBICIDE, SEED CUT

- Stand mature
- Advance regeneration inadequate
- Seed supply and deer will permit seedling establishment
- Interfering plants at least moderately abundant

131. The Herbicide, Seed Cut prescription is appropriate under the same conditions as the Seed Cut prescription, except that interfering herbaceous or woody understory plants are at least moderately abundant. In this situation the stand should be treated with herbicide to remove the interfering plants before proceeding with the seed cut.

SEED CUT, FENCE

- Stand mature
- Advance regeneration inadequate
- Seed supply and deer limit number of seedlings likely to become established
- Interfering plants not abundant

132. The Seed Cut, Fence prescription is used under the same conditions as the Seed Cut prescription, except that a combination of deer pressure and poor seed supply limit the number of seedlings that are likely to become established. A fence reduces the number of seedlings required to provide adequate advance reproduction.

HERBICIDE, SEED CUT, FENCE

- Stand mature
- Advance regeneration inadequate
- Seed supply and deer limit number of seedlings likely to become established
- Interfering plants at least moderately abundant

133. The Herbicide, Seed Cut, Fence prescription is appropriate under the same conditions of inadequate advance regeneration as the Seed Cut prescription, except that a combination of poor seed supply, high deer pressure, and at least moderately abundant interfering understory plants are likely to limit seedling establishment and growth.

HERBICIDE, WAIT

- Stand mature
- Advance regeneration inadequate
- Seed supply and deer will permit seedling establishment
- Interfering plants at least moderately abundant
- Overstory relative density below 75%

134. The Herbicide, Wait prescription is used under the same conditions of inadequate regeneration and interfering plant density as the Herbicide, Seed Cut prescription, except that the overstory relative density is already below 75 percent. Under these conditions there should already be enough sunlight to provide for seedling establishment and the only treatment necessary may be control of interfering plants. Since there is no cutting, soil disturbance caused by logging will not risk reestablishment of grasses and sedges, providing additional time to obtain advance seedlings.

FENCE, WAIT

- Stand mature
- Advance regeneration inadequate
- Interfering plants not abundant
- Overstory density low enough to permit seedling establishment
- Seed supply inadequate at current deer pressure, but would be if deer pressure was eliminated

135. The Fence, Wait prescription is used in mature stands when advance regeneration is inadequate, interfering plants are not abundant, overstory density is already low enough to permit seedling establishment, and seed supply is inadequate at current deer pressures, but would be adequate if deer pressure is eliminated. Fencing will reduce the amount of seed and numbers of seedlings required.

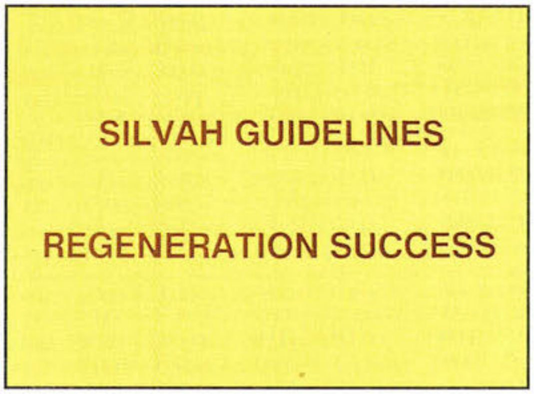
CONSIDER ARTIFICIAL REGENERATION

- Regeneration exceptionally difficult eg. seed supply inadequate even when fenced
- NB. High investment cost!

CONSIDER ARTIFICIAL REGENERATION, FENCE

- As above, but both low seed supply and high deer pressure prevent regeneration

136. The Consider Artificial Regeneration prescription may be encountered when regeneration is exceptionally difficult, for example where seed supply is inadequate even when the stand is fenced against deer. Artificial regeneration may be the only alternative possible. Due to the high investment involved, we generally recommend that no action be taken in this situation. But, if some action is necessary, it is our best judgment that this is the most likely prescription to obtain regeneration. Similar arguments apply to the Consider Artificial Regeneration and Fence prescription where a combination of seed supply failure and very high deer pressure prevent natural regeneration establishment.



SILVAH GUIDELINES

REGENERATION SUCCESS

137. By systematically following the guidelines in the SILVAH system, successful regeneration can be obtained in most stands.

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Thinning Principles and Practices: Control of Stand Density, Structure, and Species Composition During Thinning in Hardwood Stands in the Alleghenies

David A. Marquis

THINNING

1. The SILVAH stand analysis and prescription technique provides a systematic procedure for analyzing data from forest stands to decide on a silvicultural prescription. In immature stands managed under an even-age system, thinnings often will be prescribed by the SILVAH system when stand density is high enough to warrant it, and the volumes to be removed will at least pay the cost of the thinning. This paper describes the underlying principles behind thinning practices recommended by the SILVAH system.

THINNINGS

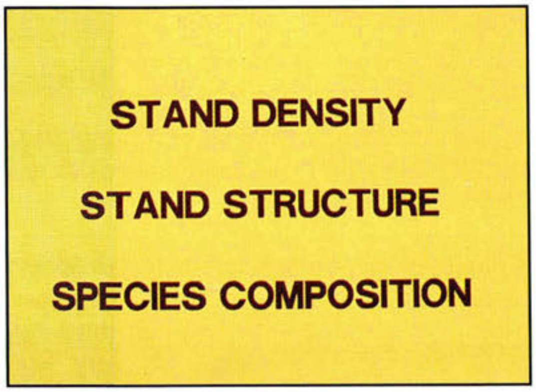
- Salvage Mortality
- Concentrate Growth on the Best Trees
- Reduce Rotation

2. Thinnings are made in even-aged stands to:

Increase yield by salvaging trees that would die

Concentrate growth on the best trees in the stand, thereby increasing value

Reduce the time required for the stand to reach maturity

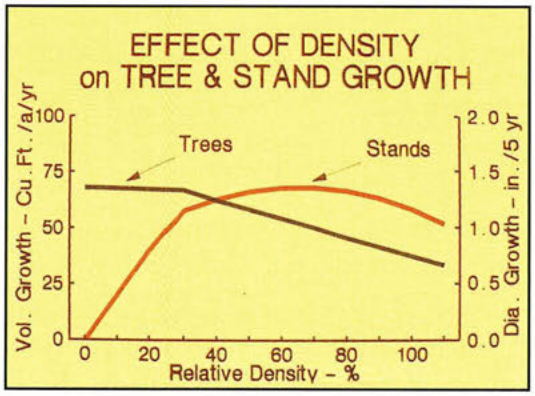


STAND DENSITY

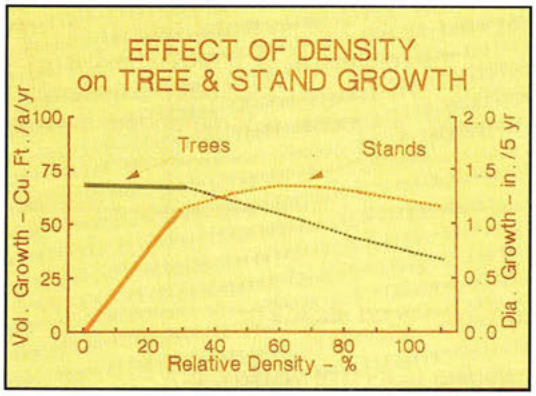
STAND STRUCTURE

SPECIES COMPOSITION

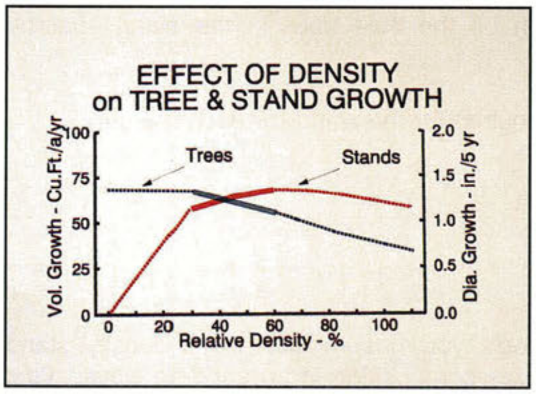
3. To achieve these goals, you must regulate stand density, stand structure, and species composition in appropriate ways. First look at the responses of individual trees and entire stands to various levels of stand density.



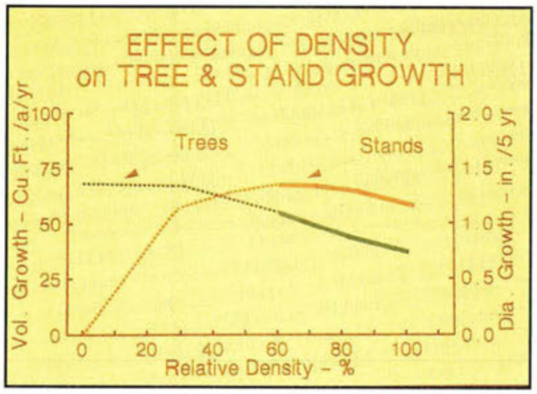
4. In general, volume growth of individual trees and entire stands is affected by density as shown here.



5. At very low relative stand densities (0 to 30%), the trees are so far apart that they do not influence each other; each tree is essentially open-grown. Growth rates of individual trees are at a maximum, and stand growth is directly proportional to the amount of growing stock present. Within this range of density, stand growth is less than the maximum because the available growing space is not fully utilized.

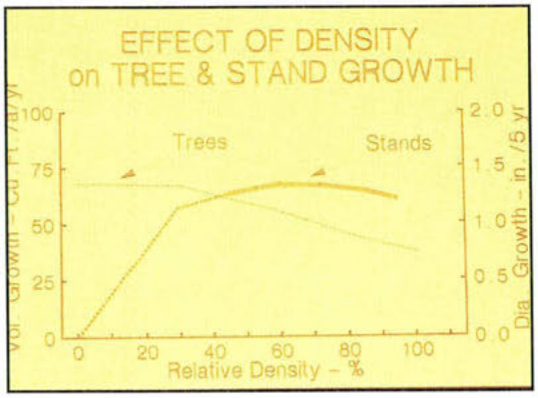


6. Between 30 and 60 percent stocking, trees are close enough to each other that growth rate is affected by the competition. Thus, individual tree growth declines as density and the amount of competition exceed 30 percent. Individual trees, nevertheless, have considerable room, and tree growth is rapid. Stand growth continues to increase because the amount of capital--or growing stock--increases, but at a slower rate than in the 0 to 30 percent density range.



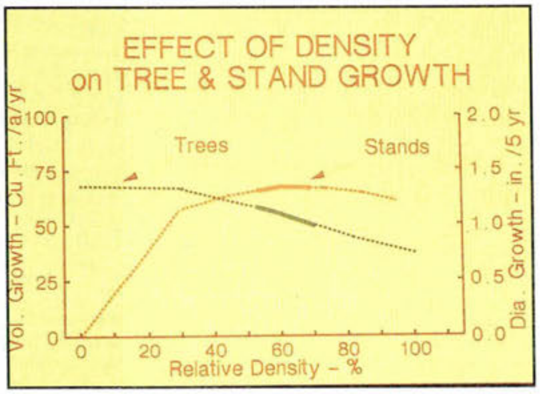
7. Above 50 to 60 percent stocking, competition among trees begins to have a major influence on individual tree growth rate and tree growth declines as density increases.

At some point in this range--usually somewhere between 50 and 80 percent relative density--stand growth reaches a maximum. At higher densities, both net stand growth and individual-tree growth decline due to excessive crowding. At very high densities, the stand may actually stagnate.

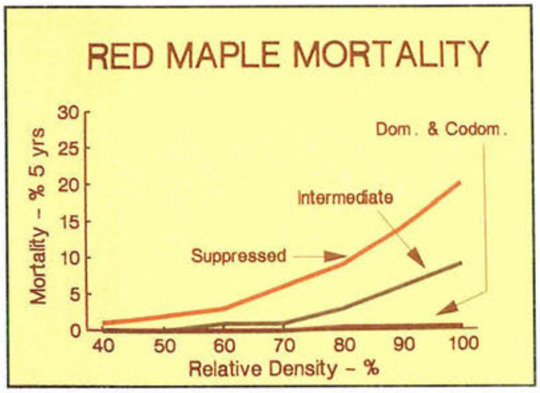


8. This means that there is a fairly broad range of stand densities over which stand growth does not vary greatly. This range may extend from as low as 40 percent to as high as 90 percent. Thus, a stand that grows at the rate of 100 cubic feet per acre per year at 80 percent density also may produce 100 cubic feet per acre per year after thinning to 50 percent density, for example. The difference is that the 100 cubic feet of growth will be distributed over fewer trees at 50 percent density. Each remaining tree will grow faster, but there are fewer of them, so total growth remains about the same.

Within this range of densities foresters can manipulate the growth of individual trees without losing any total stand growth. The usual objective of thinning is to keep the growing stock within this optimum range.

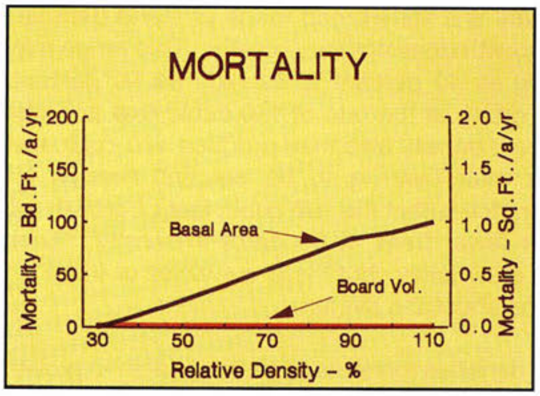


9. The breaking points mentioned are not sharp ones. Although we think of 60 percent as the point of full site occupancy (the point above which total gross growth is nearly constant), research has shown that differences in stand growth around that point (for example, between 50 and 70 percent) are usually small. So, if you miss the desired residual density by 5 percent in your marking, you need not be overly concerned about total stand volume growth.

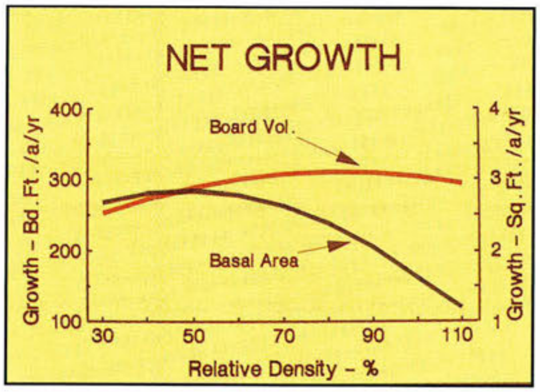


10. Mortality is another concern because one of the objectives of thinning is to utilize the volume in trees that would die from crowding if the stand were not thinned. Mortality is strongly influenced by stand density, increasing dramatically above densities of 60 to 70 percent.

But this mortality from crowding is usually concentrated in the lower crown class trees in the stand. If the trees that die are too small to be merchantable, their loss is relatively unimportant.

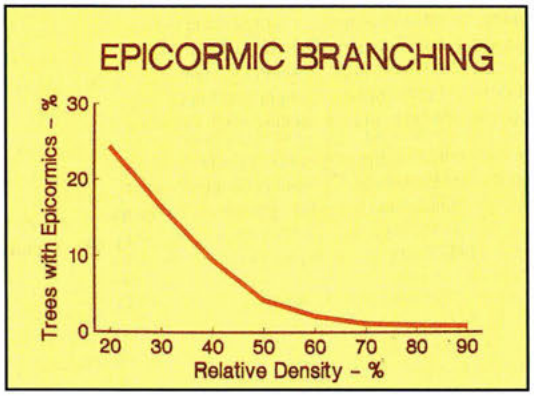


11. For example, mortality in basal area (which include trees as small as 1 inch d.b.h.) may represent 50 percent of net growth at high densities, while mortality in board-foot volume in the same stand is relatively insignificant.



12. As a result, net stand growth in basal area peaks at about 50 percent relative density and declines rapidly at higher densities where mortality is high among the small trees. But board-foot volume growth peaks at much higher densities--about 80 percent--and declines relatively little even at 100 percent relative density since there is little mortality in sawtimber-size trees. Board-foot volume growth declines, however, at lower densities.

13. Tree quality is also affected by stand density and can have a major effect on ultimate value yields. Epicormic branching, forking, and slow pruning of live branches can cause a loss in quality at low densities.



14. Our studies show that the number of epicormic branches that form on the lower bole can be excessive when density drops below 60 percent. Studies on Central States oak stands also show significant quality and value losses over the rotation if thinnings reduce density below 60 percent.

15. Understory vegetation of all kinds--tree seedlings and non-woody plants--respond to the increased availability of light, moisture, and nutrients when density is reduced. Even a small decrease in stand density will produce a response in some understory plants. Below 50 percent density, the undergrowth may become lush and dense, signifying that a significant amount of the site resources are not being used by overstory trees. Thinnings on some sites may result in the invasion of ferns and other plants that interfere with regeneration establishment, and may require herbicide treatment when it is time to harvest the existing stand and regenerate a new one.

Residual Density is a

COMPROMISE

among

Stand Growth, Tree Growth,

Tree Quality, and Understory

16. Thus, the optimum density is a compromise among several factors. Best individual-tree diameter growth occurs at densities of 30 to 50 percent, optimum stand growth in board-foot volume occurs at 60 to 80 percent, tree quality may deteriorate and dense understories develop at densities below 60 percent.

Recommended

RESIDUAL DENSITY

60 %

17. We recommend that residual density be reduced to 60 percent during thinnings. Cutting stands to this density will provide near maximum stand growth, good individual-tree growth with low mortality due to crowding, and it will minimize undesirable effects such as reduced tree quality due to epicormic branching and forking.

Relative Density

100
90 THIN
80 --------------------------------
70
60 DON'T THIN
50

18. The 80 percent relative density level makes a good breaking point in deciding whether to thin. If the stand is at or below 80 percent relative density, individual-tree growth should be good and mortality low; furthermore, the volume available for thinning usually will be too small to provide a commercial cut. When the stand is over 80 percent density, growth rates will be slowing down, mortality will be increasing, and there should be enough excess volume in the stand to make a worthwhile commercial thinning.

EXCEPTION

Fully-stocked Stands
(Over 92 % Rel. Den.)

19. Fully stocked stands are the one important exception to the general rule that stand density should be reduced to 60 percent during thinnings and other partial cuts. Fully stocked stands with maximum crowding will contain many trees with small crowns. When thinned to 60 percent in one cut, more growing space will be made available than the small-crowned residuals can immediately use, and it will be several years before crowns have expanded to fill all the growing space. In the interim, stand growth will be lost because the site is not fully occupied, and there may be some loss of tree quality or even mortality from the excessive exposure. Understory problems may develop during this period as well, making herbicides necessary when the stand is ready for harvest.

Do not remove
more than 35 % of the
Relative Density
in any one Cut

20. The rule in all situations is not to remove more than 35 percent of the relative density in any one thinning. If this rule is observed, excessive exposure and other detrimental effects of making the first thinning too heavy will be avoided. So, in some stands, the first thinning will reduce relative density to only 65 or 70 percent, and a second thinning will be needed before the stand is brought to the 60-percent level.

21. Here is a 50-year-old Allegheny hardwood stand at 100 percent stocking. Mortality due to crowding is high in this stand, especially among the small trees. As a result, net growth in basal area is low. Individual tree growth is slow, especially among the small trees. There is very little undergrowth.

22. Here is a section of that stand thinned to 60 percent relative density. There is virtually no mortality in this stand, and net volume growth is considerably higher than that in the uncut stand as a result. Also, individual tree growth is good, and there has been a modest increase in the number and size of advance seedlings.

23. This stand was thinned to 40 percent relative density 5 years before the photo was taken. Note how the understory has developed. Invasion by herbaceous plants, especially ferns, is much more likely at densities below 60 percent. Individual-tree diameter growth is excellent in this stand, but there are relatively few trees present. While stand basal area growth is still near the maximum, sawtimber volume growth is lower than it might be. Also, epicormic branching has increased on some trees, especially the intermediate crown-class maples and beeches.

24. There are several real dangers in any partial cutting that you should always bear in mind. Thinnings tend to increase understory density, as already pointed out. This may be desirable if that understory is advance seedlings, but undesirable if they are interfering plants that will persist and become a problem when it is time for regeneration. Especially on the Allegheny Plateau of Pennsylvania where deer populations are high, thinning almost certainly will result in the development of fern understories in many stands. Therefore, thinning often obligates you to perform an herbicide treatment in the future.

Several years ago, we felt that you might minimize problems with fern encroachment by thinning more lightly. But this has not been effective. Any thinning tends to produce a response in the undesirable understory plants. So, the question is whether to thin and risk the need for an herbicide at the end of the rotation, or not to thin at all.

25. Another caution in any partial cutting is the damage to residual trees by the felling and skidding operation. If care is not exercised, the damage can completely negate the benefits of thinning, through decay that enters the logging wounds, causing serious degrade or even outright mortality. The more entries made into a stand for thinning, the more of this type of damage you are likely to encounter. We tend to avoid frequent, light thinnings for this reason, and generally recommend against entry into a stand unless benefits of the thinning clearly warrant the risks.

Thinning Entries at

15 to 20 Year

Intervals

26. By using our 60 to 80 percent density rule, the interval between thinnings in most stands will be 15 to 20 years. This seems to be a practical and biologically desirable interval.

Okay, now that we know the effect of stand density, we can readily decide what level of stocking to maintain in the residual stand. Great! We're all ready to go out and thin a stand to achieve our goals of maximizing volume and value yield. Right? Wrong!

The manner in which the thinning is done will determine the extent to which these goals are actually achieved. Too often, thinnings are made in such a way as to work against these goals, because the forester marks to some density without any understanding of how stand growth and yield are also affected by stand structure and composition. A high-grading, a thinning, and an individual-tree selection cut may all leave a residual stand at 60 percent relative density. Do you REALLY understand how differences in structure and composition make these cuttings entirely different? If not, you may well be pushing your stands in a direction you do not want them to go.

Ben Roach, a well-known researcher from the Central States and Northeastern Forest Experiment Stations, used to recite an experience from the early years of his career that illustrates this problem very well:

(The following is transcribed from a tape recording made during a lecture by Ben Roach. It describes his "Seat-of-the-Pants-Forestry" experience on the Kaskaskia Experimental Forest in Illinois.)

"In my early years, I had a very interesting and educational job. I was the superintendent of a moderately large and very active experimental forest. Unfortunately, there were no timber markets in the area, so the only way we could get our cutting experiments installed was to cut the trees ourselves, so we developed our own logging crew. Now the only way we could pay the crew was to sell timber and the only way we could sell timber was as lumber, so we got our own sawmill and the logging crew was expanded and doubled as the mill crew. Then the problem was to keep the crew together, and the only way we could keep it together was to furnish year-round employment. So, this meant that we had a substantial annual payroll, which meant a substantial annual cut, which meant many cutting experiments with many replications. There were a few times there when that operational tail wagged that research dog pretty hard, but we did do quite a lot of cutting.

Now for some years I was responsible for the whole operation, except designing the specific cutting treatments, and I had quite a bit of input there. When it came time to put in another study, the four of us would sit around the table and dream up new methods of cutting. Unfortunately, our treatments generally consisted of varying the cutting cycle and the amount of volume to cut at a particular time, so we didn't learn as much from that effort as we should have. But that's another story in research administration and I won't go into that.

But anyway, after the cutting treatments had been decided, then I had the whole show. I'd select the study areas, inventory the stands, mark each stand according to the general principles that we'd agreed on, lay out and put in the skid roads, take the logging crew out, cut, skid, load, and haul the logs; then cut them into lumber, then sort, grade, stack, and dry the lumber, and then find a market and sell the lumber, and then haul it. Fortunately I had a crackerjack of an assistant and he was pretty good at finding markets and selling the stuff, which was my weak point.

On top of that, I had the task of keeping all the business records and seeing that there was enough money in the kitty to pay the crews and maintain and replace the equipment. Plus, of course, keeping all research records of treatments, stand response and growth. Now fortunately, we were located quite a ways out in the woods and so I didn't have much time to waste on hanging around street corners and pool halls and things like that. This was before the days of television, so I could work in the evenings a lot. But anyway, this proved to be an extremely valuable experience. I learned a great deal, and I marked a fair amount of timber.

Now at this time, I'd been trained in, and was a firm believer in and supporter of, what I would now call the uneven-age management syndrome. In fact, in that era, all foresters in the country were trained in this. The basic characteristics of this syndrome were that you would inventory a stand at the same time you would make a growth study, or make an estimate of the net annual board-foot growth. Then you would multiply this annual growth rate by the length of the cutting cycle you wanted, in years. This would give you the prospective volume to cut per acre.

Then we went in to mark the stand. We'd take out the mature trees, and the poor trees, and leave good growing stock. Then after logging, we would go back through, kill the obvious culls among the sawtimber sizes, and sometimes even kill some culls amongst the poles. Now these cuts were referred to, in the terminology of those days, as combined rehabilitation-improvement cuttings. Stand improvement was presumed to be automatic, each cut resulting in improved growth and increasingly better quality. This was good forestry, and in those days it was often referred to as intensive forestry. It left us practitioners in a very noble and self righteous frame of mind. The rest of the world might be raping their woods, but by golly, we were practicing good honorable forestry, perpetuating improved stands for posterity, and even showed you could make a modest profit at the same time. Just made you feel good all over.

Now as I said, I was responsible for making the periodic inventories and compiling the records of stand development and growth to prove just how good our forestry practice was. Fortunately, we had a number of treatments with short cutting cycles and fairly heavy cuts. Also our stands were generally understocked. After a few cuts, it became clearly and painfully evident that I was running out of operable volume.

Now when I first began to suspect that I was running out of timber, I used our standard excuse that we probably over-estimated our growth rate a little bit. After all, our growth studies were fairly crude and maybe our volume tables were a little bit over-optimistic. We tended to estimate merchantable heights to very small and really inoperable top diameters, for example. But I checked and rechecked a number of periodic stand inventories, and I could show on paper that the stands had about the same volumes as when we started. Often they had grown more than what we predicted.

The trouble was, that when I took off my researcher's hat and put on my timber operator's hat, (which in those days was one of those big old heavy fiberglass, Bullard WWI-type helmets) and go out to the woods to mark the volumes for the next cut, I couldn't find it. It was all in what we called the good growing stock trees, the 11-, 12-, 13-, and 14-inch small sawtimber trees that we wanted to save to put on more growth and which, although they were merchantable according to our sawtimber specifications, just weren't operable on a practical basis. Particularly in those days, there was just no way you could get a commercial or economic sawtimber cut out of 11-, 12-, and 13-inch trees, regardless of the fact that we didn't want to cut them anyway.

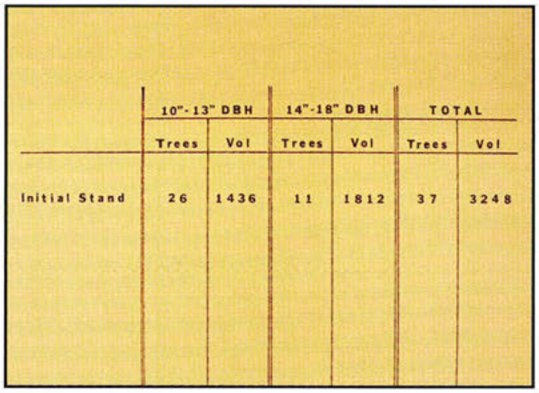
Now this came as something of a shock to me. Here I was a decent Christian boy of good morals and honorable intentions doing my best to practice honest intensive forestry and I was running out of timber. It just didn't seem fair. Now all I could think of was that I must be doing something wrong, and I hoped that I could figure out what this something was and correct it before other people, and especially the boss, discovered I was obviously a pretty lousy forester.

The most likely place where I was going wrong was in my marking, so I began to get a little gun shy about marking timber. And often thereafter, when I finished marking a stand, I'd sit down on a fallen tree at the edge of it and light up a cigarette and look back at my paint marks (or in those days, the blazes) and I'd wonder what have I done to this stand. Have I cut too little or too much? Have I changed the composition? If so, in what direction? And how much? And what difference is that going to make in growth rates? What have I done to the stand structure? And there was the problem.

We could measure stand density in terms of basal area or volume per acre, but we had no way to put it in terms of relative growing stock. We could monitor the change of composition at our next inventory, but we had no good way to predict what that change was in advance, or what effect it might have, nor how we could control it. And as for stand structure, well, nobody paid much attention to it, and even if it were important, what could you do about it, anyway?

Now since those early days, I've spent a large part of my career working on these problems, and eventually, I came to realize that it was not just a case of recognizing these things. We had to have some way to measure them, to put numbers on them. And then we had to have some way to manipulate them, some measured amount to be able to predict the response in terms of physical quantities, over some length of time. Until we could do that, our silvicultural system, which we called rehabilitation-improvement cutting, should more accurately have been called, the mark-by-the-seat-of-the-pants-silvicultural-system and, the I-sure-do-hope-the-Lord-will-continue-to-provide-system of management planning. And unfortunately, these two methods are still in somewhat rather wide use today.

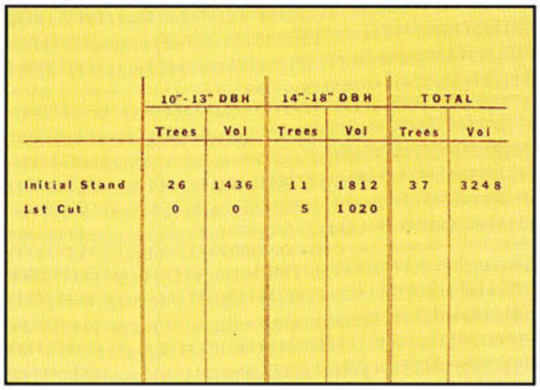
Well, to continue my story and shorten it somewhat, I eventually learned that there were basically two things wrong with my marking, or for that matter, with our basic assumptions. First, we were dealing with stands that were already understocked-- not too badly understocked, but we didn't help them any by making them more so. The second, and the more important thing, was that we were playing hob with stand structure without actually realizing it, and especially without realizing the consequences. Let me show you how it works.



	10"-13" DBH		14"-18" DBH		TOTAL	
	Trees	Vol	Trees	Vol	Trees	Vol
Initial Stand	26	1436	11	1812	37	3248

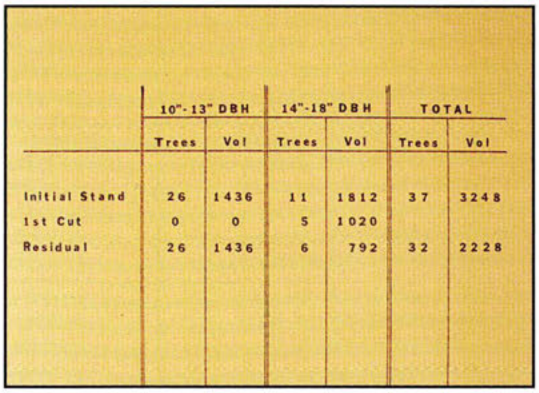
27. *Let's consider a typical stand of those days which our growth study has shown to grow 200 board feet per acre per year. We'll use a 5-year cutting cycle, so that will give me a cut of 1,000 board feet every 5 years. Ok, now these figures are developed from actual stand data. A typical stand in those days of the kind I was working with had 26 trees per acre in a 10 to 13-inch d.b.h. class with 1,436 board feet. The larger sawtimber, the 14 to 18-inch class, might have had 11 trees per acre, 1,812 board feet. So, the total stand then had 37 trees per acre, about 3,250 board feet.*

That's not much of a stand compared to our present stands that we work in around here, but for that period and location, that was not a bad stand.



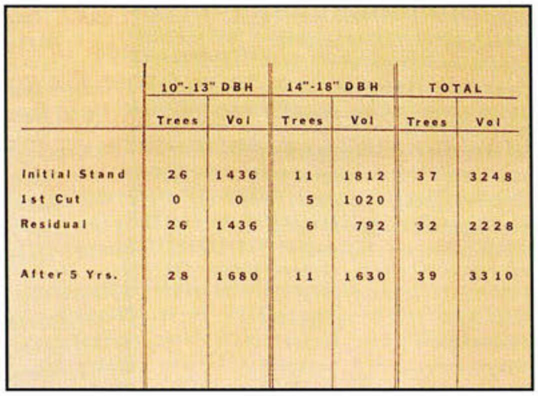
	10"-13" DBH		14"-18" DBH		TOTAL	
	Trees	Vol	Trees	Vol	Trees	Vol
Initial Stand	26	1436	11	1812	37	3248
1st Cut	0	0	5	1020		

28. *So, we'll go through and we'll cut our 1,000 board feet per acre. Now I don't want to cut these good growing stock (small sawtimber) trees, so I'll take my cut out of the mature big trees. I can get my 1,000 board feet in just five trees.*



	10"-13" DBH		14"-18" DBH		TOTAL	
	Trees	Vol	Trees	Vol	Trees	Vol
Initial Stand	26	1436	11	1812	37	3248
1st Cut	0	0	5	1020		
Residual	26	1436	6	792	32	2228

29. *Now that leaves me a residual stand of 26 good growing stock trees, 1,436 board feet. I've got six big trees left and about 800 board feet per acre. My residual stand totals 32 trees per acre and 2,228 board feet.*



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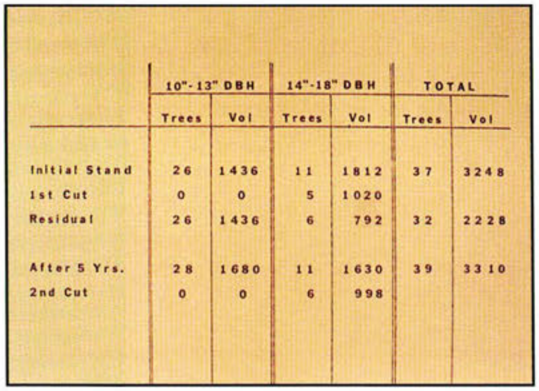
	Trees	Vol	Trees	Vol	Trees	Vol
Initial Stand	26	1436	11	1812	37	3248
1st Cut	0	0	5	1020		
Residual	26	1436	6	792	32	2228
After 5 Yrs.	28	1680	11	1630	39	3310

30. *Ok, we've made our first cut. Wait 5 years and go back, and I find I've got 28 trees in this small sawtimber class, and 1,680 board feet. Hey that's not bad you know, we're really bringing those small trees right up in there. I find that five of these trees have grown up into the 14 to 18-inch class, and by golly, I've doubled my volume there, from 800 board feet to 1,600. Who says we can't practice good forestry. I find that the total stand has 39 trees per acre, 3,310 board feet. Boy look at that! I've got more than I started with. Beautiful! Go home and get your paycheck, and say by golly I earned that one.*



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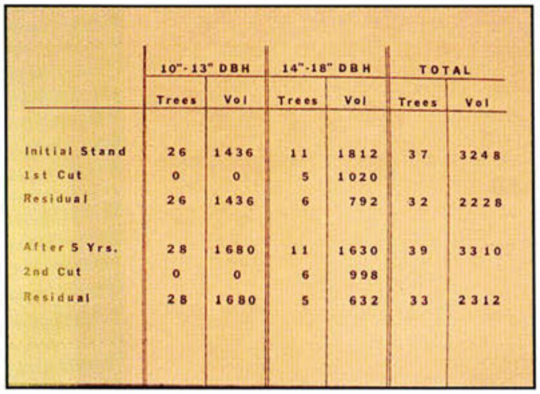
Residual	26	1436	6	792	32	2228
After 5 Yrs.	28	1680	11	1630	39	3310
2nd Cut	0	0	6	998		

31. *Ok, I'll go back and make a second cut. I'm not going to cut the small sawtimber, good growing stock. I'll take my 1,000 board feet up here in the large sawtimber again.*



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	Trees	Vol	Trees	Vol	Trees	Vol
Initial Stand	26	1436	11	1812	37	3248
1st Cut	0	0	5	1020		
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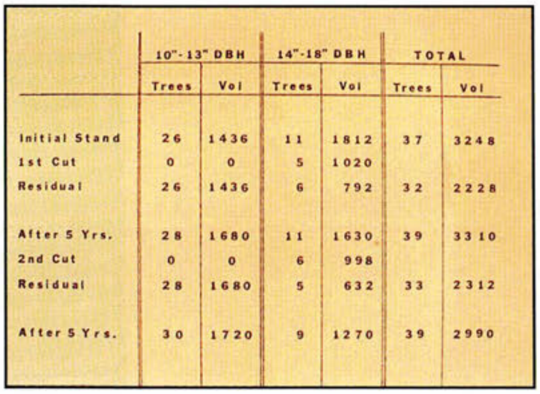
After 5 Yrs.	28	1680	11	1630	39	3310
2nd Cut	0	0	6	998		
Residual	28	1680	5	632	33	2312

32. *Now I've got a residual stand left. Look at that - I've made two cuts. I've got more left now that I had the first time. Put on good quality, good growth. This forestry really works out.*



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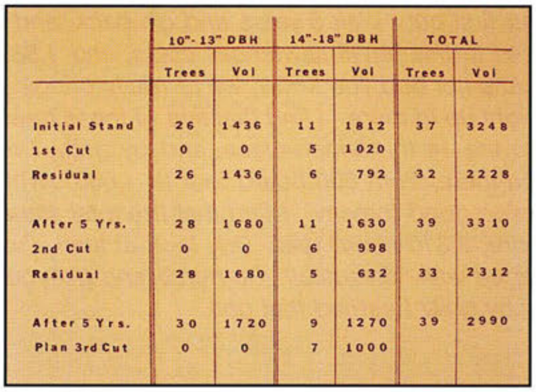
1st Cut	0	0	5	1020		
Residual	26	1436	6	792	32	2228
After 5 Yrs.	28	1680	11	1630	39	3310
2nd Cut	0	0	6	998		
Residual	28	1680	5	632	33	2312
After 5 Yrs.	30	1720	9	1270	39	2990

33. *Okay, go back 5 years later. By golly, see I did it again - I've got more trees coming up in the small sawtimber size class. Got more volume too. Of course, I'd expect some of these small trees to have moved up into large sawtimber, and they have. Ah hah, I don't have quite as many as the last time, but probably better quality. Gee, my board-foot volume is down a little bit too, but I still doubled what I left. Add up the figures for the stand, I got 39 trees per acre, that looks pretty good. Uh oh, now what happened? My volume is down. Now how come I got such good growth that period and such poor growth this time. Well, maybe it's bad weather, you know; maybe I got a period of dry years in there and they just didn't grow as much as they ought to.*



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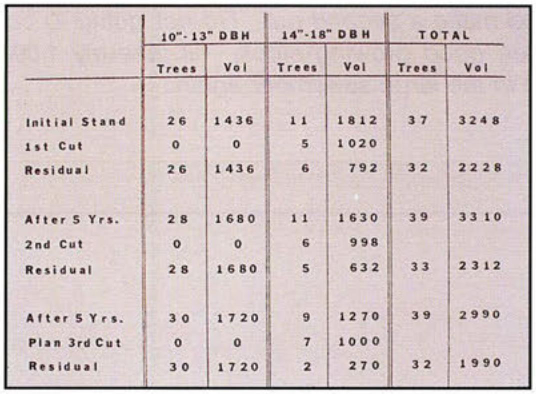
Residual	28	1680	5	632	33	2312
After 5 Yrs.	30	1720	9	1270	39	2990
Plan 3rd Cut	0	0	7	1000		

34. *Well what would happen if I made my planned third cut? Not going to cut anymore of these small sawtimber trees. If I'm going to get a 1,000 board feet out of large sawtimber, I've got to cut seven trees this time. See what's happening, I cut five, then six, and now I have to cut seven, to get the same volume.*



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Residual	28	1680	5	632	33	2312
After 5 Yrs.	30	1720	9	1270	39	2990
Plan 3rd Cut	0	0	7	1000		
Residual	30	1720	2	270	32	1990

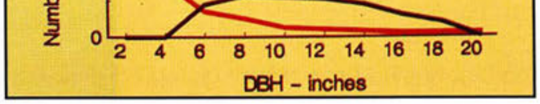
35. *If I made that cut, my residual stand is going to come out looking like this. Still have 32 trees per acre but I'm losing volume rapidly. Only got 2 trees in the large sawtimber class-only 270 board feet. There's no way that those 2 trees can grow 1,000 board feet in the next 5 years. And that's what I ran into.*

Now as I mentioned, these figures come from actual stand tables, but I did exaggerate the cutting a little bit. In order to show what happened in this process, in just a few cuts, I concentrated all my cutting up in the large sawtimber class. In actual practice we'd have taken a few trees down in the small sawtimber just for improvement purposes. When you do take some of that out of the smaller diameter classes, it delays the end result somewhat, especially if you start out with well-stocked stands and you stick to light cuts. But as long as you cut relatively more heavily among the larger trees than you do among the smaller ones, the end result is going to be the same every time. And believe it or not, it doesn't make a bit of difference whether you do that in the name of even-age or uneven-age management. You're going to end up in the same place.

Now, the thing is, when you cut one big tree, you take out a big chunk of volume all at one time. This volume can be recaptured through growth providing you leave enough stocking to use all the growing space. But the growth is distributed in much smaller chunks, among many smaller trees; or it's distributed in slightly larger chunks as ingrowth. But furthermore, as you continue to cut the larger trees, you're cutting generally the faster growing ones. The remaining trees grow, but at progressively slower rates. So sooner or later, you're either going to have to reduce the cut to where you are cutting less than the total stand growth, or else you are going to end up with all your volume clustered in a narrow range of diameters just above the threshold of *merchantability. And again, I say this doesn't matter whether you do it in the name of even-age or uneven-age management, it's going to happen.*

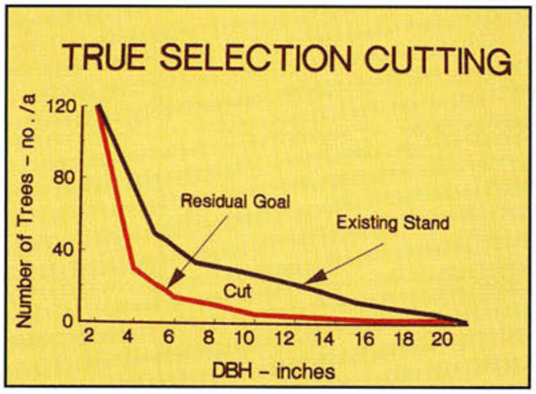
But this does point up a facet of selection cutting that has been almost totally ignored in this country. It would seem to be perfectly obvious that if you cut only the amount that the stand grows, you should have sustained yield forever. But this is one of those obvious facts, like the old one about the sun revolving around the earth, that's true only in one very special case. In the case of the sun revolving around the earth, the special case is, if you happen to be living on Earth and don't look up at the sky too often. Then you can believe that the sun revolves around the earth if you want to, and it doesn't make a whole lot of difference. But if you're an astronaut, heading out for Jupiter or Mars, you better change your assumptions in a hurry.

Now in the case of cutting only the growth in the stand and getting perpetual yields forever, the special case in which this holds true is if you cut that growth <u>from each diameter class in direct proportion to the amount of growth that occurs there.</u> And if you also continue to get reproduction. Otherwise, you are going to change the stand structure, you are going to change the rate of growth, and you are going to change the volumes that are available for cutting. So, so much for the hope-the-Lord-will-continue-to-provide-system-of-forestry. If we are actually going to manage timber, that is, to grow timber according to plan to meet a specific production schedule or to meet a specific product goal, then we are going to have to regulate stand structure."



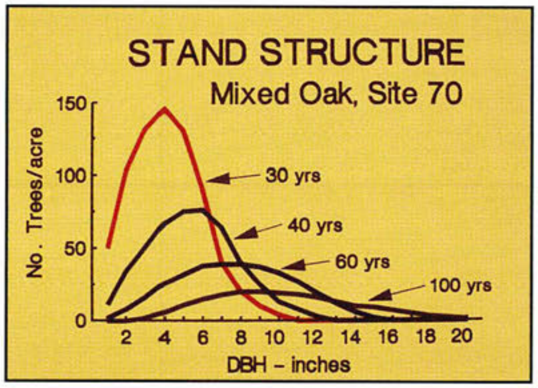
36. As Ben indicated, there are two proven silvicultural systems that have been designed specifically to regulate stand structure so as to grow timber according to a specific, planned production schedule: even-age and uneven-age management.

When numbers of trees are plotted over diameter class, a stand with a balanced uneven-aged structure has an inverse J shaped distribution. There are many ages of trees present in the stand, with large numbers of young (small) trees and relatively few older (large) trees. By contrast, the diameter distribution of typical even-aged stands plots as a bell-shaped curve. All trees are the same age, and hence, approximately the same diameter.

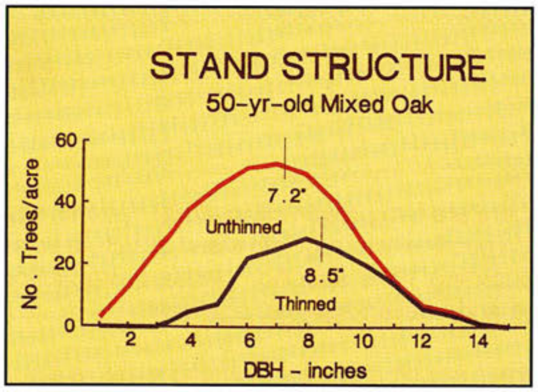


37. In uneven-age silviculture, we attempt to constantly maintain the same stand structure. We decide on the exact form of inverse J structure we want, cut in such a way as to get that structure established, and then--in each succeeding cut--remove the excess trees that have shown up in each diameter class. If the structure we have chosen is within the silvical capability of the species, we should have sustained yield thereafter in relatively equal amounts of both products and non-products.

We will consider uneven-age systems in detail in another chapter. But for now, we will concentrate on the control of stand structure in even-aged thinnings.

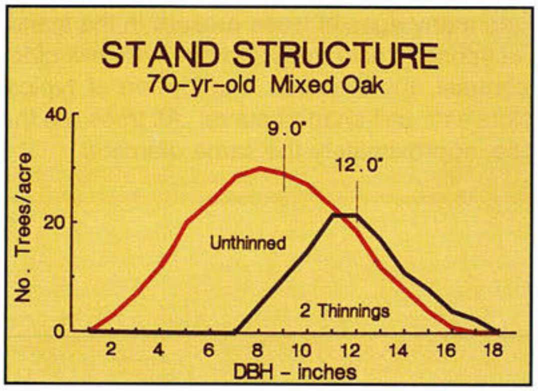


38. In even-age silviculture, stand structure changes over the life of the stand. The bell-shaped curve is narrow and high in young stands, when there are many trees in a few (small) diameter classes. As the stand gets older, the bell-shaped curve moves progressively to the right on the chart, signifying an increase in average diameter. The curve also becomes flatter and wider as the number of trees decreases and the spread in diameters increases. When most of the trees reach mature size, the stand is harvested and the cycle repeated.



39. In even-age silviculture, we use thinning to speed up the natural changes in stand structure over time--that is, to increase stand diameter and move the stand to the right on the chart, toward maturity. One way we do this is by removing trees from the small diameters, thus raising the average diameter.

For example, an oak stand was thinned to 60 percent relative density by taking two-thirds of the cut basal area in trees smaller than the average stand diameter. The cutting alone increased the average diameter by 1.3 inches, and moved the bell-shaped curve to the right on the chart.



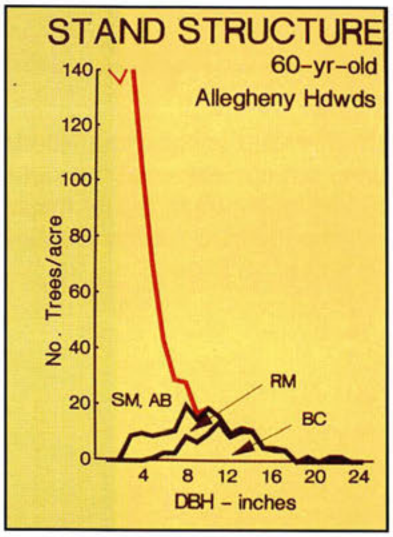
40. Thinning also gives the remaining trees more growing space and increases their individual growth rates. The combined effect of these two factors can be very significant.

In a 70-year-old stand that has had two thinnings, stand diameter was increased 3 inches by the thinning--9 inches versus 12 inches. For management purposes, the thinned stand can be considered equivalent to a 90-year-old natural stand.

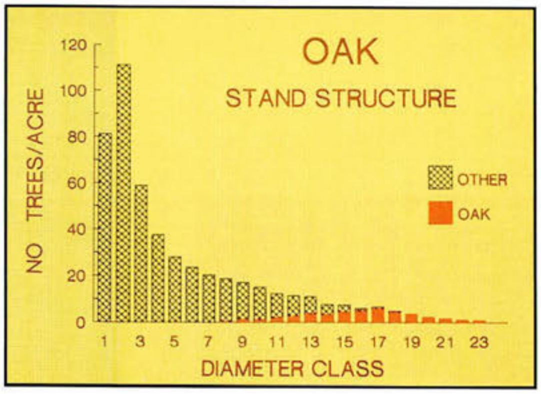
41. When managing stands for the purpose of growing timber, we want to end the rotation with a proper number of big trees properly spaced on every acre.

This is the ideal, and of course we rarely, if ever, achieve it. But we want to come as close to it as we can, and we would like to do it as soon as we can. Every thinning should be carried out with this goal in mind. We want to save the trees that come closest to meeting this goal. Therefore, we want our residual stand to contain the biggest and best quality trees that are now in it. The thinning should remove the bigger and better quality trees only if something is wrong with them, or if they need to be removed to adjust spacing--to provide needed growing space for other equally good trees. Otherwise, they should be saved for the final harvest when the big payoff for the rotation is obtained.

Thus is the theoretical goal of thinning. With stands of a single species, or group of similar species, it can be shown that this sort of cutting from below to push the large trees to maturity as quickly as possible will produce the greatest value return in the long run.



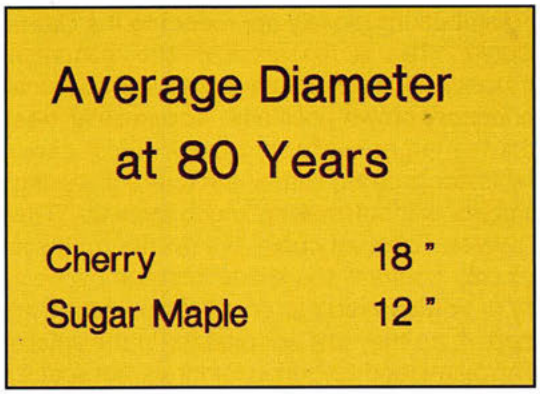
42. However, most mixed species hardwood stands do not follow typical even-age theories very well--the species in the mixture often have markedly different growth rates and tolerances to shade. As a result, many mixed hardwood stands have naturally occurring diameter distributions closely approaching the classic inverse J-shaped curve. This is the result of the mixture of species, and the presence of shade-tolerant stems in the small size classes and understory crown positions. Those small trees are the same age as the larger overstory trees in most cases. Once overtopped by faster growing stems, the tolerant saplings survive in large numbers without making much growth. They form the tail of the inverse J-shaped curve, but do not represent younger age classes. By contrast, the shade-intolerant species such as black cherry or northern red oak or yellow-poplar do not survive once overtopped, so they are not present in the smaller diameter classes. The diameter distribution for intolerant species alone forms a bell-shaped curve typical of even-aged stands.



43. The similarity between stand structure in these mixed stands and the classic all-age structure is only superficial. If we are to manage these stands by traditional even-age techniques, we must somehow convert the J-shaped diameter distribution to a bell-shaped distribution. But how does one deal with all those small trees in the lower end of the inverse J-shaped distribution?

44. If cutting is done strictly from below, the cut would be almost entirely noncommercial saplings, even in stands 50 to 60 years old. Several such pre-commercial cuts would be required in most stands to develop a bell-shaped diameter distribution.

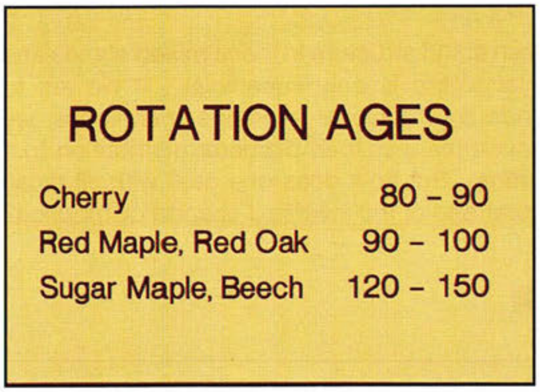
45. But if the saplings are ignored and thinning is concentrated in the merchantable sizes only, the thinnings tend to be high-grading. Much of the residual growing space will be turned over to saplings that are the same age, as the main part of the stand but much slower growing. Rotations are extended rather than reduced, and overall quality and value of the stand are usually decreased.



Average Diameter
at 80 Years

Cherry	18 "
Sugar Maple	12 "

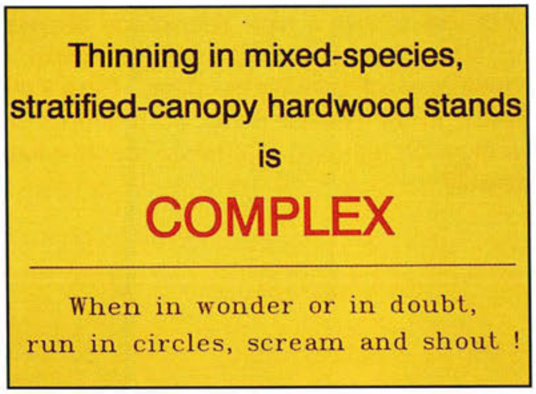
46. Another complexity in managing these mixed-species hardwoods is that the several species in a stand will not mature at the same time. In Allegheny hardwood stands, for example, sugar maple averages only 12 inches in d.b.h. when the black cherry reaches financial maturity at an average d.b.h. of 18 inches.



ROTATION AGES

Cherry	80 - 90
Red Maple, Red Oak	90 - 100
Sugar Maple, Beech	120 - 150

47. So, it may be desirable to manage the faster growing species on an 80- to 90-year rotation, whereas the slower growing ones may require 120 to 150 years to reach the same stage of development.



Thinning in mixed-species,
stratified-canopy hardwood stands
is
COMPLEX

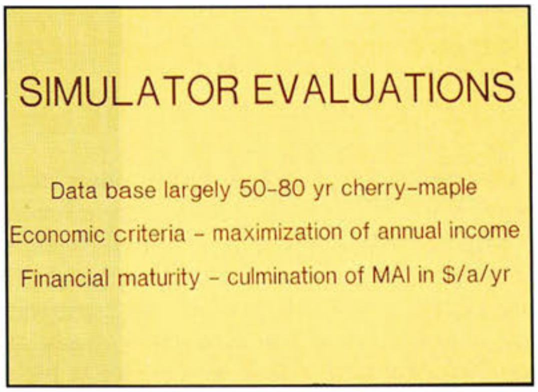
When in wonder or in doubt,
run in circles, scream and shout !

48. As a result, thinnings in these mixed hardwood stands can be very complex. Simple, textbook types of thinnings often do not work, and a wide variety of thinning practices and schedules may be needed.

THINNING

STRATEGIES

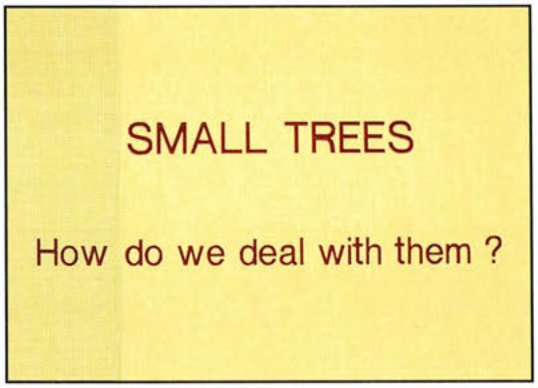
49. Many of the possible options have not been tested, and we still have much to learn. But, I will describe several thinning schemes and rotation strategies that we have tested on our computer simulator that seem to be both biologically and economically sound for use in mixed hardwood stands in the Alleghenies.



SIMULATOR EVALUATIONS

Data base largely 50-80 yr cherry-maple
Economic criteria - maximization of annual income
Financial maturity - culmination of MAI in $/a/yr

50. Our simulator correlations are based on the original SILVAH computer simulator, in which the data base is primarily 50- to 80-year-old cherry-maple stands. Economic analyses are based on the maximization of mean annual income, not on present net worth or internal rate of return.

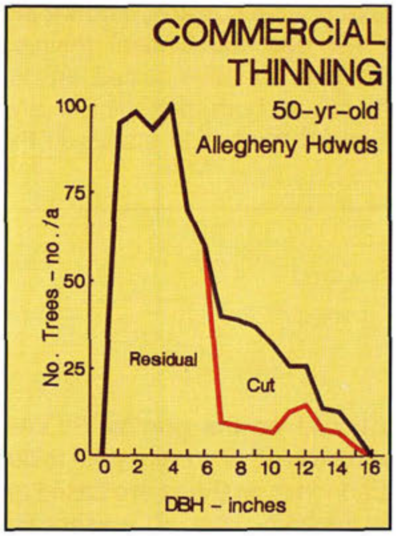


SMALL TREES

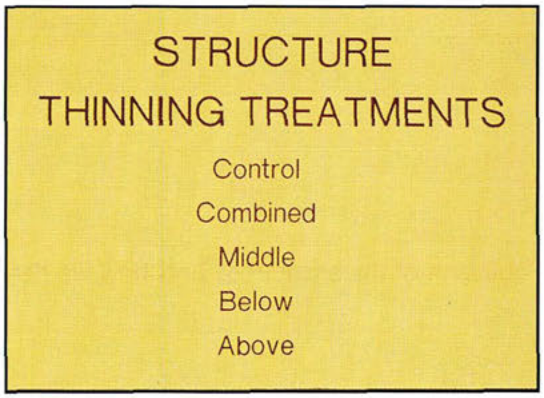
How do we deal with them ?

51. First, consider the question of the small trees and how we deal with them.

52. We have found that in stands with a high percentage of basal area in the sapling size class, it is impossible to make a commercial thinning without high-grading the stand. Even if the thinning is concentrated in the smaller poles, so much of the good growing stock must be removed that future stand values are reduced considerably.



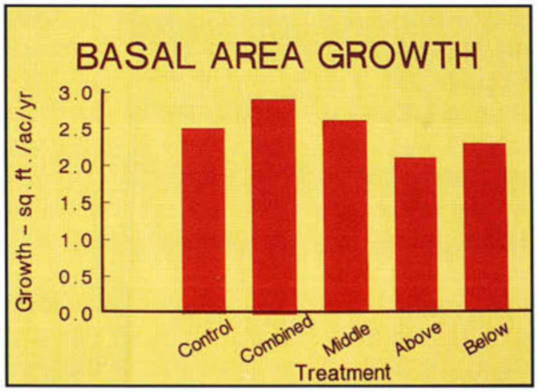
53. To illustrate, a 54-year-old stand containing 30 square feet per acre of basal area in saplings was thinned to 60 percent relative density without removing any saplings. Two-thirds of the cut basal area came from trees below the average merchantable diameter, so the trees cut averaged only about 8 inches d.b.h. The largest and best trees were retained. So, the middle size classes in the stand--the good growing-stock trees--were nearly eliminated, and a large percentage of the stand growing space became occupied by slow-growing, shade-tolerant saplings.



STRUCTURE
THINNING TREATMENTS

Control
Combined
Middle
Below
Above

54. In this same stand, we compared growth rates after other kinds of thinnings that varied stand structure in dramatically different ways, but left stand density the same (60%). The thinning from the middle treatment was an attempt to get a commercial cut without removing any saplings. Most of the cut in that treatment came from the pole class, plus a few sawtimber trees as illustrated previously. Thinning from above was a typical high-grading, removing all the larger trees and faster growing species. Thinning from below removed ONLY saplings and small poles and was a strictly noncommercial cut. The combined thinning was a commercial thinning in the merchantable size classes combined with noncommercial removals in the sapling class.


BASAL AREA GROWTH

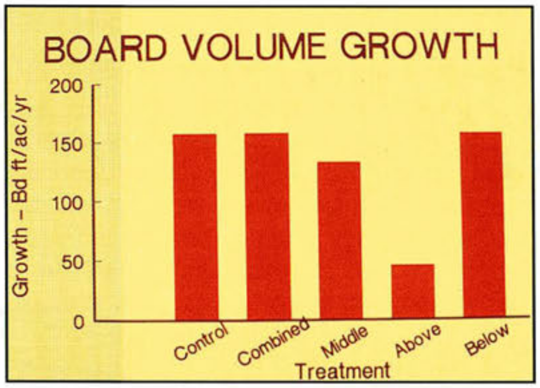
55. Total stand growth in basal area over the 10-year period after cutting was nearly as good in the thin from the middle as in the control or combined treatments which were better than that in the high-grading and precommercial thinning.

It is not surprising that total stand basal-area growth in the control treatment is nearly as good as that in the three moderate thinnings. Remember that total stand growth does not vary widely across the range of densities between 50 and 80 percent. The distribution of that growth--whether on many or few trees, or on primarily small or large trees--<u>does</u> vary, but not the overall total growth.

BASAL AREA GROWTH

	Combined Thin	Thin from Middle
Total Stand	2.8	2.6
% on Saps	11	33

56. In the thin-from-the-middle treatment, for example, a very large proportion of growth (one-third of the total) was on sapling-size trees that will not reach merchantable size within the normal even-age rotation period.

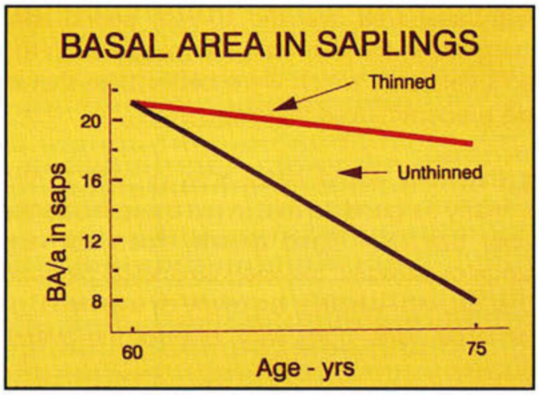

BOARD VOLUME GROWTH

57. As a result, sawtimber growth (and therefore value growth) 10 years after cutting was much better in the combined thin and the control. In the thin-from-the-middle treatment, our simulator projects total yield at age 100 to be reduced dramatically compared to the combined thin and the control. Since this thinning yielded only a marginal return from the pulpwood-size trees cut, the thinning was detrimental both in total volume yield and economic returns.

Sapling Basal Area

20 sq. ft. /a

58. Our computer simulation-runs on a variety of stands suggest that this negative effect of commercial thinning occurs when the stand contains more than approximately 20 square feet per acre of basal area in the sapling size class. If there is less than 20 square feet, a commercial thinning usually can be made without non-commercial cutting in the sapling class, and long-term yields will be greater than if the thinning is not done. But if there are more than 20 sqaure feet in the sapling class, any thinning attempted should include noncommercial removal of some of the saplings.



BASAL AREA IN SAPLINGS

59. Many stands under 60 years of age, especially in the northern hardwood, Allegheny hardwood, and oak transition types, will have more than 20 square feet of basal area in saplings. If the stand is left uncut at full density, mortality will reduce the saplings and eliminate the problem. But if the stand is thinned, the saplings will survive and grow, continuing to occupy growing space, even though they will not grow large enough during the normal rotation period to qualify for high-value products.

For example, in one 60-year-old stand that we examined, there were 21 square feet of saplings at age 60. With no thinning, mortality from crowding reduced sapling basal area to 8 square feet by age 75. But when a commercial thinning was applied, the same stand still contained 18 square feet of saplings at age 75.

RECOMMENDATION

Postpone Thinning
in Young Stands
Until Commercial Thinning
can be used
without TSI in saplings

60. So, our recommendation is to stay out of younger stands that contain more than 20 square feet per acre of sapling basal area, and let natural mortality solve the sapling problem. This avoids the need for investment in precommercial sapling removal, and produces similar long-term yield.

COMBINED THINNING

Commercial Thinning
plus TSI

61. Sometimes stands with large numbers of saplings also have sufficient volume to permit noncommercial cutting of saplings and commercial removal of merchantable trees too. Generally, the products removed are small-diameter material suitable primarily for pulp or even firewood. This combined commercial thinning plus-TSI (timber stand improvement) operation is recommended where the merchantable products will at least pay the cost of the thinning.

62. When the products to be removed will not pay the cost of thinning, the economic returns from an investment in precommercial thinning are questionable. Simulation-runs to date do not show that such investments are universally beneficial. These early thinnings do increase diameter growth of the crop trees.

EARLY THINNING CAN:

- Increase Taper
- Increase Forking
- Delay Natural Pruning
- Reduce Yield

63. But, they also have some negative effects such as:

Increased taper of crop trees (lower sawtimber volume for the same diameter)

Increased forking

Delay of natural pruning

Reduced total volume yields and later initiation of commercial thinnings in some situations.

PRE-COMMERCIAL THINNING

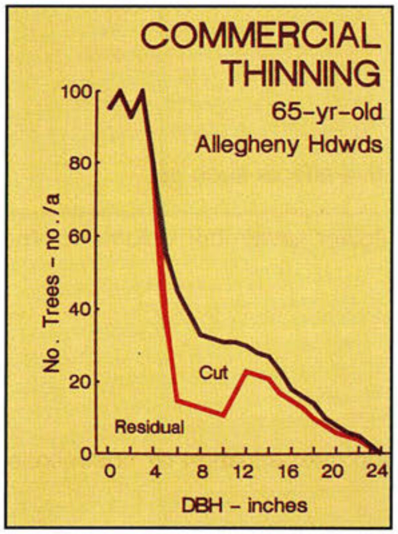
Use it only where:
SPECIES COMPOSITION
or
STAND QUALITY
can be significantly improved

64. So, in general we recommend no precommercial thinnings unless there are many good-quality stems of high-value species being overtopped by poor-quality trees or undesirable species.

COMMERCIAL THINNING

Cut from below
in merchantable sizes only

65. In stands with less than 20 sqaure feet of basal area in saplings, our simulation- runs suggest that the saplings can be ignored in marking for commercial thinnings. In such stands, cutting is concentrated in the smaller merchantable size classes, though sufficient volume also is removed from sawtimber sizes to make an operable cut.



66. We recommend that commercial thinnings be designed to create a bell-shaped structure among the merchantable size classes. This is achieved by removing about two-thirds of the cut basal area from below the average merchantable diameter and one-third from above that diameter. Although the sapling class is unregulated and remains a part of the stand that eventually will have to be removed at final harvest, it does not significantly interfere with stand growth during the intermediate culture period.

EFFECT ON ROTATION

	DIA.	MATURITY
Before Thinning	13.9"	26 yrs
After Thinning	14.8"	20 yrs

67. Such cuts guarantee that the usual objectives of thinning are met: an increase in average diameter and a shorter rotation. In the stand illustrated, this thinning increased merchantable stand diameter from 13.9 to 14.8 inches, and reduced the time to maturity by 6 years.

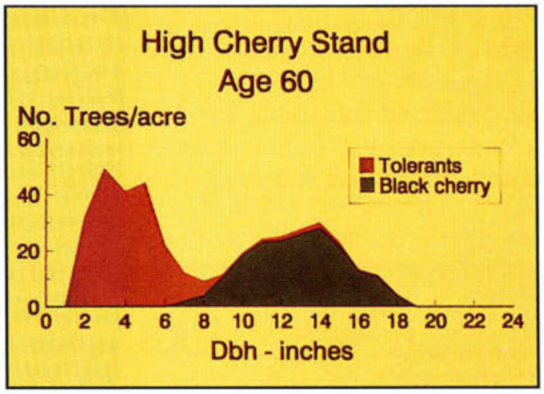
THINNING STRATEGIES

depend on

Species Composition

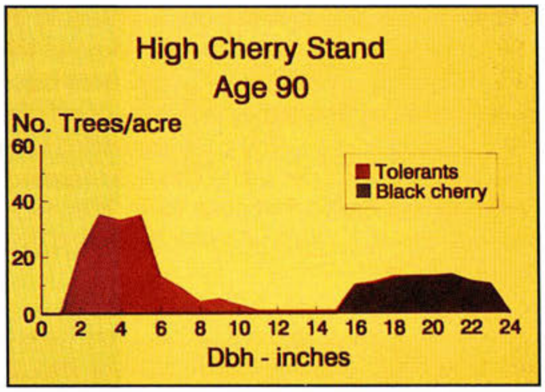
Size Distribution

68. In our simulation-runs, we have found that different strategies are needed to maximize financial returns. The appropriate strategy depends upon the species composition and size distribution of the particular stand.


High Cherry Stand

Age 60

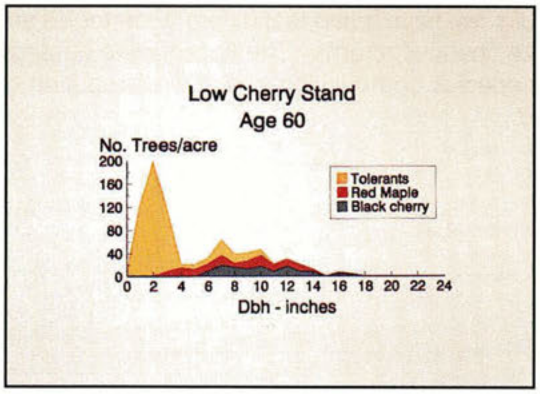
69. In stands such as this one, high-value black cherry dominates the stand even though there is a large number of saplings in the lower canopy and smaller diameters. In the stand illustrated, black cherry represented 81 percent of the stand basal area at age 60, when stand diameter averaged 12.6 inches.


High Cherry Stand

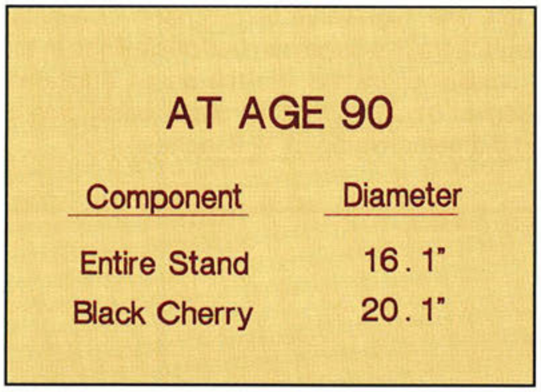
Age 90

70. At age 90, after two commercial thinnings that reduced density to 60 percent and removed two-thirds of the cut basal area from below the average merchantable diameter, the diameter reached 18.2 inches. At that point, the stand was financially mature by our calculations. This cutting strategy and rotation length of 80 to 90 years based upon a stand diameter of 18 inches produced the best financial returns of any of the several cutting alternatives and rotation lengths tested.

Remember that this stand was dominated by high-value, fast-growing black cherry. Also note that the 6 or 8 square feet of sapling basal area remained pretty much unchanged during the 30-year period. The saplings did not die because the thinning gave them enough light and moisture to survive. But they did not grow much either, so most of them are still present and must be treated at final harvest. Removing them earlier during the thinnings did not justify the expense.



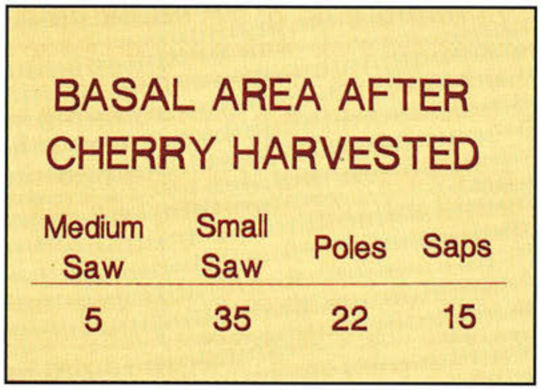
71. In another stand, the simulator-run gave different results. This stand, also 60 years old, contained only 36 percent black cherry and had a stand diameter of 10 inches. There was a considerable amount of red maple which was smaller than the cherry, but larger than the sugar maple and beech.



AT AGE 90

Component	Diameter
Entire Stand	16 . 1"
Black Cherry	20 . 1"

72. At age 90, after two thinnings just like those in the previous stand, the black cherry was mature, but the stand as a whole was not, with an average diameter of only 16 inches. The most profitable strategy in this stand was to harvest the black cherry at age 90 but carry the balance of the stand for another 30 years until the red maple and larger sugar maple reached maturity.

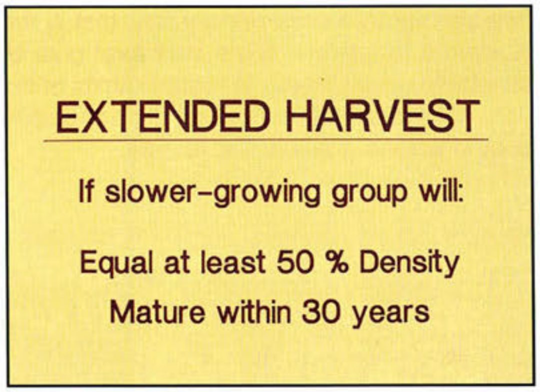


BASAL AREA AFTER CHERRY HARVESTED

Medium Saw	Small Saw	Poles	Saps
5	35	22	15

73. This makes good sense, if you consider the basal area and its distribution at age 90, after the cherry is removed. Most of the red maple trees are in the small sawtimber or larger pole class where they are growing into sizes where they will soon qualify for high-value sawtimber and veneer. Thus, they are increasing very rapidly in value at this time. It does not make sense to clearcut such stands when the cherry matures, because there is enough growing stock in other species to make a fully stocked stand that will increase in value rapidly.

However, regeneration could be a problem if all the cherry seed sources are removed at age 90. So, this cherry harvest should actually be spread over the remaining cuts, and attempts made to regenerate and hold cherry advance seedlings until the end of the rotation.



EXTENDED HARVEST

If slower-growing group will:

Equal at least 50 % Density

Mature within 30 years

74. As a general rule, our simulations suggest that this extended harvest or double rotation is profitable if the stocking in the slower growing species size group is at least 50 percent, and if that group will mature within 30 years of the faster growing group.

THIN - HARVEST

Near end of rotation, to harvest individually-mature stems while thinning from below in the rest of the stand

75. Actually, our simulations show that economic returns in nearly all stands will benefit if the last thinning in the rotation shifts from a strict thinning-from-below to include the removal of those individual stems that have reached large sawtimber size and are individually mature. This captures their yield earlier while avoiding undue risk from natural catastrophes that become more common on larger, mature trees. However, such thin-harvests must be used with care as they can easily turn into high-grading. And, as before, care must be taken to ensure that adequate seed sources of the faster maturing and more valuable species are retained to permit regeneration of these species in the next stand. With care, all of these objectives can be achieved.

76. I have so far ignored one major aspect of thinnings--tree quality. In hardwoods, tree quality often is the major factor affecting value, and one that must receive priority attention in selecting trees to be removed. It is far more important to remove poor-quality trees than to achieve some theoretical diameter distribution. For this reason, we record tree quality during stand inventory. Once a theoretical distribution of cut has been made based on size classes, we check to see that this cut can be made without leaving poor-quality stems in one size class while cutting good-growing stock stems in another class. If necessary, adjustments are made in the cut to eliminate the unacceptable quality trees first. So quality takes priority over stand structure in deciding which trees to cut.

MARKING PRIORITIES

1. Stand Density
2. Tree Quality
3. Stand Structure

77. In order of priority, we attempt to control density first; that is, we do not overcut or undercut to achieve some structural goal or remove all the unacceptable quality trees. Within the limits of the density to be removed, we give priority to removal of poor-quality trees. Achievement of structural goals is last priority.

EFFECT ON QUALITY

	AGS	UGS
Before Thinning	75	25
After Thinning	100	0

78. Using our guides will automatically improve quality, as the guides call for removal of unacceptable growing stock trees (UGS) before removal of acceptable growing stock (AGS).

SPECIES COMPOSITION
and
STAND STRUCTURE

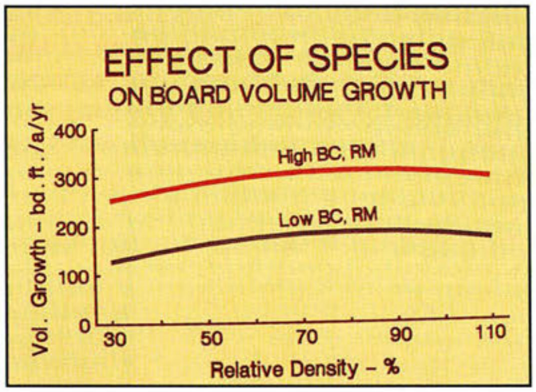
are closely related

79. The procedures described for manipulating stand structure automatically favor the faster growing species and individuals in the stand. These usually are the shade-intolerant and more valuable species.

EFFECT ON SPECIES

	% BL. CHERRY
Before Thinning	41
After Thinning	48

80. In the example mentioned earlier, the proportion of black cherry was increased from 41 to 48 percent using these guides.

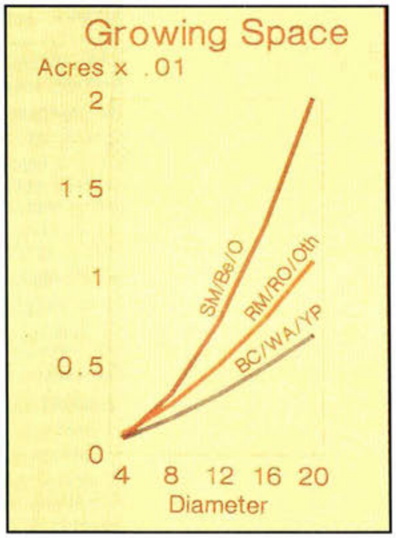


81. The manipulation of species composition can be one of the most important factors affecting stand yields. For example, in our Allegheny hardwood stands, board-foot volume growth of the entire stand can be 50 percent higher in stands that contain a high percentage of black cherry, than in comparable stands with little cherry. Northern red oak and yellow-poplar often perform in a similar way in oak-hickory or transition stands.

STUMPAGE PRICES

Black Cherry	$ 750
Red Oak	$ 500
White Ash	$ 350
Sugar Maple	$ 125
Beech	$ 50

82. When this faster growth is coupled with the significantly higher stumpage values of cherry or northern red oak,



83. and with the fact that stands with a high percentage of cherry can carry higher volumes,

AT AGE 100:

% Cherry	Mbf	Value
Low	9.1	$ 791
Medium	15.2	$ 3091
High	22.9	$ 6702

84. the end result may be a very large increase in economic returns over the rotation from stands with a high percentage of fast-growing, shade-intolerant, high-value species. For example, Allegheny hardwood stands containing a high percentage of black cherry yield nearly 10 times as much as stands with a low percentage of cherry.

EVEN–AGE TREATMENT SCHEDULES

85. Let me summarize some of this discussion about stand structure, species composition, and our general strategy for thinning and rotation length in mixed-species, even-aged hardwoods.

86. It is our belief that these hardwoods generally should be grown in dense stands when they are young; this produces clean, straight boles with little taper. It also provides for high mortality among the slower growing tolerants in the lower canopy, helping to minimize the problem later on of using even-age thinning techniques in stands with an inverse J-shaped diameter distribution. Although diameter growth is less than the maximum in these dense stands, it is still very good on the dominants and codominants during this period. So, during the period of rapid height growth, while sapling size stems still represent a major proportion of stand basal area (the first 40 to 50 years), we recommend that you stay out of these stands and allow them to develop naturally, unless they need a weeding to eliminate poor species or low-quality stems.

Early Commercial Thinnings:

Yield primarily pulpwood.

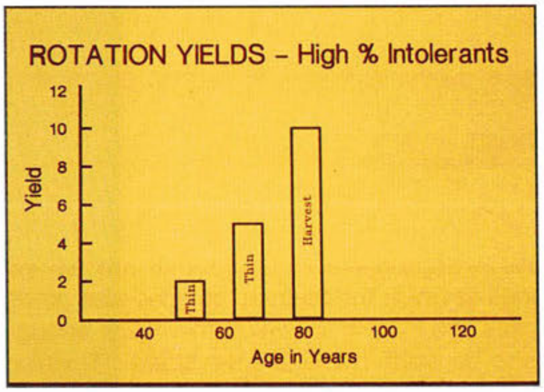
Later Commercial Thinnings:

Yield both sawlogs and pulpwood.

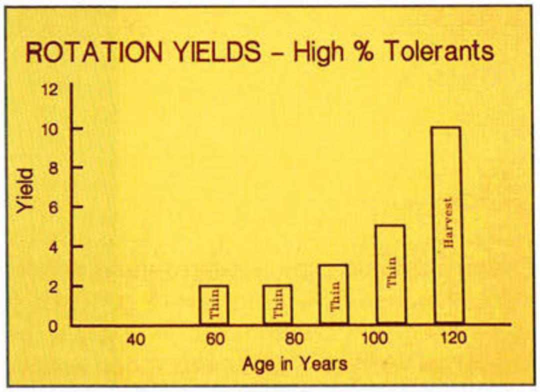
87. Once height growth begins to slow down and the basal area in saplings drops below about 20 square feet per acre, commercial thinnings can begin. The first one or two cuts will yield mostly small diameter products--pulpwood with perhaps a few smaller sawlogs. These thinnings should be primarily from below, to establish the start of the bell-shaped diameter distribution and increase average stand diameter.

Later in the rotation, as the stand approaches maturity, the thinnings will change slightly in character. Cutting will continue to be heavy in the small size classes (the poles), but by now some of the faster growing species and individuals will be mature and can be removed. This narrows the bell-shaped distribution from both ends and makes the stand more nearly even-sized. It also maximizes value yield by harvesting those individuals and species that are no longer increasing rapidly in value. This concentrates growth on the small sawtimber sizes that are increasing most rapidly in value due to both diameter increase and grade improvement.

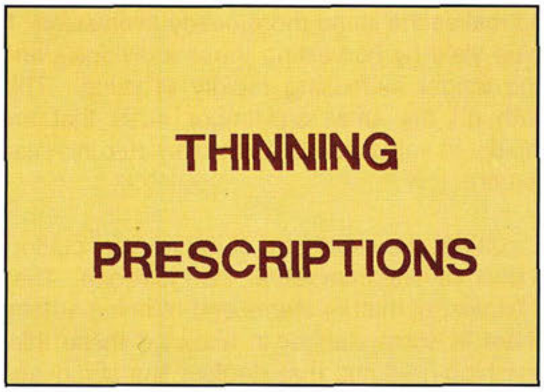
So, the final partial cuttings are really part of the harvest cutting, which may extend over several cuts rather than just one. They are a combination harvest of mature stems and thinning among smaller stems. There is some danger in allowing these thin-harvests to become high-gradings that deplete the stand and leave genetically inferior seed sources for establishment of the next stand. But, if used only at the very end of the rotation, they can improve economic returns substantially without causing the silvicultural problems usually associated with repeated high-grading.



88. Rotation lengths and number of thinnings will vary depending upon the mix of species present. In stands with a high percentage of black cherry, white ash, red oak, and yellow-poplar, we might expect the first commercial thinning at age 50, a second one at age 65, and final harvest at age 80.



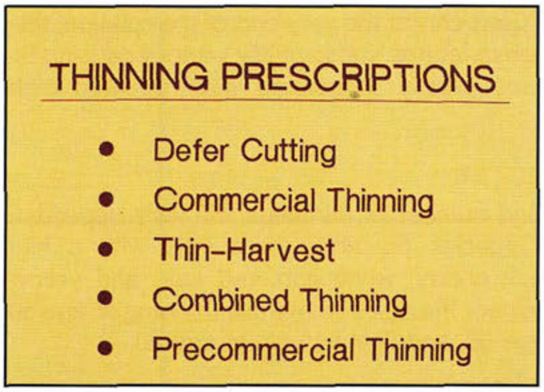
89. In stands with more sugar maple, beech, white oaks, hickory, and other slow-growing species, thinnings might occur at ages 50, 70, 90, 110, and a final harvest at 120 or 125 years. The thinning prior to final harvest would undoubtedly be a thin-harvest, and even the one at age 90 would include moderate amounts of large trees. Care would have to be taken during the last few cuts to ensure retention of enough of the faster growing species to provide seed for regeneration at the end of the rotation.



THINNING

PRESCRIPTIONS

90. In the article "Development of a Silvicultural Prescription," Ernst discusses the use of our prescription (decision) charts. I will review quickly the decisions involved in preparing a prescription for thinning.



THINNING PRESCRIPTIONS

- Defer Cutting
- Commercial Thinning
- Thin-Harvest
- Combined Thinning
- Precommercial Thinning

91. We recognize five major thinning prescriptions:

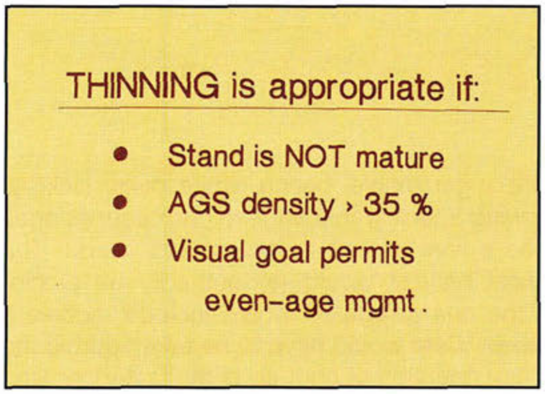
Defer cutting

Commercial thinning

Thin-harvest

Combined thinning

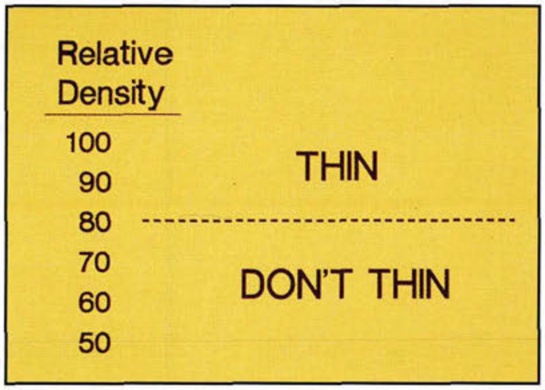
Precommercial thinning



THINNING is appropriate if:

- Stand is NOT mature
- AGS density › 35 %
- Visual goal permits even-age mgmt.

92. Thinning of all types is appropriate in stands that are not yet mature; that is, stands in which the featured species-size group is less than 18 inches d.b.h., and in which there are enough good quality stems to be worth managing the stand. Thinning is also an even-age practice, so visual goals must not preclude even-age culture.



Relative Density

100

90 THIN

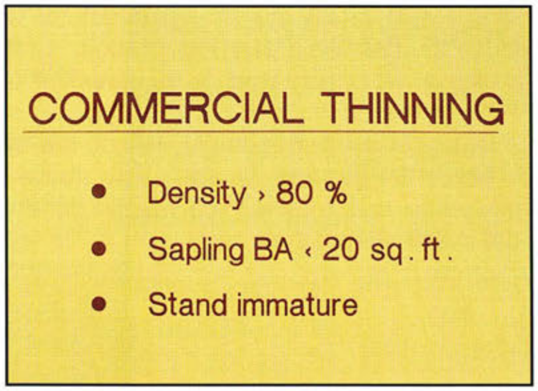
80 --------------------------------

70

60 DON'T THIN

50

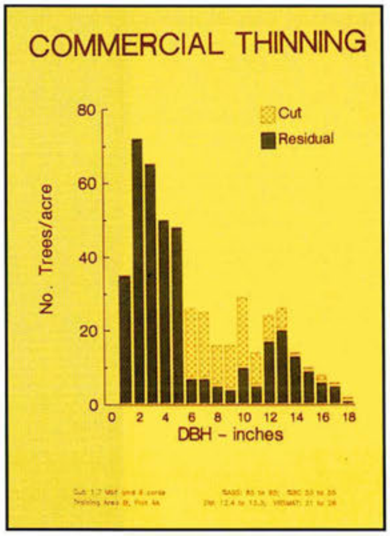
93. Regardless of other stand characteristics, if relative stand density is less than 80 percent, there is no need for thinning. Growth and mortality should be adequate, and there is not likely to be enough volume available to warrant a commercial cut without overcutting. So, the prescription for stands at less than 80 percent density is to defer cutting now, examine again in 10 to 15 years.



COMMERCIAL THINNING

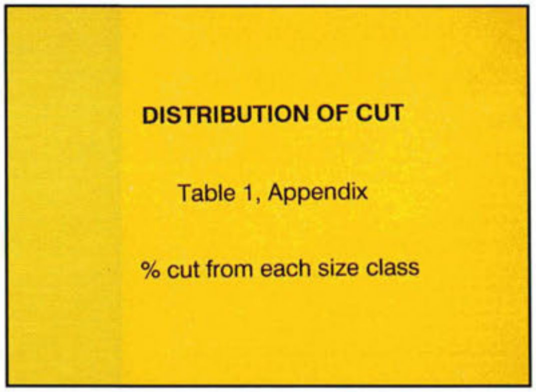
- Density › 80 %
- Sapling BA ‹ 20 sq. ft.
- Stand immature

94. Commercial thinning is used when relative density is above 80 percent, the stand is not close to the end of the rotation, and the basal area in saplings is less than 20 square feet.



COMMERCIAL THINNING

95. Commercial thinnings should cut heavily in the pole sizes, lightly to moderately in the small and medium sawtimber sizes. Most sawtimber trees that are cut should be ones that are of low quality, are in danger of dying, or must be removed to provide growing space for better quality stems of similar size. The effect of applying this distribution of cut to a typical cherry-maple stand averaging 14 inches (medial diameter in merchantable trees) is illustrated here. Notice that most of the cut has occurred in the 6- to 12-inch diameter classes. In this example, the cut produced about 1600 board feet of sawtimber and 6 cords of pulpwood, or 8.5 cords if it all goes into pulp. Notice that the residual stand has begun to assume a bell-shaped curve in the merchantable size classes, rather than the inverse J-shaped curve it had before. Subsequent thinnings would reinforce this distribution.

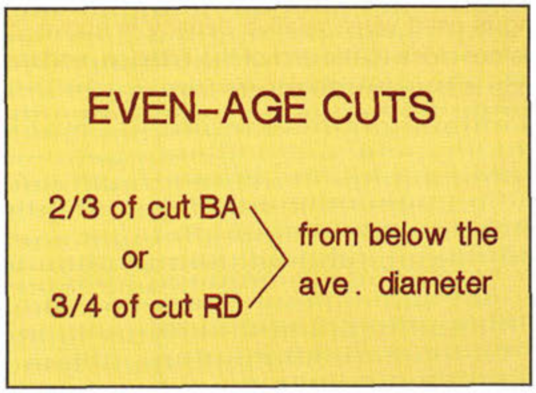


DISTRIBUTION OF CUT

Table 1, Appendix

% cut from each size class

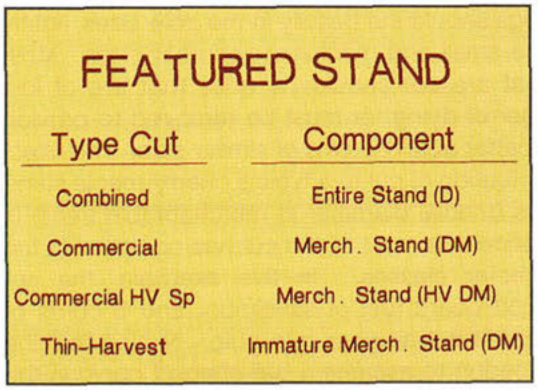
96. To provide objective and easily followed guidelines for distribution of cut among size classes, we have prepared a table showing the percentage of the cut that should come from each size class for stands of varying stand diameter (Table 1 in the Appendix). To use this table, you must know the diameter of the merchantable size trees. We use the average diameter of only merchantable trees because we are ignoring the saplings and working only with the merchantable sizes.



EVEN-AGE CUTS

2/3 of cut BA
or
3/4 of cut RD
from below the
ave. diameter

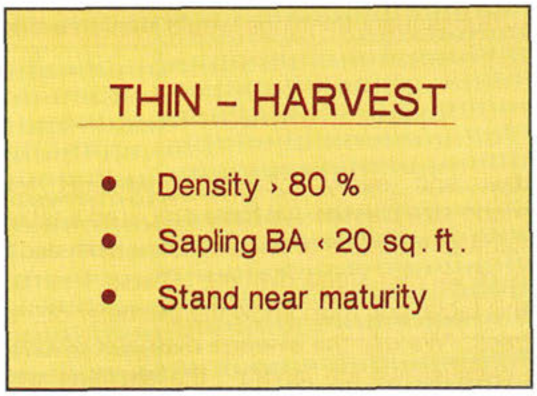
97 . We are currently testing a wide variety of even-age structures to learn which will produce the best yield over the rotation. Until that information is available, we simply work in the direction of creating a bell-shaped diameter distribution within the portion of the stand that we will feature in our management. We do this by cutting more heavily below the average diameter than above--two-thirds of cut basal area or three-fourths of cut relative density comes from below the average diameters.



FEATURED STAND

Type Cut	Component
Combined	Entire Stand (D)
Commercial	Merch. Stand (DM)
Commercial HV Sp	Merch. Stand (HV DM)
Thin-Harvest	Immature Merch. Stand (DM)

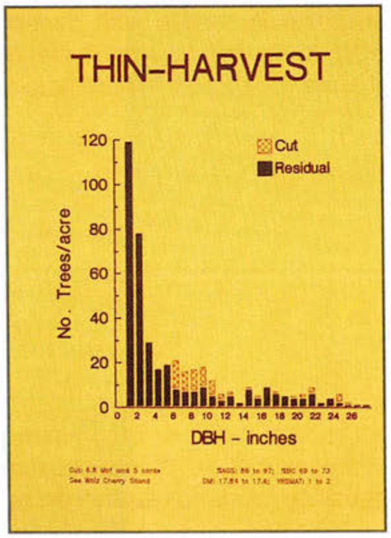
98. The particular average diameter used depends upon the type of cut--that is, the portion of the stand to be featured in management.



THIN - HARVEST

- Density › 80 %
- Sapling BA ‹ 20 sq. ft.
- Stand near maturity

99. Thin-harvests are used toward the end of the rotation, as the last regular thinning in most stands. As with other commercial thinnings, the stand should be above 80 percent density and sapling basal area less than 20 square feet.

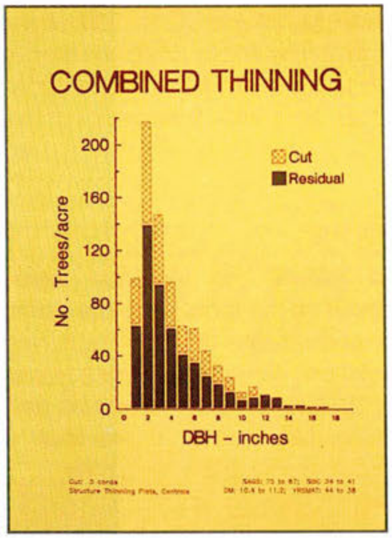


100. Notice in this chart that the thin-harvest distribution looks very similar to the commercial thinning shown earlier, except for slightly less cutting in the small sawtimber and slightly more cutting in the large sawtimber sizes. So, it is primarily a thinning, but modified for the special purpose described. Unlike commercial thinnings, the thin-harvest may slightly reduce stand diameter and proportion of fast-growing species rather than increase them. But, a final harvest about 15 years later will still be appropriate, and the overall yields will be improved over those obtainable from a more conventional thinning (thin from below) at this time.

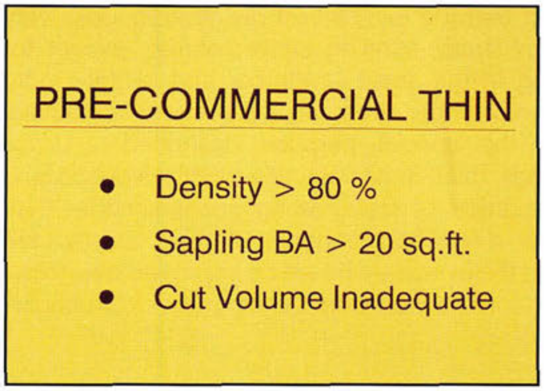
COMBINED THINNING

- Density > 80 %
- Sapling BA > 20 sq.ft.
- Cut Volume Operable

101. Combined commercial thinning with TSI in the sapling class is appropriate in young stands with density greater than 80 percent, that have more than 20 square feet in basal area, but also have enough merchantable volume to warrant a commercial sale.



102. The distribution of cut for a combined thinning is handled in the same manner as with a commercial thinning, except that cutting is extended into the sapling class, and the diameter of all sizes (not just merchantable sizes) is used in distribution of the cut. Density and quality considerations are identical to the commercial thinning. Notice that cutting in the sapling class is aimed only at reducing that class to a level where it does not dominate residual stand stocking. If these guides are applied to a stand that has less than 20 square feet of basal area they result in removal of all saplings--which is neither necessary nor economical.



PRE-COMMERCIAL THIN

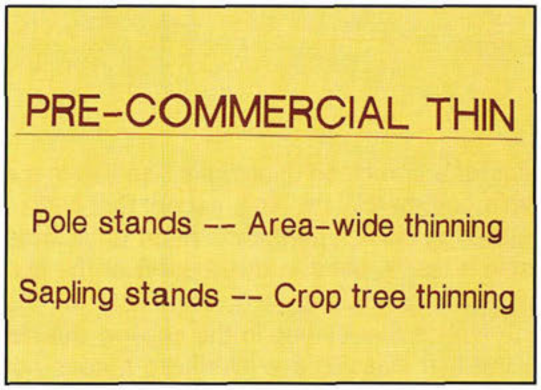
- Density > 80 %
- Sapling BA > 20 sq.ft.
- Cut Volume Inadequate

103. Precommercial thinning is appropriate in stands with density greater than 80 percent that contain more than 20 sqaure feet of basal area and have too little volume to support a commercial thinning.

PRE-COMMERCIAL THINNING

Use it only where:
SPECIES COMPOSITION
or
STAND QUALITY
can be significantly improved

104. This treatment requires an investment. We do not recommend precommercial thinning investment except in those unusual cases where either species composition or stand quality can be significantly improved.



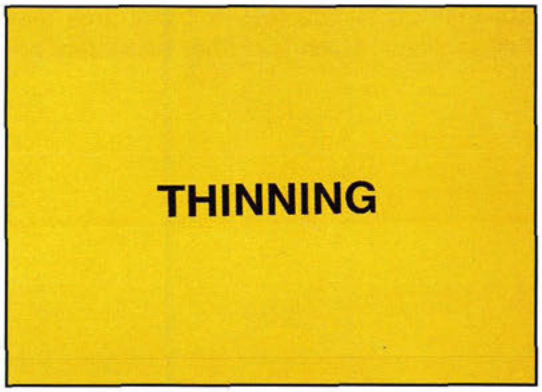
PRE-COMMERCIAL THIN

Pole stands -- Area-wide thinning

Sapling stands -- Crop tree thinning

105. If used, precommercial thinnings in pole-size stands can be done on an area basis using the same distribution of cut procedures as the combined thinning.

In younger--sapling-size--stands, precommercial thinning is more easily handled as a crop tree release, where 50 to 200 of the best trees are selected per acre, and thinning is done to remove only those trees competing with the crop trees. This reduces cost and provides better results than area-wide treatments at this age.



THINNING

106. Thinnings in mixed hardwood stands can increase yields significantly by concentrating growth on the most valuable stems in the stand, by increasing their growth rate, and by capturing some of the yield earlier in the rotation. To achieve these goals, thinning must include regulation of stand density, structure, and composition. The SILVAH prescription system provides a precise way of regulating thinning to achieve these results.

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APPENDIX

Table 1. -- 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 50% 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 75% of original density in large saws and adjust other sizes proportionally.

[4] In all-age cuts, all existing sapling density is retained.

Source: 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.

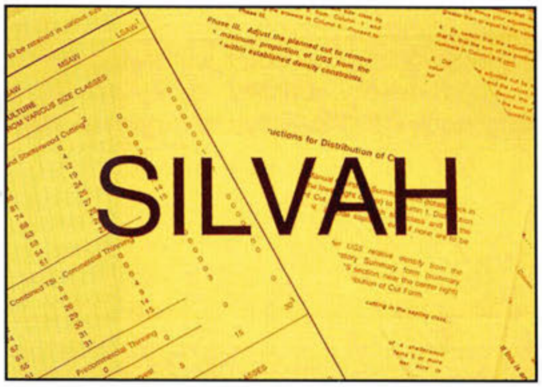
Distribution of Cut Under Even-Age Management

Richard L. Ernst

Distribution of cut

Decide which trees to cut

1. If a partial cutting is prescribed in the SILVAH system, there must be a plan regarding species, sizes, quantity, and quality of trees to be removed. This article concentrates on thinnings under even-age silviculture and works through the mechanics of developing the cutting plan. Refer to the forms in Appendix C and D. Procedures for distributing the cut under all-age silviculture are slightly different and are described later by Stout in, "Uneven-age Management Principles and Practices".



SILVAH

2. This entire process of distributing the cut among species, size, and quality classes is part of the three step SILVAH process, and has been automated in the SILVAH computer program. The procedures for the manual distribution of cut described here essentially duplicate the algorithm in the computer program.

Phases of Distribution of Cut Procedures

- Prepare worksheet and determine density and structure
- Adjust the structure to fit distribution of actual stand
- Adjust the planned cut to remove maximum proportion of UGS
- Translate planned cut to marking guides

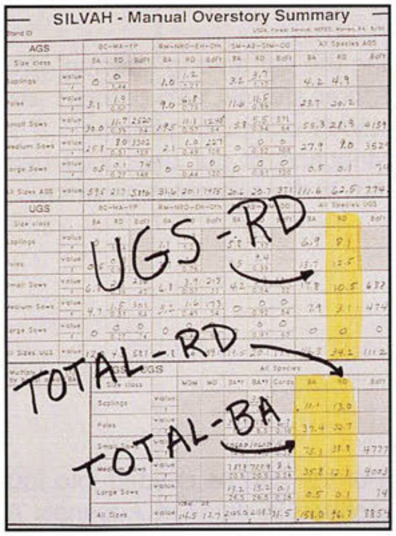
3. The procedures for distribution of cut can be divided into four phases. These phases are described in detail in Appendix A. We will discuss each phase for an even-age intermediate thinning and will use the same sample stand as that in the analysis article.

Distribution for COMMERCIAL THINNING

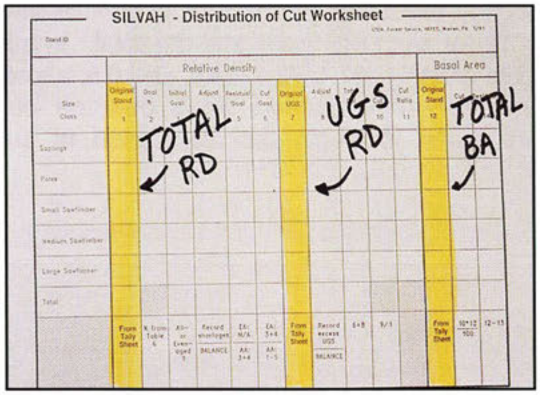
4. The inventory, data summary and analysis, and prescription have been completed for the sample stand previously. The recommended prescription is a commercial thinning; the distribution of cut for a commercial thinning is discussed here.

Distribution in RELATIVE DENSITY

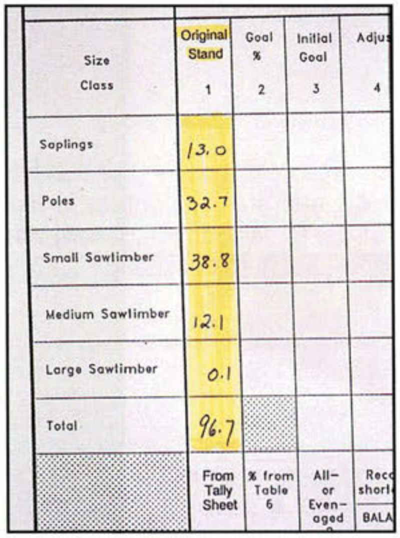
5. The distribution of cut calculations are made using relative density rather than basal area or number of trees. This makes it easy to achieve the desired residual density goal. At the end of the procedure, we convert to basal area/acre and cut ratios for field implementation.


SILVAH - Manual Overstory Summary

6. The first phase is to copy values from the stand summary and to determine the density and structure parameters. Copy three columns of data from the Manual Overstory Summary worksheet (Appendix D) to the Distribution of Cut worksheet (Appendix C). Copy the original stand density, original stand density in unacceptable growing stock (UGS density), and original stand basal area

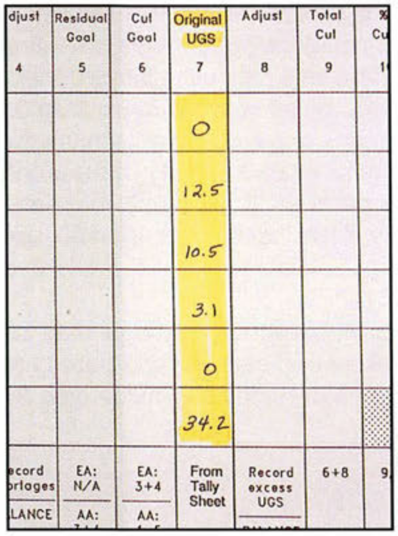


7. to the Distribution of Cut worksheet, columns 1, 7, and 12, respectively.



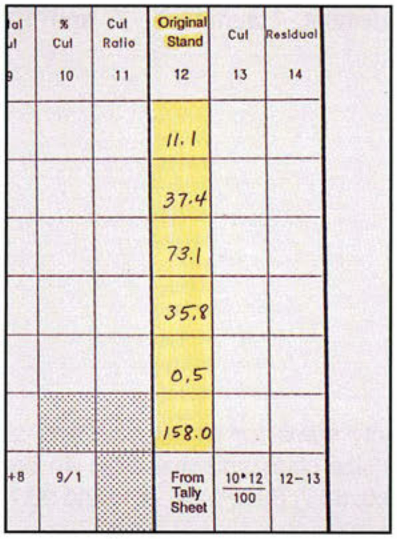
Size Class	Original Stand 1	Goal % 2	Initial Goal 3	Adju 4
Saplings	13.0			
Poles	32.7			
Small Sawlimber	38.8			
Medium Sawlimber	12.1			
Large Sawlimber	0.1			
Total	96.7			
	From Tally Sheet	% from Table 6	All- or Even-aged	Rec short BALA

8. Copy the original relative density sums for all species and all qualities to column 1, for each size class and the total. In our example, these numbers are 13.0, 32.7, 38.8, 12.1, 0.1, and 96.7.



djust 4	Residual Goal 5	Cut Goal 6	Original UGS 7	Adjust 8	Total Cut 9	% Cu 1
			0			
			12.5			
			10.5			
			3.1			
			0			
			34.2			
ecord ortages LANCE	EA: N/A AA:	EA: 3+4 AA:	From Tally Sheet	Record excess UGS	6+8	9

9. Then copy the original relative density in unacceptable growing stock (UGS density) for all species, for each size class to column 7. This is a commercial thinning, so there will be no cutting in the sapling class. Even though there may be UGS in the sapling class, they will not be removed. So, put a zero in the sapling class. For this example, the numbers are 0, 12.5, 10.5, 3.1, and 0, with a total of 34.2, or a total of 26.1 UGS in commercial size classes.



al t	% Cut	Cut Ratio	Original Stand	Cut	Residual	
9	10	11	12	13	14	
			11.1			
			37.4			
			73.1			
			35.8			
			0.5			
	▨	▨	158.0			
+8	9/1	▨	From Tally Sheet	10*12 / 100	12-13	

10. Finally, copy the original basal area per acre of all species and qualities to column 12 for each size class and the total. In our example, the numbers are 11.1, 37.4, 73.1, 35.8, and 0.5, a total of 157.9. We now have the required stand data on our worksheet, and are ready to begin the distribution of cut calculations.

Thinning Priorities

- Stand density
- Tree quality
- Stand structure

11. In a thinning, we want to control three conditions in the residual stand: stand density, tree quality, and stand structure in that order of priority. However, it is easier to perform the density and stand structure calculations first, then adjust for quality.

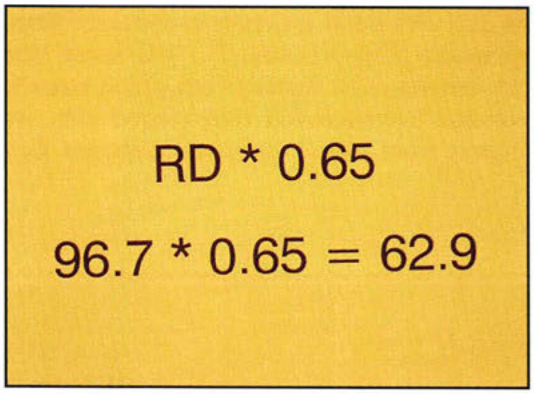
Residual density

RD * 0.65

must be >= 60

12. So, begin by calculating the desired residual stand density (Phase I, step 5). The goal is to reduce the relative density in the stand so the remaining trees can grow faster. This is the first priority. For thinnings, we recommend a residual relative density of 60 percent, but we suggest you never remove more than 35 percent of the relative density in any one cut. To determine the residual density, multiply the original relative density of the stand by 0.65 (the complement of 35 percent). If the result is greater than 60, use the calculated value; if the result is less than 60, use 60.

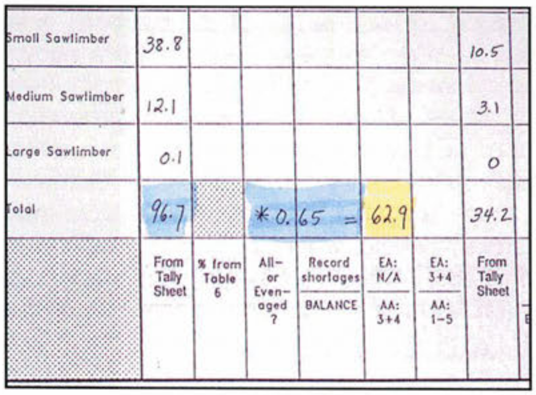
    The desired residual density for shelterwood cuttings may be either 50 or 60 percent. For shelterwood cuts, reduce density to the desired level even if that results in removal of more than 35 percent at one time.



RD * 0.65

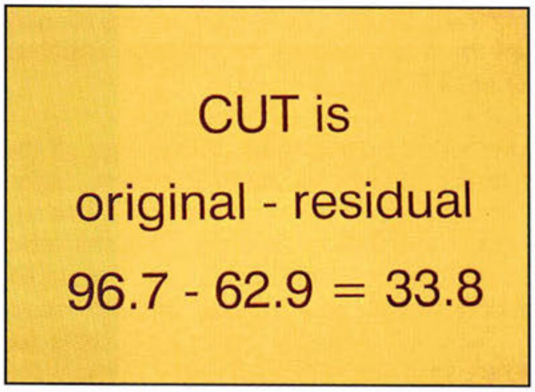
96.7 * 0.65 = 62.9

13. The sample stand has a density of 96.7, as shown in the total row of column 1. So, multiply that total density, 96.7, by 0.65 to get a residual density of 62.9. It is above the recommended minimum density of 60 for commercial thinnings, so use 62.9 as the goal. Multiplying by 0.65 prevents removing more than 35 percent of the relative density that is there. Taking it all the way back to 60 percent relative density in this stand would have removed more than the limit of 35 percent.



Small Sawlimber	38.8						10.5
Medium Sawlimber	12.1						3.1
Large Sawlimber	0.1						0
Total	96.7		*0.	65 =	62.9		34.2
	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

14. Record the desired residual density of 62.9 in the total row of column 5.

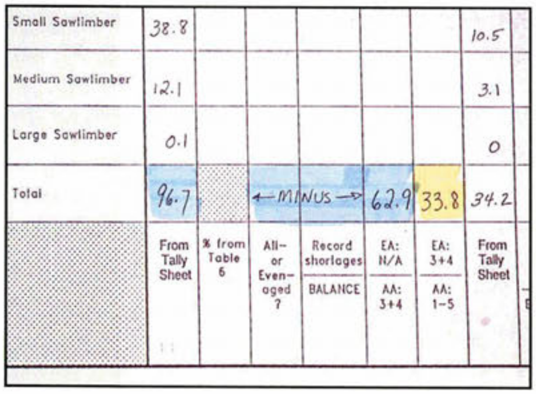


CUT is

original - residual

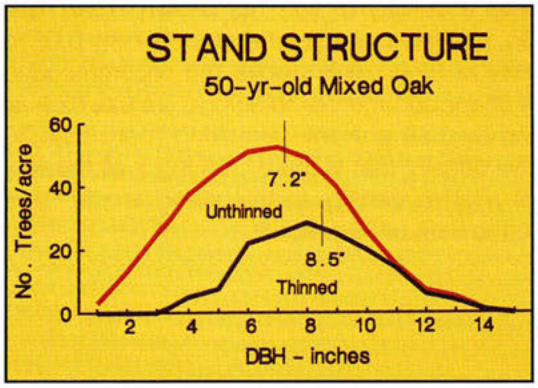
96.7 - 62.9 = 33.8

15. The total density to be cut can now be calculated (Phase I, step 6). It is the original relative density minus the residual, or the total from column 1 minus the total from column 5. For this stand, it is 96.7 - 62.9 = 33.8.



Small Sawlimber	38.8						10.5
Medium Sawlimber	12.1						3.1
Large Sawlimber	0.1						0
Total	96.7		←MI	NUS→	62.9	33.8	34.2
	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

16. Record the 33.8 to be cut in the total row of column 6. Fill in only the TOTAL row of this column at this time. We have now completed our calculations of total stand residual and cut density.


STAND STRUCTURE

50-yr-old Mixed Oak

17. The next calculations deal with stand structure, or the distribution of cut among size classes (Phase I, step 7). We know how much we want to cut, but we must decide from which sizes to take the cut. In even-age thinnings and shelterwood cuts, we want to cut more heavily from below the stand diameter than from above.

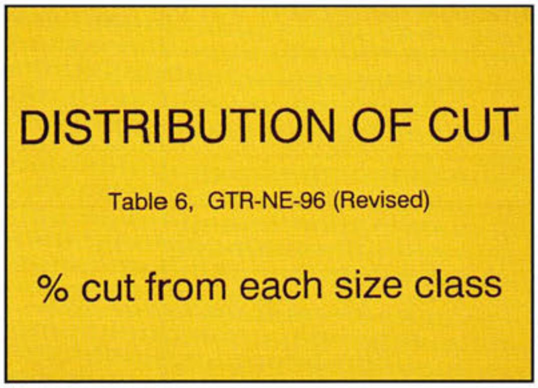
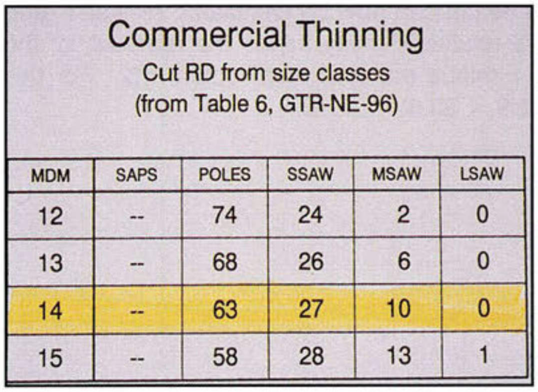

DISTRIBUTION OF CUT

Table 6, GTR-NE-96 (Revised)

% cut from each size class

18. As a general rule, we like to remove 2/3 of the cut basal area from below the average stand diameter and 1/3 from above. This is equivalent to removing 3/4 of the relative density from below, and 1/4 from above. Appendix B shows the proportion of the total cut relative density that should come from each of the major size classes, based on the average stand diameter. For a typical stand, these tabulated values achieve the cut from below. For commercial thinning, where cutting is confined to merchantable size trees, use the average diameter of merchantable trees (MDM) to select the appropriate row in this table.


Commercial Thinning

Cut RD from size classes

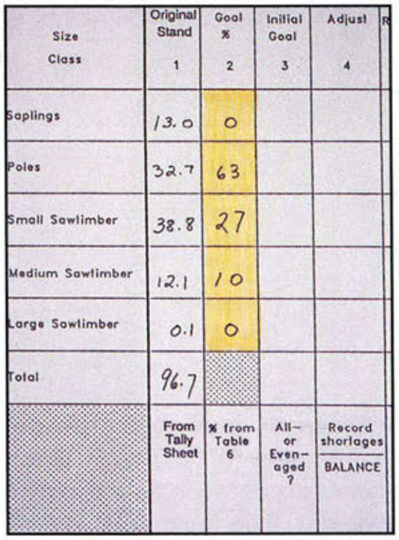
(from Table 6, GTR-NE-96)

MDM	SAPS	POLES	SSAW	MSAW	LSAW
12	--	74	24	2	0
13	--	68	26	6	0
14	--	63	27	10	0
15	--	58	28	13	1

19. For this stand, look up the cut factors in the commercial thinning section of the table for a stand with an average diameter (merchantable sizes) of 14 inches.

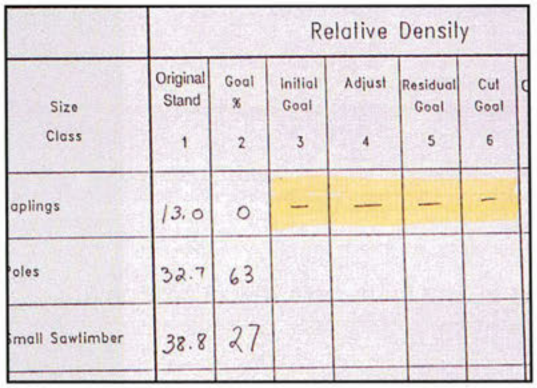
This table also accommodates other types of thinnings. If the prescription were for a combined thinning/timber stand improvement or a pre-commercial thinning; we would use the average diameter (DM) instead of average merchantable diameter (MDM) in the appropriate section of the table. Combined and pre-commercial cuts include all tree sizes, including saplings. There are also sections in the table for thin-harvest cuts and for selection cuts.

The factors for a commercial thinning in a stand with an average merchantable diameter (MDM) of 14 inches are: 0, 63, 27, 10, and 0 for saplings to large sawtimber. Most of the cut, 63 percent, is concentrated in the pole class, which is below the average stand diameter.



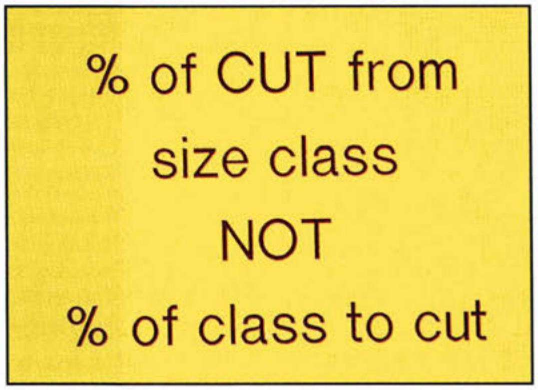
Size Class	Original Stand 1	Goal % 2	Initial Goal 3	Adjust 4
Saplings	13.0	0		
Poles	32.7	63		
Small Sawtimber	38.8	27		
Medium Sawtimber	12.1	10		
Large Sawtimber	0.1	0		
Total	96.7	▨		
▨	From Tally Sheet	% from Table 6	All- or Even- aged ?	Record shortages BALANCE

20. Record these values in column 2 in the rows for the appropriate size classes.



	Relative Densily					
Size Class	Original Stand 1	Goal % 2	Initial Goal 3	Adjust 4	Residual Goal 5	Cut Goal 6
aplings	13.0	0	—	—	—	—
oles	32.7	63				
mall Sawtimber	38.8	27				

21. The percentage of the cut that will come from the saplings is zero since this is a commercial cut. So there is no need to record calculations for this row. Just mark out the sapling row from column 3 to 11 to avoid using it in any of the calculations.



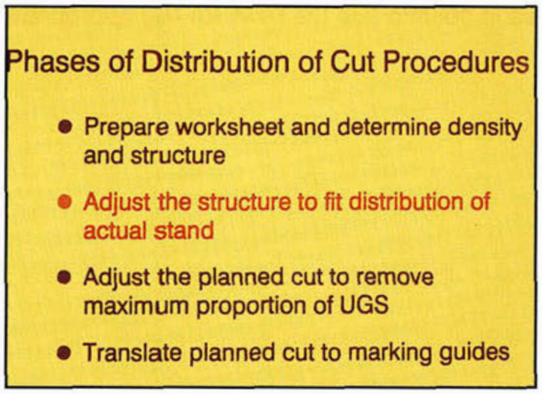
% of CUT from

size class

NOT

% of class to cut

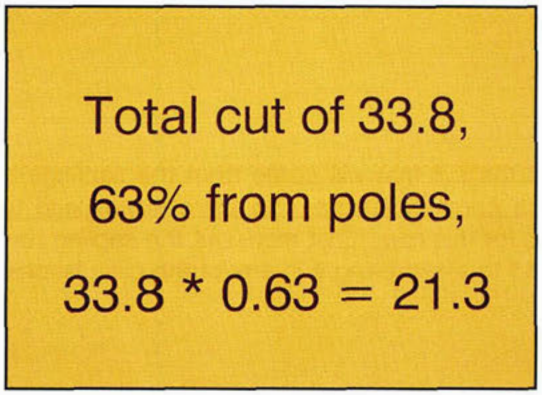
22. Remember that these proportions represent the <u>percentage of the cut</u> that should come from each size class. It is <u>not</u> the proportion of each class to cut. That will be determined later.



Phases of Distribution of Cut Procedures

- Prepare worksheet and determine density and structure
- Adjust the structure to fit distribution of actual stand
- Adjust the planned cut to remove maximum proportion of UGS
- Translate planned cut to marking guides

23. The next phase of the procedure is to adjust the structure to fit the actual stand.

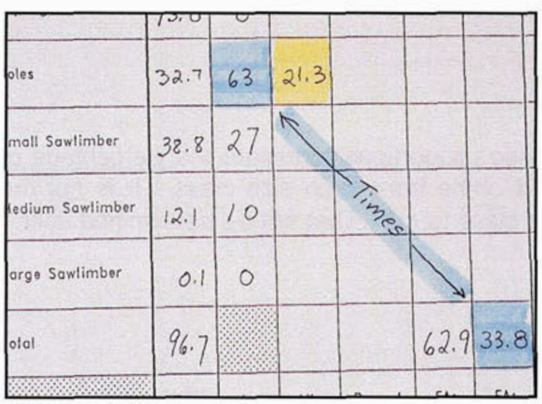


Total cut of 33.8,

63% from poles,

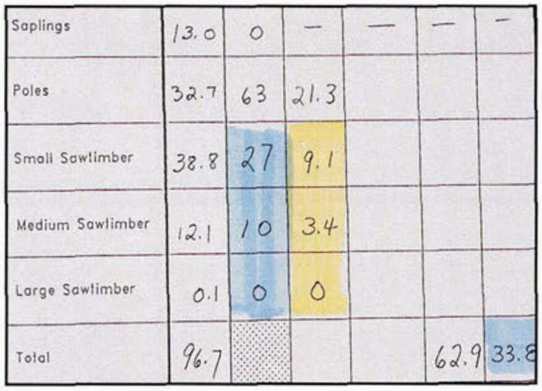
33.8 * 0.63 = 21.3

24. In the example, the total cut will remove 33.8 relative density units. That number is found in the total row of column 6. Sixty-three percent of the total cut needs to come from the poles; therefore, the cut in the poles will be: 0.63 times 33.8 = 21.3 relative density units. Remember, take 63 percent of the total 33.8 cut; do <u>not</u> take 63 percent of the 32.7 that is present in the pole class.



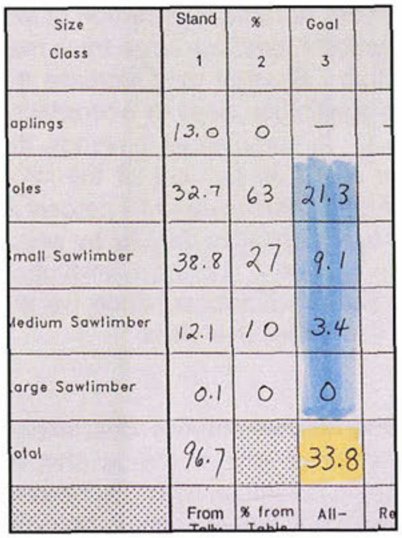
oles	32.7	63	21.3			
mall Sawtimber	38.8	27				
edium Sawtimber	12.1	10				
arge Sawtimber	0.1	0				
otal	96.7				62.9	33.8

25. Record the pole cut of 21.3 in the pole row of column 3.



Saplings	13.0	0	—	—	—	—
Poles	32.7	63	21.3			
Small Sawtimber	38.8	27	9.1			
Medium Sawtimber	12.1	10	3.4			
Large Sawtimber	0.1	0	0			
Total	96.7				62.9	33.8

26. Similarly, 27 percent of the 33.8 total cut relative density, or 9.1 relative density units should come from the small sawtimber; and 10 percent of the 33.8 total cut relative density, or 3.4 relative density units from the medium sawtimber. The key here is to remember that the proportions in column 2 apply to the total cut in column 6.



Size Class	Stand 1	% 2	Goal 3	
aplings	13.0	0	—	-
oles	32.7	63	21.3	
mall Sawtimber	38.8	27	9.1	
edium Sawtimber	12.1	10	3.4	
arge Sawtimber	0.1	0	0	
otal	96.7	▨	33.8	
▨	From	% from	All-	Re

27. Check to see that the cuts in each size class sum to the total you wanted to cut; that is, the total of column 3 equals the total in column 6. In the example they do, within the limits of rounding.

Cutting more

than you have ?

(compare col. 1 and col. 3)

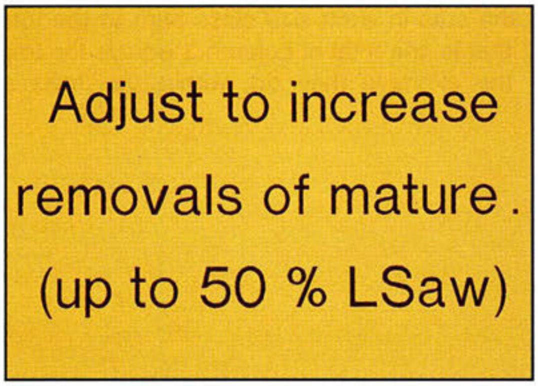
28. Usually, this distribution can be met without any trouble, but sometimes the initial distribution may call for cutting more from a class than is actually there. If that is the situation, there needs to be an adjustment. Compare the initial estimates of the cut in column 3 with the actual density present in column 1 for each size class.

Record deficiencies

as negatives

in Col. 4

29. Record any deficiencies -- the amount by which the trial cut exceeds the actual density present -- in column 4 for each size class. Record these deficiencies as negative numbers, since any adjustment would need to reduce the cut in that size class.

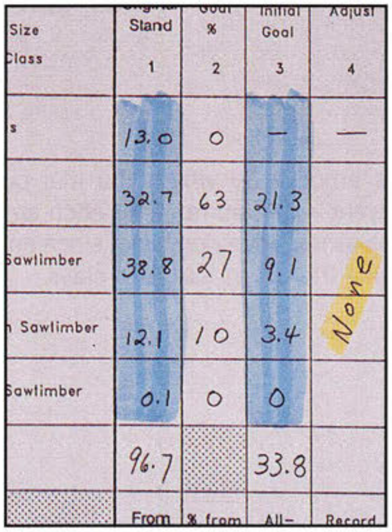


Adjust to increase removals of mature. (up to 50 % LSaw)

30. Another adjustment could be made to remove a portion of any large sawtimber (24+ inches) present, because large trees may be considered individually mature. So, you may increase the amount to be cut in the large sawtimber class in accordance with the footnotes in Appendix B. In commercial thinnings, the recommendation is to remove up to 50 percent of the large sawtimber class; in thin-harvest cuts, remove up to 75 percent of this class. Just record the amount of relative density by which you want to increase the cut in column 4, for large sawtimber. Record these adjustments as positive numbers, since we are increasing the cut in the large sawtimber size class.

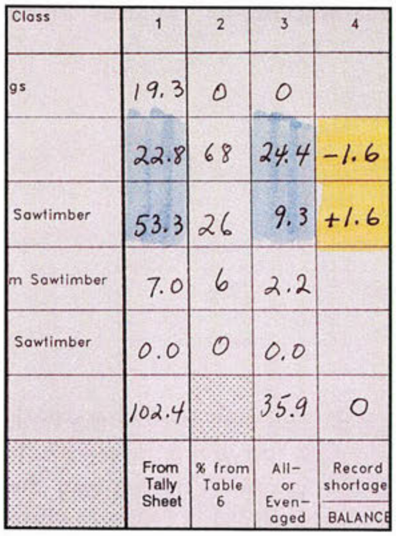
Balance any adjustments

31. If you have recorded any negative numbers (that is, deficiencies requiring a decrease in the cut) or positive numbers (that is, increases in large sawtimber cut) in column 4, then you need to complete the adjustment process. Any adjustments in one size class must be compensated for by adjusting other classes so the density goal is maintained. That is, the sum of the adjustments should be zero.



Size Class	Stand 1	% 2	Initial Goal 3	Adjust 4
s	13.0	0	—	—
	32.7	63	21.3	
Sawtimber	38.8	27	9.1	None
Sawtimber	12.1	10	3.4	
Sawtimber	0.1	0	0	
	96.7		33.8	
	From	% from	All-	Record

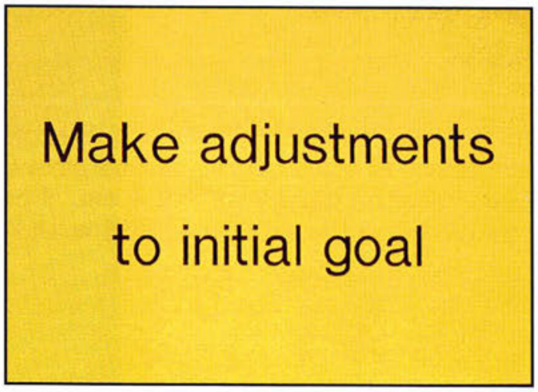
32. In the sample stand, there are no deficiencies, and the amount of relative density in large trees is so small that you really could not take half of it. So, no adjustments are necessary.



Class	1	2	3	4
gs	19.3	0	0	
	22.8	68	24.4	-1.6
Sawtimber	53.3	26	9.3	+1.6
m Sawtimber	7.0	6	2.2	
Sawtimber	0.0	0	0.0	
	102.4		35.9	0
	From Tally Sheet	% from Table 6	All- or Even-aged	Record shortage BALANC

33. Examining a stand where an adjustment is necessary if the initial cut calls for cutting more than is present (a negative in column 4), decrease the cut in the class that has the deficiency, and balance it by increasing the cut in some other class. In this example, we have a deficiency of 1.6 in the pole class. So, we need to reduce the cut in that class by 1.6, and balance it by increasing the cut in the small sawtimber by 1.6. This balance can be done using your best judgment, or it can be done in proportion to the initial cut goal percentage from column 2. The computer program adjusts the cut using the proportions, but the common sense approach is recommended when calculations are done manually. The adjustments are usually minor, so differences between the manual approach and the proportion approach will be insignificant.

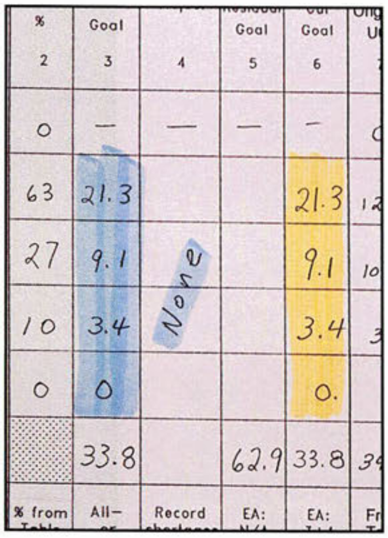
    If an adjustment is needed, write down compensating adjustments to other size classes (either increasing the cut with positives or decreasing it with negatives) until the total is in balance. That is, the increases in any size classes are offset by decreases in others, resulting in a zero total in the adjustment column.



Make adjustments

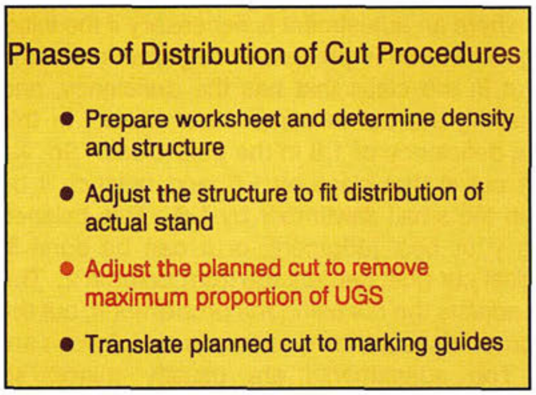
to initial goal

34. Make adjustments recorded in column 4 by adding the values in columns 3 and 4 for each size class, and record the new values in column 6. Check to be sure the total cut equals the planned cut, within rounding error.



% 2	Goal 3	4	Goal 5	Goal 6	U
0	—	—	—	–	
63	21.3			21.3	1
27	9.1	None		9.1	10
10	3.4			3.4	3
0	0			0.	
	33.8		62.9	33.8	3
% from	All-	Record	EA:	EA:	Fr

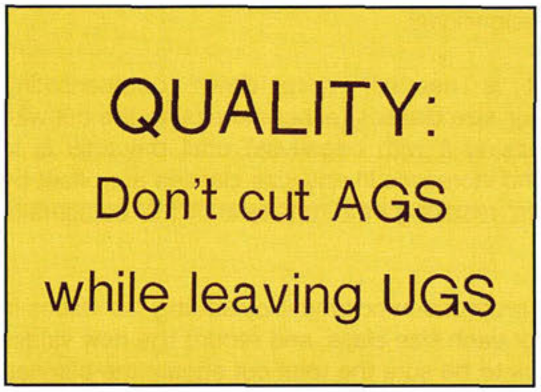
35. If there are no adjustments, as in the original sample, the new cut goal is the same as the original. Copy the values from column 3 to column 6.



Phases of Distribution of Cut Procedures

- Prepare worksheet and determine density and structure
- Adjust the structure to fit distribution of actual stand
- Adjust the planned cut to remove maximum proportion of UGS
- Translate planned cut to marking guides

36. The third phase of the procedure is to adjust the structure for quality.

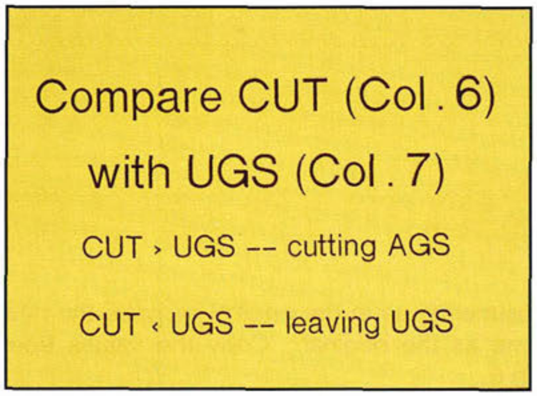


QUALITY:

Don't cut AGS

while leaving UGS

37. Up to this point, you have been dealing with two of the three priorities: stand density and structure. Now it is necessary to account for quality in the distribution of cut. It makes very little sense to cut acceptable growing stock (AGS) in one size class, while leaving unacceptable growing stock (UGS) in another simply to meet the structure goal. The importance of recording the AGS/UGS during the inventory is apparent, because we strive to remove all UGS in thinning. So, an adjustment may be needed for quality. Begin by comparing the UGS present in the stand with the cut goal just calculated.



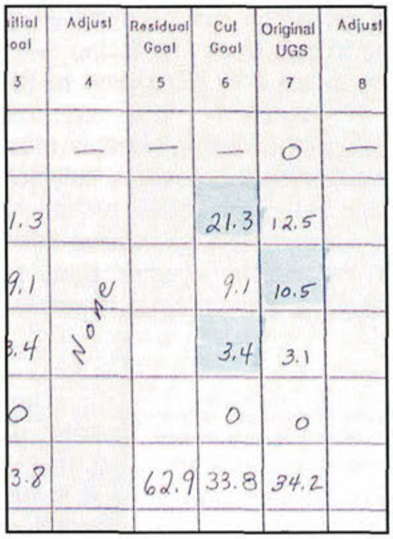
Compare CUT (Col. 6)

with UGS (Col. 7)

CUT › UGS -- cutting AGS

CUT ‹ UGS -- leaving UGS

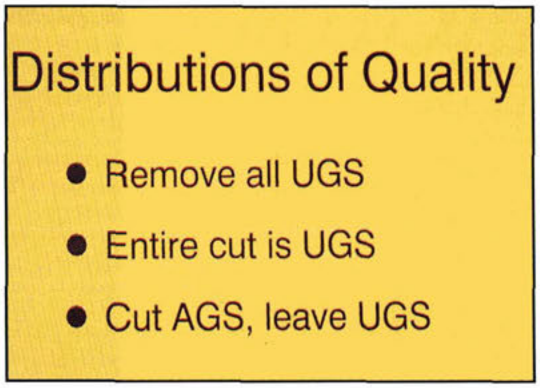
38. For any size class, if the value for the cut, column 6, is larger than the UGS, column 7, then all of the UGS in that size class is scheduled for removal in addition to the AGS that is cut. If on the other hand the cut is less than the UGS, then UGS is left in that size class.



itial oal 3	Adjust 4	Residual Goal 5	Cut Goal 6	Original UGS 7	Adjust 8
—	—	—	—	O	—
1.3			21.3	12.5	
9.1	None		9.1	10.5	
.4			3.4	3.1	
O			0	0	
3.8		62.9	33.8	34.2	

39. For example, in the sample stand we plan to remove 21.3 relative density units from the pole class. There is 12.5 relative density units of UGS in that class. So, all of the UGS will be cut along with some acceptable growing stock poles as well.

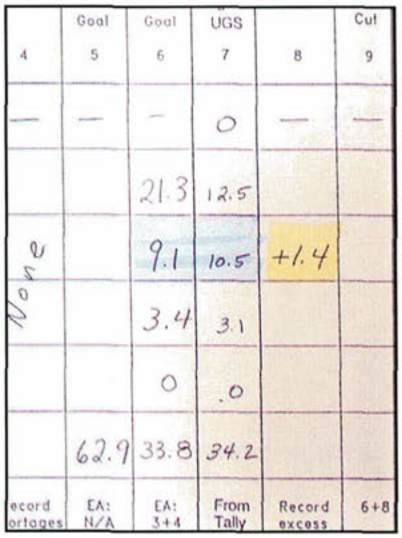
We also plan to remove 9.1 relative density units from the small sawtimber class. But there are 10.5 in UGS, which is more than the cut. So, this would leave some UGS in the small sawtimber class after the cut while cutting AGS in the pole class. In such instances, the cut should be increased in the small sawtimber class to remove all the UGS there, and the cut in the pole class should be reduced by a similar amount to compensate.



Distributions of Quality

- Remove all UGS
- Entire cut is UGS
- Cut AGS, leave UGS

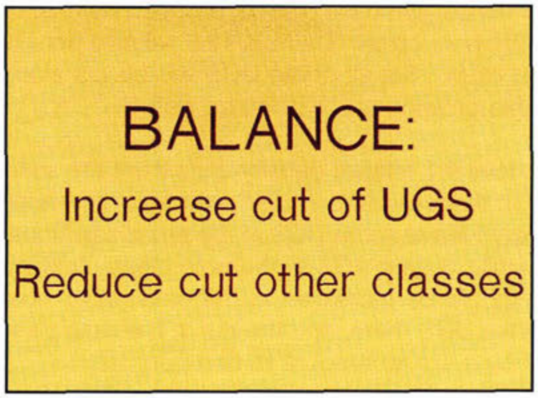
40. Three situations can exist in our initial plan for cutting that is based on structure alone. If the stand is of high quality, that is, the cut removes all of the UGS in every size class, then there are no problems, and there is no adjustment to be made. If the stand is uniformly poor and there is more UGS than can be cut in every size class, then the entire cut in every size class is UGS and again there is no adjustment needed. In such stands, it may take more than one cut to remove all the UGS. But some stands will have UGS being left in one class, while AGS is being cut in other classes. It is in this situation that an adjustment can be made.



4	Goal 5	Goal 6	UGS 7	8	Cut 9
—	—	–	O	—	—
		21.3	12.5		
None		9.1	10.5	+1.4	
		3.4	3.1		
		0	.0		
	62.9	33.8	34.2		
ecord ortages	EA: N/A	EA: 3+4	From Tally	Record excess	6+8

41. To make this adjustment, compare columns 6 and 7; if there is more UGS in any size class than that which is being cut from the class, record the excess in column 8.

This stand does have some excess UGS in the small sawtimber, while AGS is being cut in poles and medium sawtimber, so an adjustment is possible. There is only one class, the small sawtimber class, where UGS is being left uncut. Take all of them; that is, increase the cut in that class by 1.4. Record this adjustment with a positive sign since we are increasing the cut. If you increase the cut in the small saw size class, then you need to decrease the cut in other classes so that the total being removed is not changed.

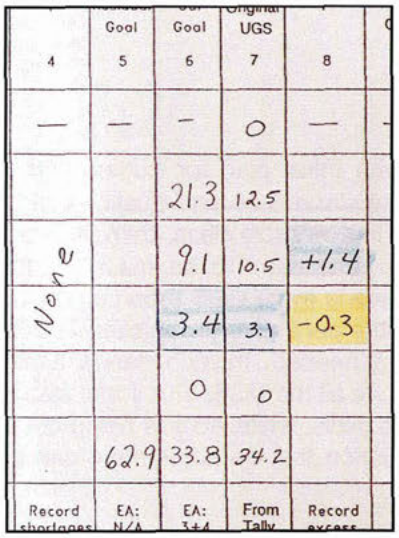


BALANCE:

Increase cut of UGS

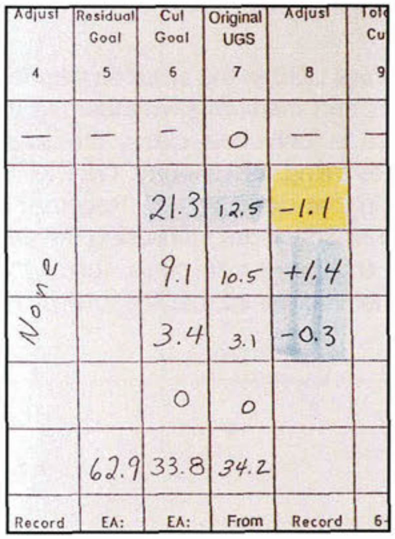
Reduce cut other classes

42. This adjustment is a balancing act which can be done using common sense by adding some to one class and taking away some from another class or by doing it in proportion to the percentages of cut recorded in column 2. The computer program redistributes the cut using those proportions; in most situations the differences in the adjustment procedure between the common sense procedure and the mathematical procedure will be minimal. Increasing the cut in a class to remove more UGS, requires a decrease of the cut in another class to compensate. As a rule, decrease the cut in a class where we were removing AGS.



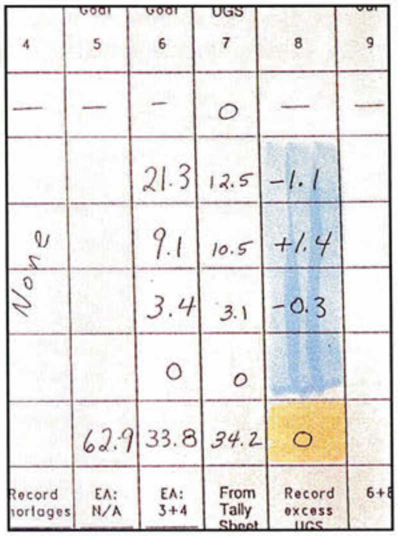
	Goal	Goal	UGS	
4	5	6	7	8
—	—	–	0	—
		21.3	12.5	
None		9.1	10.5	+1.4
		3.4	3.1	-0.3
		0	0	
	62.9	33.8	34.2	
Record shortages	EA: N/A	EA: 3+4	From Tally	Record excess

43. The medium sawtimber has the potential for value increase, so in this stand reduce the cut in that class. But reducing the cut by the whole 1.4 relative density percent would result in the same predicament: leaving UGS in the medium sawtimber class. So, reduce the cut as much as possible. Reducing it by 0.3 avoids cutting any AGS, but gets all the UGS. Since you are reducing the cut, record a negative 0.3 for this class.



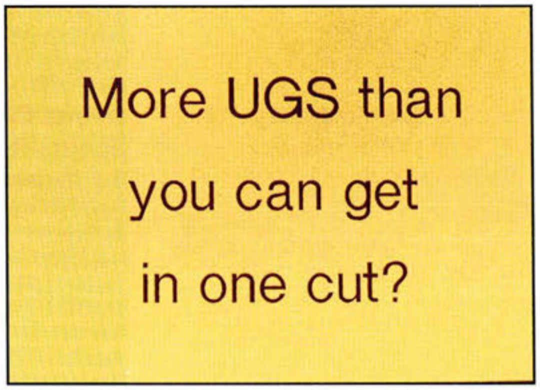
Adjust	Residual Goal	Cut Goal	Original UGS	Adjust
4	5	6	7	8
—	—	–	0	—
		21.3	12.5	-1.1
None		9.1	10.5	+1.4
		3.4	3.1	-0.3
		0	0	
	62.9	33.8	34.2	
Record	EA:	EA:	From	Record

44. That leaves 1.1 relative density units, and the only other class that can be adjusted is the pole class. So, reduce the cut by 1.1 in the poles.



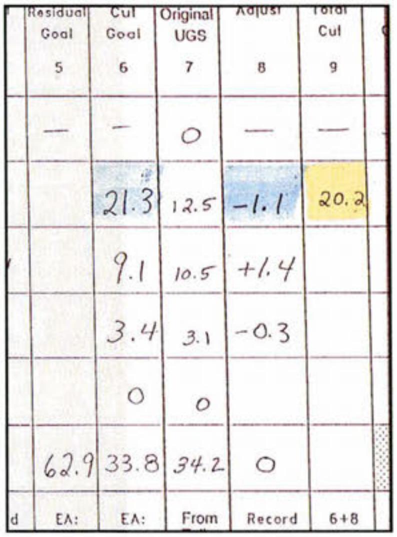
	Goal	Goal	UGS		
4	5	6	7	8	9
—	—	–	0	—	—
		21.3	12.5	-1.1	
None		9.1	10.5	+1.4	
		3.4	3.1	-0.3	
		0	0		
	62.9	33.8	34.2	0	
ecord ortages	EA: N/A	EA: 3+4	From Tally Sheet	Record excess UGS	6+

45. The bookkeeping works out, since the adjustments written in column 8 sum to zero.



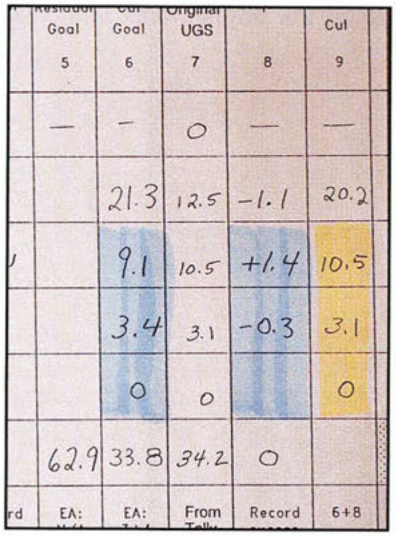
More UGS than you can get in one cut?

46. Some stands will have so many UGS that you cannot get them all in one cut. If that is so, make as many adjustments as possible (so that you are not cutting AGS in any class), and do not worry about the rest. Just cross out the excess UGS and write down as much as you actually can remove. The procedures to make the adjustment in this situation are described in detail in Appendix A.



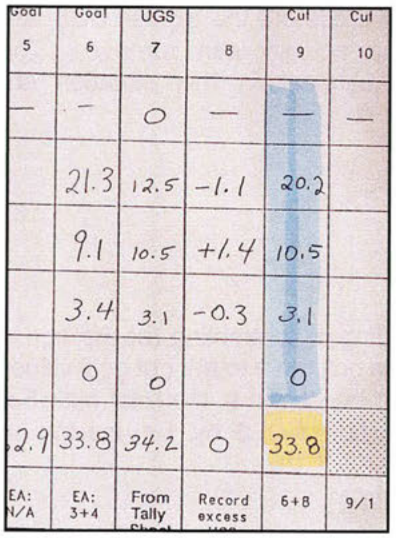
Residual Goal 5	Cut Goal 6	Original UGS 7	Adjust 8	Total Cut 9
—	–	0	—	—
	21.3	12.5	-1.1	20.2
	9.1	10.5	+1.4	
	3.4	3.1	-0.3	
	0	0		
62.9	33.8	34.2	0	
EA:	EA:	From	Record	6+8

47. Make these adjustments by adding or subtracting (as the sign in column 8 indicates) the values in column 8 to the cut goal values in column 6. Record the result in column 9, the total cut. For this example, reduce the pole cut of 21.3 by 1.1, leaving an adjusted pole cut of 20.2.



	Goal 5	Goal 6	UGS 7	8	Cut 9
	—	—	O	—	—
		21.3	12.5	-1.1	20.2
		9.1	10.5	+1.4	10.5
		3.4	3.1	-0.3	3.1
		0	0		0
	62.9	33.8	34.2	0	
rd	EA:	EA:	From	Record	6+8

48. Repeat this for the other size classes resulting in total cuts of 10.5 in the small sawtimber and 3.1 in the medium sawtimber.



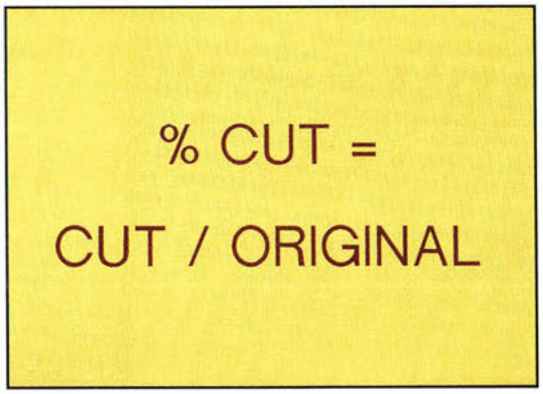
oal 5	Goal 6	UGS 7	8	Cut 9	Cut 10
—	—	O	—	—	—
	21.3	12.5	-1.1	20.2	
	9.1	10.5	+1.4	10.5	
	3.4	3.1	-0.3	3.1	
	0	0		0	
2.9	33.8	34.2	0	33.8	
EA: N/A	EA: 3+4	From Tally	Record excess	6+8	9/1

49. Be sure that the total cut shown in column 9 is the same as the cut goal in column 6. It is, within rounding, so the adjustments have not changed the residual density; the first priority, density control, has been maintained. This ends the distribution of cut calculations.

Phases of Distribution of Cut Procedures

- Prepare worksheet and determine density and structure
- Adjust the structure to fit distribution of actual stand
- Adjust the planned cut to remove maximum proportion of UGS
- Translate planned cut to marking guides

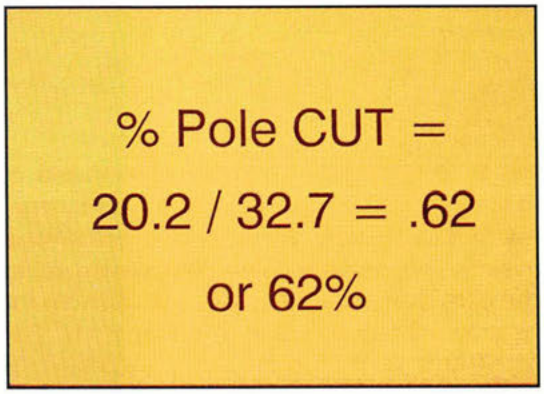
50. In Phase IV all that remains is to translate this cut into marking ratios that can be used as guides by the marking crew.



% CUT =

CUT / ORIGINAL

51. The figures just calculated are not easily used as a marking guide. It would be a difficult task to go out and mark 20.3 relative density units per acre from the pole class. So, we convert the density values to percentage and finally to marking ratios that are easy to use. For each size class, first calculate the percentages of the original stand density to be removed, by dividing the cut density in column 9 by the original density in column 1. Multiply by 100 to convert to a percentage and record that value in column 10. This is the percentage of the actual density or basal area in each size class to be cut.

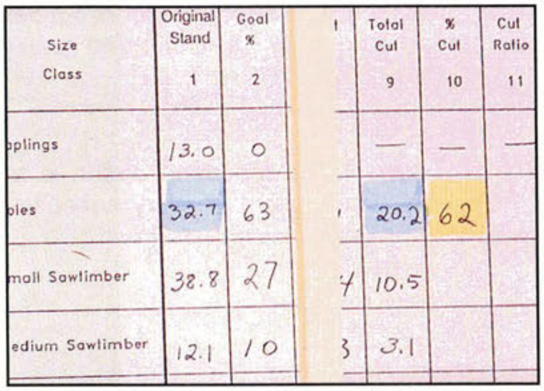


% Pole CUT =

20.2 / 32.7 = .62

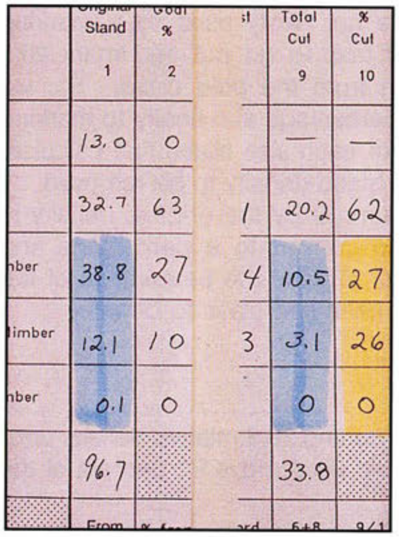
or 62%

52. For example, in the pole class, cutting 20.2 relative density units from the original 32.7, means we will remove 62 percent of the original density.



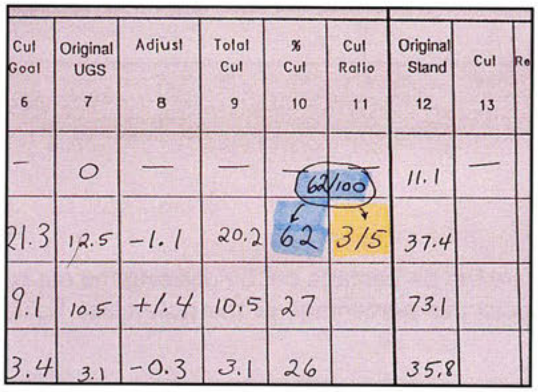
Size Class	Original Stand 1	Goal % 2		Total Cut 9	% Cut 10	Cut Ratio 11
plings	13.0	0		—	—	—
les	32.7	63	,	20.2	62	
mall Sawtimber	38.8	27	4	10.5		
edium Sawtimber	12.1	10	3	3.1		

53. On the form, calculate the percentage cut by dividing the cut by the original and record this percentage of the pole class being cut in column 10.



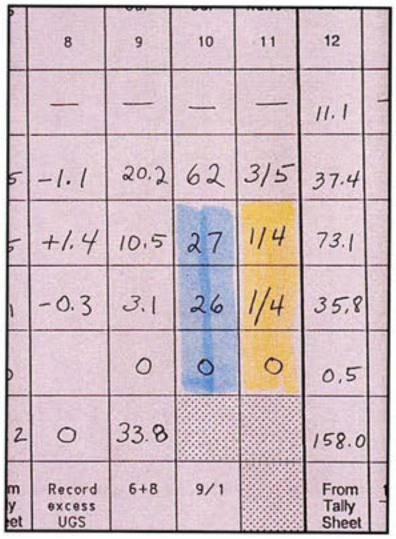
	Stand 1	% 2		Total Cut 9	% Cut 10
	13.0	0		—	—
	32.7	63	1	20.2	62
nber	38.8	27	4	10.5	27
imber	12.1	10	3	3.1	26
nber	0.1	0		0	0
	96.7	▨		33.8	▨
▨	From			6+8	

54. Repeat by size class, and record these values in column 10. For the example, the values are 27 percent of the small sawtimber class and 26 percent of the medium sawtimber class.



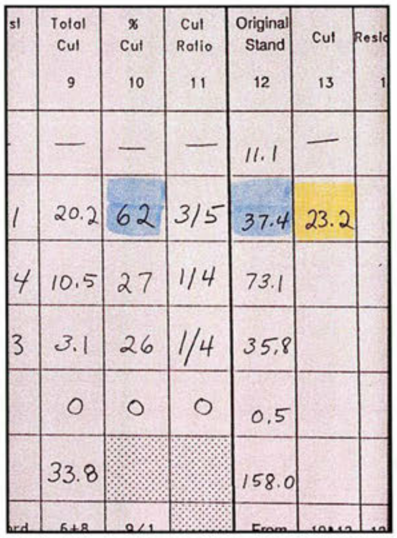
Cut Goal 6	Original UGS 7	Adjust 8	Total Cut 9	% Cut 10	Cut Ratio 11	Original Stand 12	Cut 13
—	0	—	—	—	62/100	11.1	—
21.3	12.5	-1.1	20.2	62	3/5	37.4	
9.1	10.5	+1.4	10.5	27		73.1	
3.4	3.1	-0.3	3.1	26		35.8	

55. Percentages are easier to implement than actual amounts of relative density, but they are still somewhat difficult to manage. Further simplify these percentages by converting the percentage to a cut ratio. Convert the percentage being cut, column 10, to a ratio (that is, cut percent over 100 and reduce the fraction) for use by the marking crew. Enter the ratio in column 11. For example, cutting 62 percent of the poles, is the equivalent of removing 62/100, which can be reduced to approximately 3/5 of the poles. The marking guide then, is to remove 3 out of 5 poles in this cut to achieve the desired density, structure, and quality distribution.



	8	9	10	11	12
	—	—	—	—	11.1
5	-1.1	20.2	62	3/5	37.4
5	+1.4	10.5	27	1/4	73.1
1	-0.3	3.1	26	1/4	35.8
		0	0	0	0.5
2	0	33.8	▨	▨	158.0
m y et	Record excess UGS	6+8	9/1	▨	From Tally Sheet

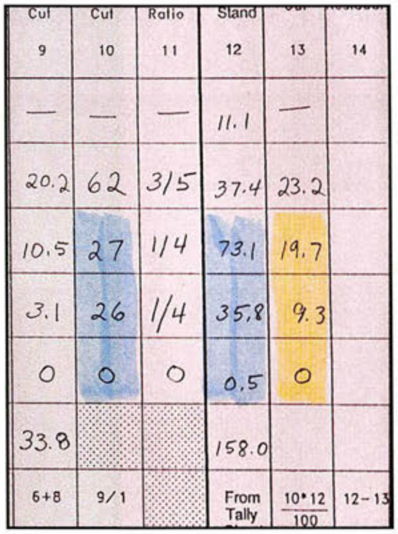
56. Repeat this for each size class. The recommendation is to remove 1 of every 4 small sawtimber and 1 of every 4 medium sawtimber trees.



st	Total Cut 9	% Cut 10	Cut Ratio 11	Original Stand 12	Cut 13	Resi 1
	—	—	—	11.1	—	
1	20.2	62	3/5	37.4	23.2	
4	10.5	27	1/4	73.1		
3	3.1	26	1/4	35.8		
	0	0	0	0.5		
	33.8			158.0		

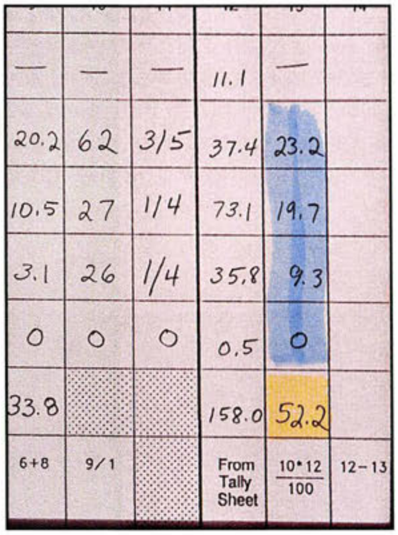
57. A ratio of 3 in 5 means that you should remove 3 out of every 5 trees of that size class. Within any size class, it also means that you will remove 3/5 of the basal area in that size class. Thus, these ratios can be used for marking without tallying the total actual basal area or relative density. But, the markers might like to use a prism to check residual basal area and verify that they are achieving the desired residual density. Or, you may wish to estimate the cut or residual stand averages. So, convert the relative density calculations back to basal area.

    Calculate the basal area to be cut in each size class using the percent cut in column 10 and the original basal area in column 12. Record these values in column 13. For example, in the pole class, removing 62 percent of the 37.4 square feet of basal area means cutting 23.2 square feet.



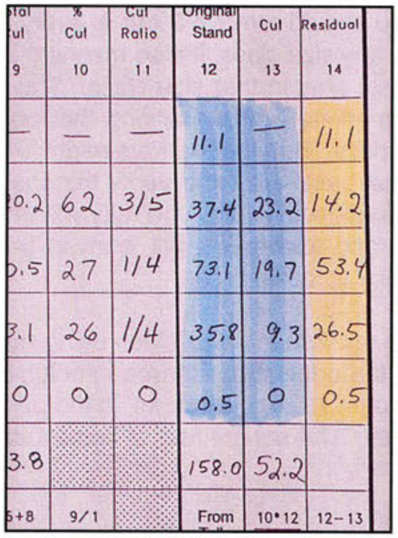
Cut 9	Cut 10	Ratio 11	Stand 12	13	14
—	—	—	11.1	—	
20.2	62	3/5	37.4	23.2	
10.5	27	1/4	73.1	19.7	
3.1	26	1/4	35.8	9.3	
0	0	0	0.5	0	
33.8			158.0		
6+8	9/1		From Tally	10•12 / 100	12−13

58. Calculate the cut basal area for the remaining size classes. For the example stand, the figures are 19.7 square feet from the small sawtimber class and 9.3 square feet from the medium sawtimber class.



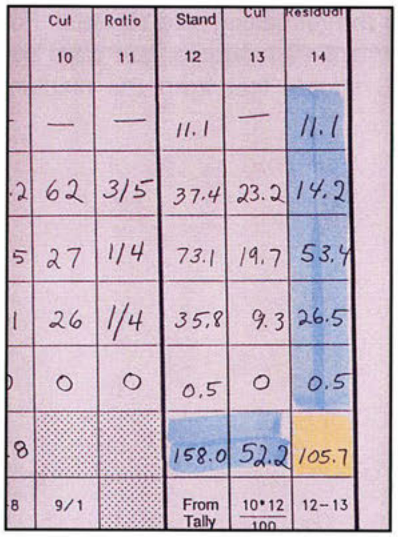
—	—	—	11.1	—	
20.2	62	3/5	37.4	23.2	
10.5	27	1/4	73.1	19.7	
3.1	26	1/4	35.8	9.3	
0	0	0	0.5	0	
33.8			158.0	52.2	
6+8	9/1		From Tally Sheet	10•12 / 100	12−13

59. The sum of the five size classes is the total basal area cut. These basal area values can be converted to volumes using the conversion factors from the Overstory Manual Summary worksheet (Appendix D), as was done for the original stand.



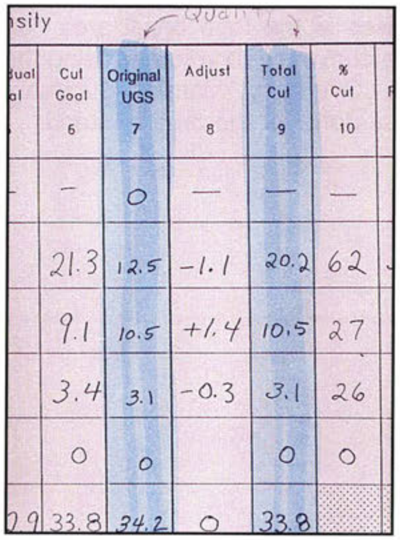
ul 9	% Cut 10	Cut Ratio 11	Original Stand 12	Cut 13	Residual 14
—	—	—	11.1	—	11.1
0.2	62	3/5	37.4	23.2	14.2
0.5	27	1/4	73.1	19.7	53.4
3.1	26	1/4	35.8	9.3	26.5
0	0	0	0.5	0	0.5
3.8			158.0	52.2	
6+8	9/1		From	10•12	12–13

60. Calculate the residual basal area by subtracting the cut basal area, column 13, from the original basal area, column 12, and enter these values in column 14.



	Cut 10	Ratio 11	Stand 12	Cut 13	Residual 14
	—	—	11.1	—	11.1
.2	62	3/5	37.4	23.2	14.2
5	27	1/4	73.1	19.7	53.4
1	26	1/4	35.8	9.3	26.5
	0	0	0.5	0	0.5
.8			158.0	52.2	105.7
8	9/1		From Tally	10•12 / 100	12–13

61. Again, sum the values in column 14 to get the total residual basal area.

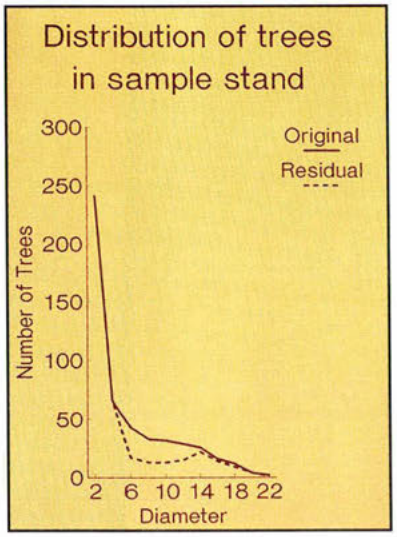


sity

Quality

ual al	Cut Goal 6	Original UGS 7	Adjust 8	Total Cut 9	% Cut 10
	—	0	—	—	—
	21.3	12.5	-1.1	20.2	62
	9.1	10.5	+1.4	10.5	27
	3.4	3.1	-0.3	3.1	26
	0	0		0	0
7.9	33.8	34.2	0	33.8	

62. One additional piece of useful information is a comparison of the total cut in column 9 with the UGS in column 7. In the example, just about all of the cut in the sawtimber sizes will be UGS and about half of the poles will be UGS. So, our cut in this stand will clean up the sawtimber by removing most of the UGS, and hitting the poles fairly hard, including removing some good quality poles.



63. These data provide a basis on which to judge the proposed cut and its effect on the residual stand. Implementing such a cut, would remove most of the pole size class from this stand and start creating a desired bell-shaped curve in the small and medium sawtimber sizes. The residual stand would be dominated by good quality trees in the small and medium sawtimber sizes where we want to concentrate the growth. And because we have thinned throughout all size classes and opened the crown canopy, we should increase the growth on these residual trees.

It is possible to try a variety of cutting alternatives, and evaluate the impact on volumes to be cut, and residual stand characteristics. This provides a powerful means of testing alternative cutting schemes, in addition to providing guidance for stand marking to ensure that the prescription is applied to the stand in the manner intended.

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APPENDIX A

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 (Appendix B). 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 (Appendix B). 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 (Appendix C). 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 Appendix C is consulted as an example.

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 (Appendix D)(totals block in the lower right corner) to Column 1, Distribution of Cut Form (Appendix C), 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% or more, record it in the total row of Column 5. If it is less than 60%, record 60%.
>
> **If this is a shelterwood seed cut in an area with moderate to high deer pressure, . . .**
> . . . record 60%.
>
> **If this is a shelterwood seed cut in an area with low deer pressure, . . .**
> . . . record 50%.
>
> **If this is the second cut (first removal cut) of a three-cut shelterwood** sequence, . . .
> . . . record 35%.

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 Appendix B (Cut relative density to come from and relative density to be retained in various size classes, in percent) to Column 2, Distribution of Cut Form, by size classes. Use the line on Appendix B 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 implemented as 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 summing the 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.

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% 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 Manual Overstory Summary Form (Appendix D).

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.

APPENDIX B

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 Code 3)				
	--[4]	41	37	22	0
	Single-tree Selection Cutting with Maximum Large Trees (Mgmt Code 4)				
	--[4]	22	30	27	21

[1] For commercial thinning only, take up to 50% 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% of original density in large saws and adjust other sizes proportionally.

[4] In all-age cuts, all existing sapling density is retained.

Source: Marquis, David L.; Ernst, Richard L.; Stout, Susan L. 1991. 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.

SILVAH - Distribution of Cut Worksheet

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

Stand ID

	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

SILVAH - Distribution of Cut Worksheet

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

Stand ID Comp 171, Stand 23 - Commercial Thinning

	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	0	—	—	—	—	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	NONE		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	0		0	0	0	0.5	0	0.5
Total	96.7		33.8		62.9	33.8	26.1	0	33.8			158.0	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	$\frac{10*12}{100}$	12-13

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		4		
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		

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	0	0		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			0.76			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	227	0	0	0	27.9	9.0	3529
	f		0.31	128		0.49	106		0.92	106			
Large Saws	value	0.5	0.1	74	0	0	0	0	0	0	0.5	0.1	74
	f		0.27	148		0.44	120		0.91	120			
All Sizes AGS	value	59.5	21.7	5896	31.6	20.1	1475	20.6	20.7	371	111.6	62.5	7742

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	0	0		1.1	1.3		5.8	6.8		6.9	8.1	
	f		1.44			1.21			1.17				
Poles	value	0.5	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	173	0	0	0	7.9	3.1	474
	f		0.31	64		0.49	53		0.92	53			
Large Saws	value	0	0	0	0	0	0	0	0	0	0	0	0
	f		0.27	74		0.44	60		0.91	60			
All Sizes UGS	value	12.0	4.5	587	14.8	9.6	391	19.5	20.1	134	46.3	34.2	1112

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		4 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	4003
	f			20.5	20.5	0.24			
Large Saws	value			13.2	13.2	0.1	0.5	0.1	74
	f			26.5	26.5	0.28			
All Sizes	value	1/(3-4) 14.5	2/3 13.7	2125.0 1	2158.3 2	31.5	158.0 3	96.7	8854

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Marking Ratios and the SILVAH System

James C. Redding

The SILVAH stand analysis and prescription system provides a systematic procedure for collecting, summarizing, and analyzing stand data to arrive at an appropriate silvicultural prescription. If that prescription includes a partial cutting, the system also provides a way to quantify marking instructions. These instructions indicate the desired residual stand density and structure, and provide information on change in species composition and quality expected as a result of cutting.

The final, crucial step is to apply the carefully prepared prescription by marking the stand in the prescribed way. Improper marking wastes all of the time, effort, and considerable expense incurred in the stand inventory and analysis.

Most markers mark stands to a specific residual density and select trees for removal to improve tree spacing, total stand quality, and species composition. The SILVAH system adds another factor--control of stand structure to ensure that the cutting achieves its long-term objective within the framework of the particular silvicultural system being used. This control of stand structure is achieved by removing the desired density within specific tree size classes.

One of the field exercises in our silvicultural training sessions is a marking exercise. The class marks an actual stand and evaluates how close their marking comes to the prescribed density, structure, composition, and quality goals. Most people have difficulty in meeting the stand structure goals.

To improve marking to a prescribed structure, we have developed a procedure that uses cut ratios, by three or four major size classes. In this article, I describe how the ratios are applied, provide some hints on marking stands to a given prescription, and discuss some of the initial reactions to the use of marking ratios.

In the procedures for distributing the cut among size classes, and for calculating the marking ratios, figures are carried to the closet tenth of a square foot of basal area. Then we reduce those precise calculations to broad ratios--1:5 large sawtimber, or 2:3 poles--for marking. We spend time being precise because if you begin rounding off too soon, your ratios are likely to come out much differently due to the accumulation of errors caused by rounding. By not rounding the calculations until the last step, you know that the ratios are based on good, sound figures. The simpler ratio derived from these sound figures is easy to apply in the woods, and is adequately precise for marking.

Once learned and properly applied, use of the ratios considerably reduces the variation among markers. This is particularly important to large forestry organizations because personnel change frequently and continuity in marking quality is a concern.

USING THE RATIOS IN THE WOODS

Using the ratios in the woods is fairly simple. As you progress through the stand, stop at regular intervals and consider the circle of trees immediately around you. Decide which trees are best to leave for the final crop and which must be removed to achieve the residual density goal. Select for removal those trees that are of poor quality, poor risk, or those that are interfering with a better stem. In addition to these usual marking procedures, use the ratios to guide your selections of how many trees to remove in each broad size class.

Within the circle of trees you are considering, choose the best quality sawtimber to leave and using the ratios, mark the appropriate number of sawtimber trees to improve spacing, quality, and species composition of the residual stand. Do the same in the pole size classes. For example, if your ratio in poles is 2:3 and there are six poles in your area of consideration, choose the best two and mark the other four for removal. If you let your marking be guided by the ratios, you will achieve both the desired structure and the desired density in your residual stand.

These ratios automatically help you adjust your marking as conditions within the stand vary. For example, if your ratio in poles is 2:3, you will automatically mark heavier in spots where the poles are numerous, and you will mark lighter where there are fewer poles. The same is true of the other size classes.

But do not ignore traditional marking criteria. Use the ratios as a guide, not as an absolute rule. Cutting 2:3 poles simply means that you want to mark very heavily in the pole size class. Cutting 1:5 small sawtimber simply means that you really do not want to remove very many of that size class at all--mostly those of poor quality or those that must be removed to provide more room for a better tree of the same size.

For example, suppose you examine a circle of trees and find five small sawtimber trees of which two are such poor quality and/or spacing that they need to be removed even though your ratio only calls for taking 1:5. Also suppose your pole ratio is 2:3, and you find six poles of which only one is poor quality. By all means, take out the two poor-quality small sawtimber, and compensate by removing fewer poles. On the other hand, if all the poles are also of poor quality, adhere more closely to the ratios prescribed.

Do not try to compensate from one circle of trees to the next. If you find seven poles instead of six and the ratio is 2:3, mark either 4 or 5 poles, whichever seems most appropriate in terms of quality and spacing. But do not try to remember that you marked one too many or one too few and compensate for it in the next area of consideration--it is too confusing and unnecessary. So, use the ratios as a guide, not as a rigid rule, to determine how heavily you should cut in each size class. Add this guide to those you already use in marking, not as a substitute for the usual attention to quality and spacing.

INITIAL REACTIONS TO USE OF RATIOS

At first a seasoned marker using ratios will probably become frustrated by what seems to be needless complexity, and may return to their usual method of marking. If the prescription and timber type are similar to those with which you usually work, you will be close to what was prescribed anyway. However, if you are asked to mark a stand in a different manner to satisfy some different management goal, you may have a problem. If, for example, you are accustomed to marking even-age thinnings, and you are asked to mark a group-selection cut and do not apply cut ratios, you probably will not achieve the residual stand density goal and almost certainly will not achieve the intended stand structure. This happens when given a prescription you have never marked before because you have no idea what the residual stand should look like. Proper application of cut ratios overcome this problem.

The value of the system became clear to me when I marked a stand for a study designed to compare various management strategies with our traditional even-age strategies. The study consisted of twenty 5-acre plots marked to five very different prescriptions. The residual densities stayed about the same, but the stand structure and species composition changed dramatically. This gave the residual stand of each treatment a very different look even though all plots were cut to the same relative density.

I began marking an even-age thinning since I was used to that type of prescription, and tried to apply the ratios generated by the SILVAH program. I had marked timber on the national forest for a number of years using residual basal area as my guide. At first I resented being locked into the numbers by the new system. After marking one acre, I could not see much difference from what I usually marked, so I stopped using the ratios and finished marking the stand in the usual way. We had 100 percent inventories for each plot, so I could subtract what I had marked from what was there originally to see how close I met my target. In the even-age thinning, I was right on target even though I ignored the ratios for most of the marking.

Feeling confident, I moved onto the next 5-acre plot--an economic selection cut. After marking one acre of this treatment and ignoring the ratios, I looked back at the residual stand I was leaving. To my surprise, it looked just like the residual for the even-age thinning. I knew there should be a difference, but because I had never marked an economic selection cut before, I had no concept of what kind of stand I should be leaving.

I slowly pulled the SILVAH printout from my cruiser's vest and looked at the marking ratios and began applying them. After finishing the plot, I subtracted what I had marked from the original 100 percent inventory and to my surprise I had left the exact residual stand prescribed. I still was not totally comfortable using the ratios, but the results from the economic selection plot made me think that these ratios might be practical in the woods. Sure enough, in a week I had applied the ratios and marked 100 acres in these 5-acre blocks, resulting in the prescribed residual stand each time. Also, after using the ratios for a week, I was comfortable with them, and convinced that I would never go back to my old way of marking. In the 10 years since my introduction to this system of marking, I let the ratios guide my marking with good success.

GUIDES FOR NEW MARKERS

Those who have little or no marking experience are likely to apply the ratios too rigidly and mark trees that should have been left or vice versa. If your crewmate is an experienced marker, you will probably disagree and cease talking to each other halfway through your first strip. The following can help you through the familiarization period.

1. Emphasize the residual stand. As you mark a group of trees, ask yourself, "Am I making the stand more uniform? Are the trees I am leaving well spaced and generally of good quality?"

2. Remember that the stand analysis figures from which you have derived a marking guide are average figures for the stand as a whole. Every circle of trees you consider in the stand is not going to be average. Your prescription may call for removing all of the UGS large sawtimber. What are you going to do if all the UGS material is concentrated in one small area of the stand? Remember too that your inventory is based on a sample cruise that may not have adequately sampled all conditions within a stand. Do not get locked into the numbers--use common sense. If you feel you can justify marking a tree that is not called for, mark it and move on.

3. Density within a stand will vary from point to point. Using traditional marking methods you have to lighten up your marking in open patches and mark more heavily in the dense portions. Applying the ratios does this automatically for you.

4. When marking a large tree, consider how that tree will be felled. If other trees are in its path and will likely be damaged, mark those trees too, even if your ratios do not call for it.

5. When working in stands of sprout origin, thin sprout clumps to one or two of the better stems.

6. Remove all trees that, in your judgment, will not survive 15 years. This may be due to a split crotch, poor vigor of the crown, excessive lean, rot, or insect damage and disease.

7. Favor retaining species that are a minor component in the stand you are working in. These residuals will provide a seed source for that particular species which may improve species diversity in the next forest.

8. Favor retaining trees that are important for wildlife. This may include leaving trees with suitable nesting cavities, coniferous trees for cover, and mast-producing species for food.

9. Try to thin areas where trees are clumped together to improve spacing and growth of the trees that remain. Tree crowns need to have adequate growing space on at least three sides to maximize growth. But, do not hesitate to leave two good trees side by side.

10. Favor, where possible, leaving species that will enhance the management objective for a particular property.

SUMMARY

No matter how much or how little timber marking experience you have had, your first exposure to this system of marking will, like any change, probably make you uncomfortable. Do not give up on it--give it a fair trial.

Keep in mind the advantages of this system. First, it gives prescription writers the assurance that the residual stand will be close to the prescription. For markers, it gives you confidence that you will end up with a residual stand fairly close to the prescription. This is true especially if the prescrition deviates from the normal way you have been marking similar stands.

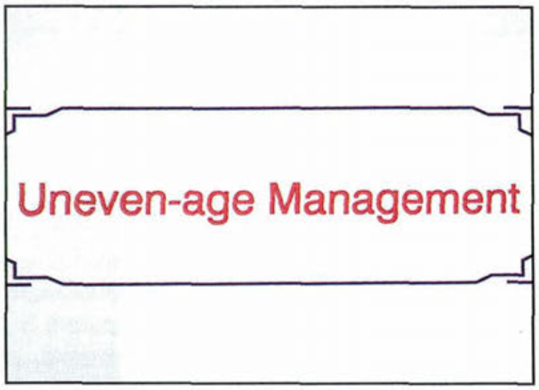
Most of all, recognize the numbers for what they are: guides to aid you in achieving your density, structure, and species composition goals. Exercise your professional skill and judgment each time you pull the trigger of your paint gun.

Selected References

Leak, William B.; Gottsacker, James. 1985. New approaches to uneven-age management in New England. Northern Journal of Applied Forestry. 2:28-31.

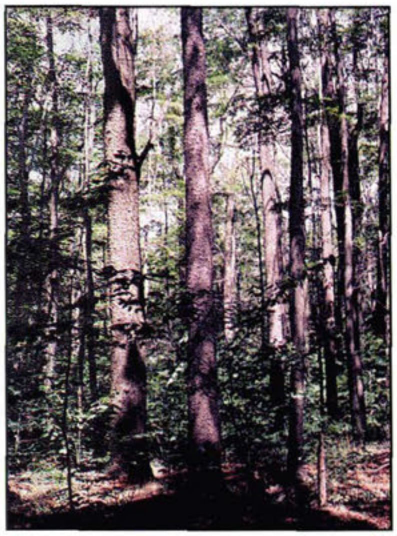
Principles and Practices of Uneven-age Management

Susan L. Stout



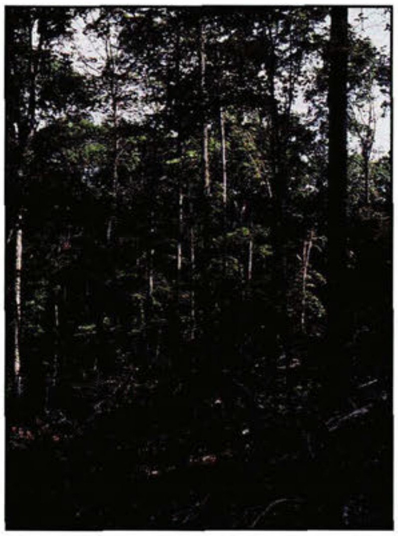
Uneven-age Management

1. The SILVAH system of stand inventory, analysis, and prescription includes prescriptions from both even- and uneven-age silvicultural systems. Uneven-age silvicultural systems are used when management goals, usually aesthetic, require maintenance of continuous high forest cover, even though this usually means a shift to a less valuable species composition over time. In this article, the principles of uneven-age management and their application in the SILVAH system are discussed. This is a shift of focus. Most of the lectures in this series are focused on even-age management.

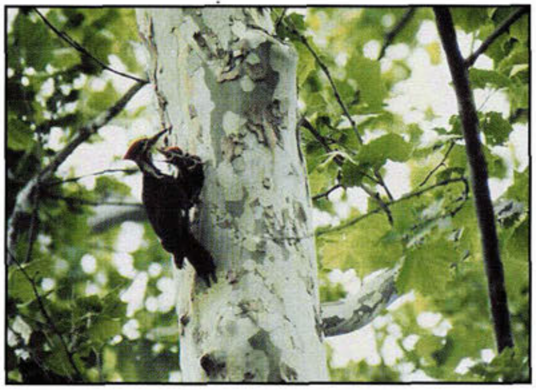


2. Under even-age management we can focus on the often high proportions of less shade-tolerant species such as black cherry, white ash, red maple, yellow-poplar, and red oak. These species grow fast and have high value per unit volume. They also occupy less growing space per tree than their more shade-tolerant associates, so stands with high proportions of these species have higher volumes per acre.

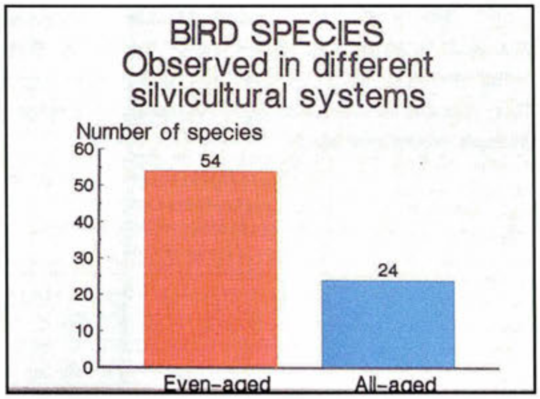
3. Uneven-age management, on the other hand, and particularly single-tree selection cutting, results in a gradual change in species composition toward more shade-tolerant species, and Allegheny hardwood stands managed under this system will eventually consist primarily of sugar maple, beech, and hemlock. So selection cutting and uneven-age management will usually be less profitable than even-age management in Allegheny hardwoods. In forest types where the highest value species are shade-tolerant ones like sugar maple and less valuable competitors are shade intolerant, uneven-age management may be preferable to even-age management for timber production objectives. This is true in some parts of Canada.



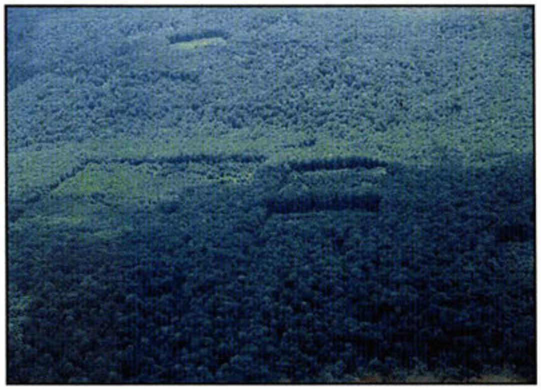
4. In the oaks, the probable outcome of single-tree selection cutting will be more variable. On hot dry sites, such as ridgetops or southerly aspects, oaks may be replaced by noncommercial and very tolerant species such as dogwood and sassafras over many years. On other sites, with low oak site index, more tolerant but sometimes acceptable species such as hickory; red maple; or slow growing white, chestnut, or post oaks may come to dominate the stand. And on some sites, the stand may convert from an oak to a northern hardwood stand over many years of repeated single-tree selection cutting.



5. Uneven-aged forest stands have desirable habitat characteristics for species, such as the pileated woodpecker, that can or must meet all habitat needs in mature forests, with relatively unbroken canopy and many large trees.

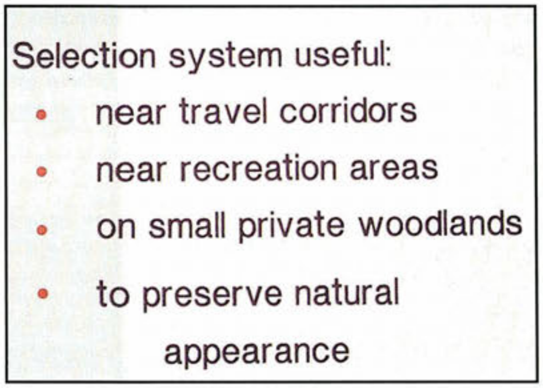

BIRD SPECIES
Observed in different silvicultural systems

6. The mix of vegetative conditions found in a balanced even-aged forest provides for more diversity of wildlife, however. Uneven-age management does not create large blocks of early seedling-sapling stages, with an abundance of accessible foods and low cover. Because forests managed under uneven-age silvicultural systems lack the vegetative and structural diversity of forests managed under even-age systems, the abundance and species diversity of wildlife will be lower, as shown in this graph developed from research done in mixed hardwoods in New England.



7. Forest fragmentation has become an increasingly important biological and political concern for forest managers. Much of the eastern work on forest fragmentation was done in places where the forces fragmenting the forest involved permanent changes, like development or agriculture. The effects of the temporary changes associated with both even- and uneven-age partial cuttings and harvest openings have not been adequately assessed. Preliminary reports about the effects of openings created by forest management on forest interior bird species are encouraging.

8. Uneven-age management, especially single-tree selection cutting, offers a significant advantage over all forms of even-age management. It maintains a more natural, undisturbed appearance than any other cutting method. A high forest canopy is maintained at all times, leaving the appearance of a completely undisturbed forest when viewed from a distance, and absorbing most of the impact of disturbance even when viewed close-up immediately after a cutting. This photo was taken in the first growing season after cutting in this stand.


Selection system useful:

- near travel corridors
- near recreation areas
- on small private woodlands
- to preserve natural appearance

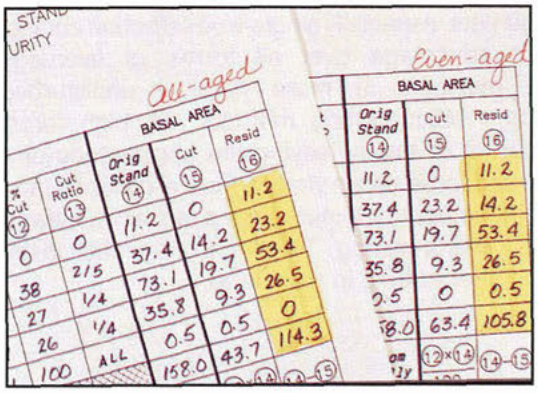
9. For these reasons, selection system silviculture is especially appropriate in heavily traveled zones or areas of high recreation use on public forests. It is often the preferred, and sometimes the only, acceptable cutting method on small, privately owned woodlands where timber production is secondary to the recreation or aesthetic goals of the owner. And it preserves natural appearance in managed forest stands.

10. Selection system also offers an alternative to the three-cut shelterwood on sites with limitations, particularly wetness, that would put them at risk of regeneration failure if seedlings were exposed to the harsh conditions following complete overstory removal under even-age management.

UNEVEN-AGE SILVICULTURE

- Principles
- Research results
- SILVAH Prescriptions
- Application

11. Thus, uneven-age silvicultural systems have specific advantages. Here we begin to explore the application of the SILVAH system in uneven-age management. Specifically, we review the principles underlying uneven-age silviculture and some research results. We also describe SILVAH's uneven-age prescriptions and the application of these prescriptions to actual stands.



STAND
URITY

All-aged

% Cut ⑫	Cut Ratio ⑬	BASAL AREA Orig Stand ⑭	Cut ⑮	Resid ⑯
0	0	11.2	0	11.2
38	2/5	37.4	14.2	23.2
27	1/4	73.1	19.7	53.4
26	1/4	35.8	9.3	26.5
100	ALL	0.5	0.5	0
		158.0	43.7	114.3

Even-aged

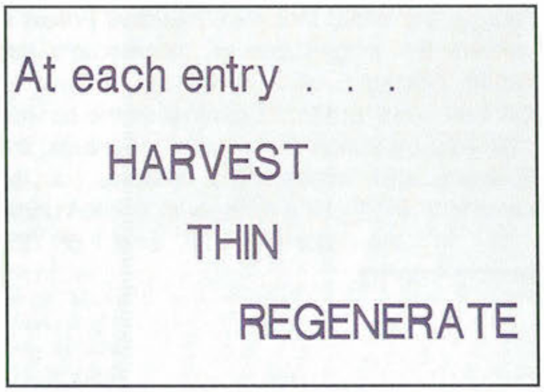
BASAL AREA Orig Stand ⑭	Cut ⑮	Resid ⑯
11.2	0	11.2
37.4	23.2	14.2
73.1	19.7	53.4
35.8	9.3	26.5
0.5	0	0.5
58.0	63.4	105.8
	⑫×⑭	⑭-⑮

12. We take a detailed look at the planning of an actual selection system cut for the sample stand that is used throughout this volume, using one of the uneven-age alternatives within SILVAH.

SELF-SUSTAINING FOREST:

Predictable flow of resource benefits, including wood products, at regular intervals.

13. Uneven-age silviculture attempts to create a self-sustaining forest, within a single stand, in which regeneration, growth, and removals act to maintain a stable population of trees from which a predictable flow of products can be harvested at regular intervals.



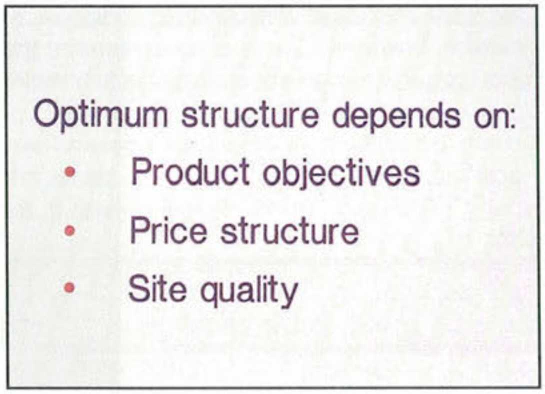
At each entry . . .

HARVEST

THIN

REGENERATE

14. Silviculture of a such a stand consists of regular entries during each of which (a) mature and high risk trees are harvested, (b) immature age classes are thinned to concentrate growth on the best stems and ensure the continuous flow of trees to the large size classes, and (c) space and conditions are created for the establishment and development of new regeneration.



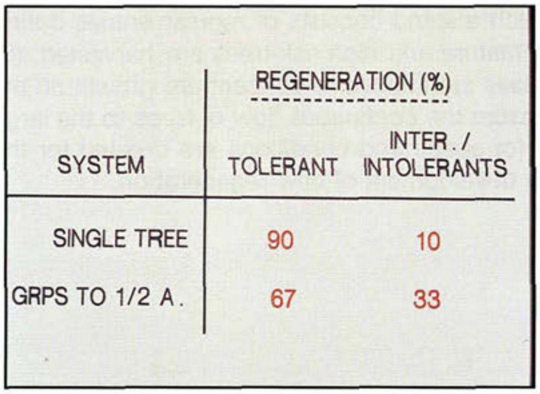
Optimum structure depends on:

- Product objectives
- Price structure
- Site quality

15. Within this conceptual framework, a wide variety of options are available. Options range from the strictest individual-tree selection cuttings through group-selection systems that some might be inclined to call a patchwork of small clearcuts. These options have in common the conscious creation and thinning of several age classes within one forest stand, and silvicultural efforts to mold these age classes into a stable and sustainable size distribution over the area of the stand. Furthermore, trees that develop in an uneven-aged stand will spend at least part of their early development under the influence of older and larger trees in the same stand.

16. Species composition can vary greatly, depending on the size of canopy openings created during silvicultural operations in managed uneven-aged stands. With single-tree selection, 90 percent or more of the regeneration will be of shade tolerant species. In Allegheny hardwoods, these will be sugar maple, American beech, and hemlock. In oaks, as already mentioned, the results may range from white and chestnut oaks through red maple, sassafras, and dogwood.

17. A slightly higher proportion of intolerants can be retained if uneven-age management consists of a mix of single-tree selection cutting with small group selection cutting, in which openings up to half of an acre are created whenever a group of trees growing together could logically be removed. The openings provide more variety of wildlife habitat as well.



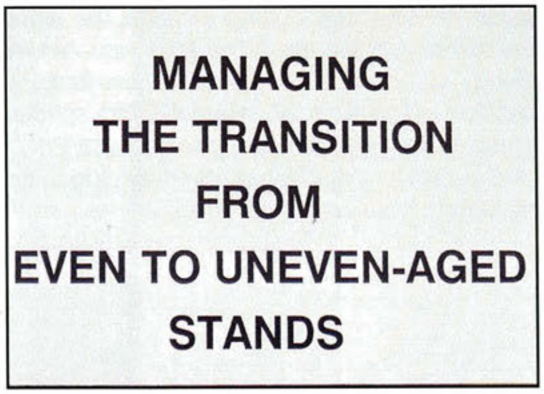
	REGENERATION (%)	
SYSTEM	TOLERANT	INTER. / INTOLERANTS
SINGLE TREE	90	10
GRPS TO 1/2 A.	67	33

18. This table, from work on the White Mountain National Forest in New Hampshire, shows the proportions of intermediate and intolerant regeneration obtained using different varieties of uneven-age management. As the size of openings in the canopy increased from single-tree openings to 1/2-acre openings, the proportion of intolerant and intermediate species in the regeneration increased too. Most of the regeneration even under group selection is at the intermediate end of the intermediate/intolerant grouping.

19. We must include one very important warning in our discussion of uneven-age silviculture, however. There is no assurance that uneven-age management can be used successfully in any region where deer populations are high. The success of selection cutting depends on the establishment of a new age and size class at each cut, and the eventual growth of these stems into the main crown canopy. The long period of slow growth in the understory, however,

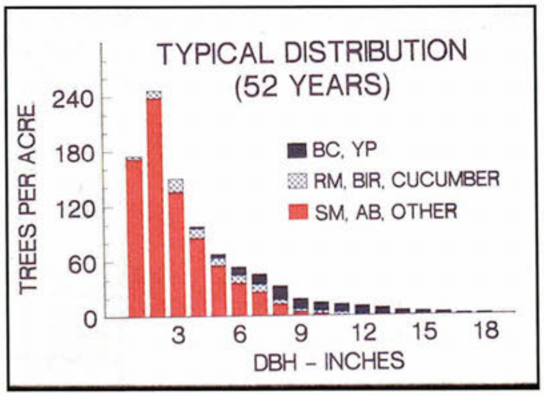
20. greatly increases the length of time that seedlings are subject to deer browsing compared to those under even-aged management, and the small openings created by group selection are very attractive to deer. In addition, deer seem to browse preferentially on those species that would otherwise be favored by the selection system. There are many locations where reproduction simply CANNOT be obtained. Unfortunately, regeneration failures are not nearly so apparent under selection cutting, and it is possible to apply three or four selection cuts before it becomes obvious that you are running out of trees. So, special care should be taken to monitor the progress of age class replacement if uneven-age management is used in areas of moderate to heavy deer population.

21. Interfering plants further complicate this story. The selection system depends on successfully bringing through an age-class from each entry to the stand. When we treat interfering understories in an even-aged stand, we eliminate existing advance reproduction along with interfering plants. Then we count on the post-cutting conditions to favor germination of numerous seedlings that can outgrow the returning fern, grass, or weed species in the full light after even-aged overstory removal. We cannot afford to eliminate the existing small trees from the last cutting cycle, nor can we expect fast growth from new seedlings in the perpetual partial shade of the selection system. So, interfering plants need to be assessed carefully in selecting stands to be managed under this system.



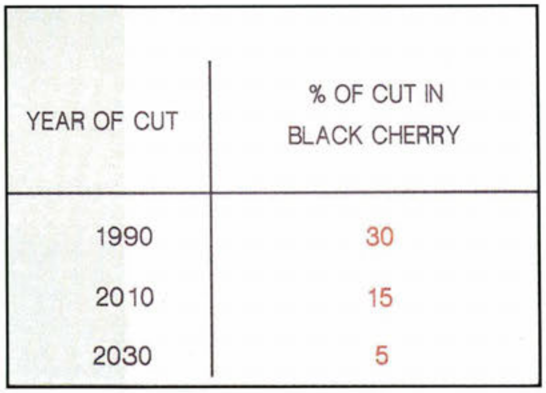
MANAGING THE TRANSITION FROM EVEN TO UNEVEN-AGED STANDS

22. Remember that almost all existing eastern hardwood stands are even-aged in character. A period of adjustment is required to establish a stable uneven-age condition with the desired distribution of ages and tolerant species; this adjustment period may require two or three cuts spanning 30 to 50 years. So, most uneven-age management practiced during the foreseeable future will involve stands in this transition from an even-age condition to an uneven-age condition.



23. Many even-aged mixed hardwood stands exhibit an inverse J-shaped diameter distribution. This structure is due to the variety of species present and their widely different growth rates. The intolerants are clustered in the large sizes, whereas the tolerants are concentrated in the smaller size classes and lower crown positions. Although this structure is not truly a balanced uneven-age structure, it does make the job of conversion somewhat easier.

24. As the large intolerants are removed during selection cutting, they will be replaced by the tolerants in the smaller size classes, and the stand will eventually be dominated by tolerant species.



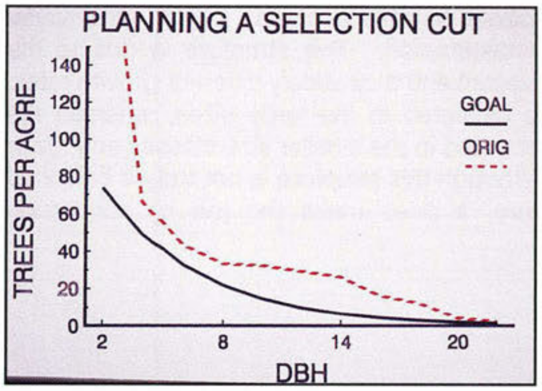
YEAR OF CUT	% OF CUT IN BLACK CHERRY
1990	30
2010	15
2030	5

25. A fully stabilized uneven-aged stand will not be obtained until most of the intolerants have been replaced by new age classes of vigorous tolerant stems in all size classes. However, there is no reason to hurry this adjustment process. The intolerants present now are fast-growing and valuable and retaining some intolerant species for as long as possible will help maximize value from the stand. And because the system for distributing the cut requires that the cut in each size class be proportional to the existing species composition, this will happen automatically over the first two or three cuts under the selection method. The intolerants will "grow out the top" and be replaced by tolerant species growing up from the small size classes.

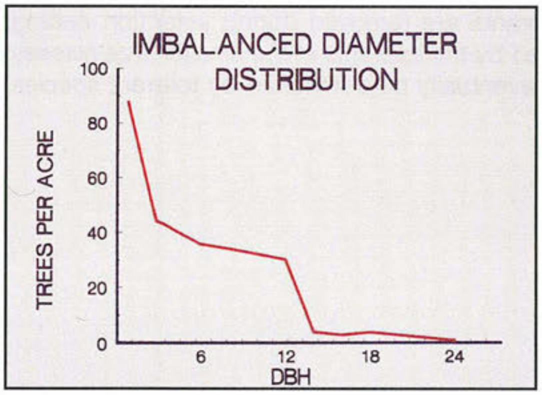
SELECTION PRESCRIPTION

- Stand Density
- Stand Structure
- Species Composition

26. Planning a prescription for selection cutting involves the same factors considered in planning a thinning. You must account for stand density (stocking), stand structure (diameter distribution), and species composition. The type of structure and species composition sought are quite different than those sought under thinning. But once the residual stand has been decided, the mechanics of distributing the cut are quite similar.



27. Fundamental to uneven-age management is the selection of a basic structure for the stand. This will be the residual stand after every cutting cycle. Ideally, this structure should sustain itself. If each cut returns the stand to this structure, the stand will respond with regeneration of a new age class and healthy, vigorous growth on the residual stems.

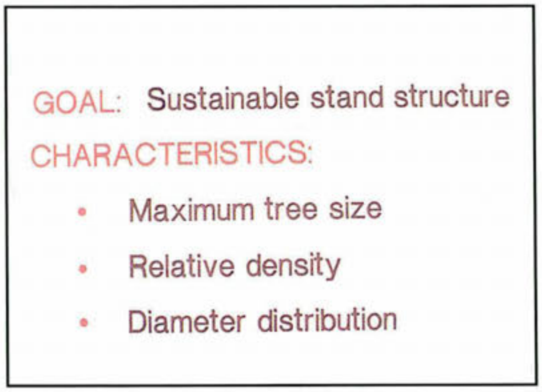


28. Merely matching the volume cut to the volume you believe has grown in the stand since the last cutting does not provide adequate regulation of a stand under the selection system. Even when calculations of volume growth are good, and volume growth exceeds the cut, concentrating the cut in the largest classes can badly imbalance the diameter distribution. The example from the Kaskaskia Experimental Forest provided by Marquis and Roach in the article "Thinning Principles and Practices" illustrates this problem very well.

SOLUTION:

CONTROL STAND STRUCTURE

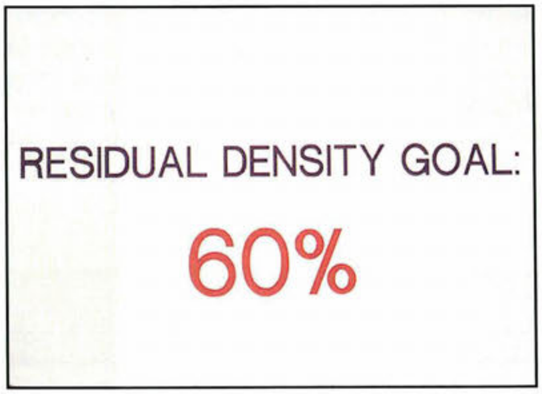
29. The solution is careful selection of a sustainable residual stand structure.


GOAL: Sustainable stand structure

CHARACTERISTICS:

- Maximum tree size
- Relative density
- Diameter distribution

30. The residual stand structure can be defined by three parameters: residual relative density, maximum tree size, and diameter distribution of the residual stand.


RESIDUAL DENSITY GOAL:

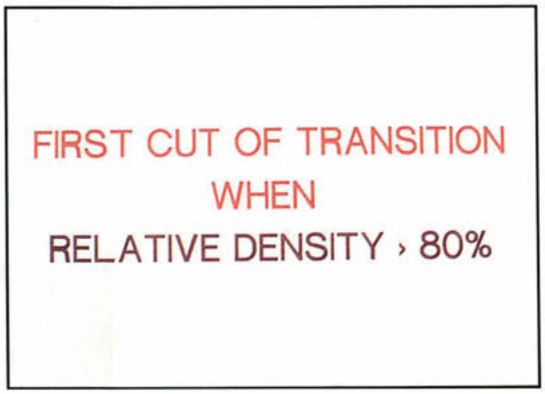
60%

31. The choice of residual relative density is handled exactly as in thinning, and for the same reasons. We wish to distribute stand growth among the best residual stems, maintain the quality of those stems, and open the canopy enough to foster the development of a new age class after every cut. Stands should be cut back to 60 percent relative density in each cycle, but no more than 35 percent relative density should be removed in any one cut.


DENSITY TRADE-OFFS

- Growth
- Tree quality
- Regeneration
- Cutting cycle length

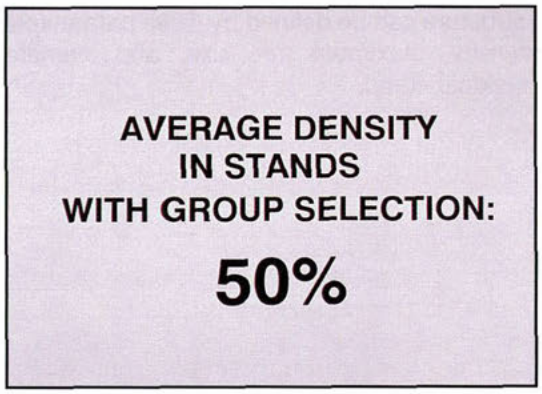
32. Some work done by Ralph Nyland and his students in New York and simulation work done elsewhere suggest that lower residual densities may be appropriate in some situations, such as stands being managed with long cutting cycles. Lower residual densities may have a negative effect on stem quality. Epicormics, in particular are a concern. Work done in the Lake States suggests that residual densities around 60 percent are compatible with natural pruning on pole-size and larger stems. Density also affects regeneration established through selection system cutting. Sixty percent seems to be the appropriate residual density for most situations.


FIRST CUT OF TRANSITION

WHEN

RELATIVE DENSITY › 80%

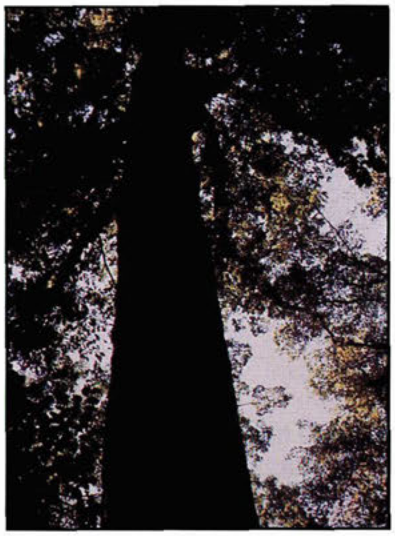
33. When the relative density of a stand to be managed under the selection system is below 80 percent, defer cutting in the stand. More than likely growth on all stems is good, mortality is low, and sufficient volume is not available for a commercial cut. But if relative density is above 80 percent, volume for a commercial cut should be adequate, and the better quality residual stems should respond to such a cut with improved growth.



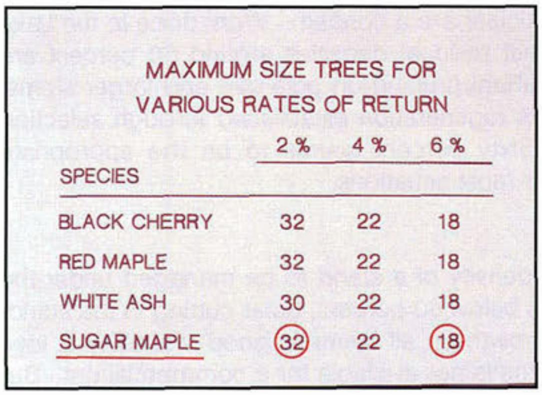
AVERAGE DENSITY
IN STANDS
WITH GROUP SELECTION:

50%

34. Density in stands managed by the group selection variant of uneven-age silviculture will average closer to 50 percent, when the zero density openings are included in a standwide average density. Most trees will grow in the same conditions as those in a 60 percent relative density single-tree selection cut stand except those on the edge of group openings.



35. The choice of maximum tree size has both visual and economic consequences. Many landowners prefer to have large trees for aesthetic reasons, and the existence of large trees does contribute to the 'natural' appearance that we associate with uneven-age management. But the decision on maximum tree size also influences economic returns from timber.



MAXIMUM SIZE TREES FOR
VARIOUS RATES OF RETURN

SPECIES	2 %	4 %	6 %
BLACK CHERRY	32	22	18
RED MAPLE	32	22	18
WHITE ASH	30	22	18
SUGAR MAPLE	32	22	18

36. For example, this rate of return information indicates that sugar maple can be grown only to 18 inches d.b.h. on good sites if a reasonably high rate of return, such as 6 percent, is desired, but that it can be grown to 32 inches d.b.h. on the same site if the owner is satisfied with a lower rate of return, such as 2 percent. The lower rate of return and larger trees that result might very well be appropriate for aesthetic reasons, and one of the model stand structures that we suggest reflects this possibility. Twenty-two inches is a better compromise where timber production is more important, and the visual effect of large trees less necessary.

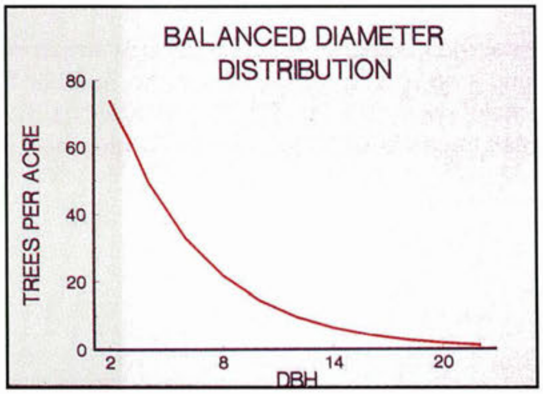
"Q" – THE QUOTIENT OR RATIO BETWEEN NUMBERS OF TREES IN SUCCESSIVE DIAMETER CLASSES.

37. The most widely accepted procedure for setting stand structure goals under selection cutting is to utilize the QUOTIENT (called 'q') between numbers of trees in successive diameter classes as a means of calculating a desired diameter distribution. Recent evidence shows that distributions other than those based on a 'q' may be advantageous under certain circumstances, but these distributions have not been fully evaluated in the forest yet. So, we will base our discussion on the quotient 'q'.

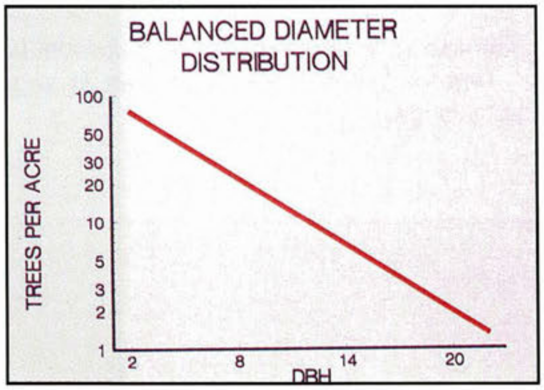
Q = 1.3

DBH	# TREES/ACRE
18	1.69
20	1.3
22	1.0

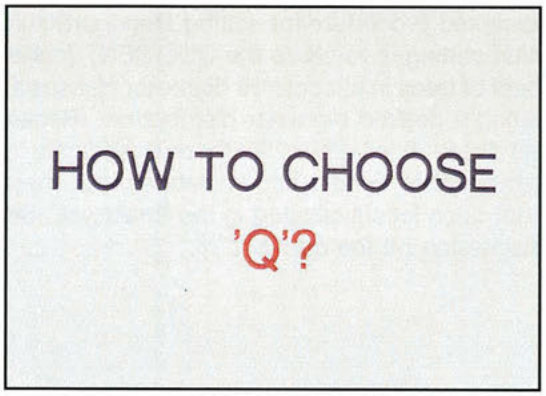
38. This stand has a 'q' of 1.3. Each diameter class has 1.3 times as many trees as the next larger diameter class. That is, if you divide the number of trees in the 20-inch class, for example, by the number of trees in the 22-inch class, the QUOTIENT would be 1.3.


BALANCED DIAMETER DISTRIBUTION

39. When the number of trees is plotted over diameter class for a stand with a 'q' distribution, the plot has a typical inverse J-shape.

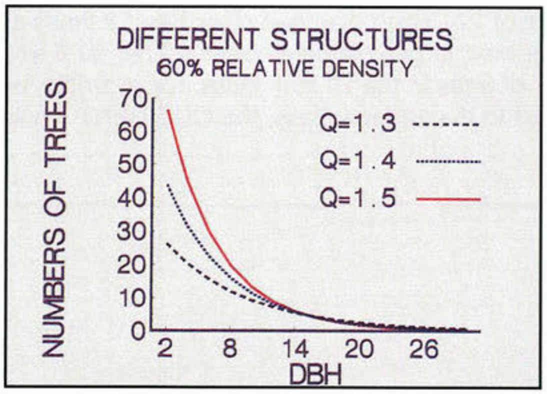

BALANCED DIAMETER DISTRIBUTION

40. Or, if the same distribution is plotted on semilog paper, the distribution follows a straight line. The distribution can be expressed mathematically by fitting a logarithmic regression to it. When this is done, the slope of the regression equation is equal to 'q'; this provides a useful method of calculating the 'q' of an actual stand. For our purposes, a 'q' for 2-inch classes is needed, but the literature contains 'q's for both 1- and 2-inch classes. The 'q' for 2-inch classes is the square of the 'q' for 1-inch classes.



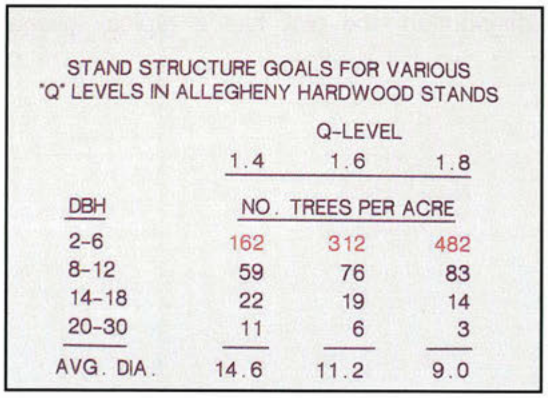
HOW TO CHOOSE
'Q'?

41. This gives some idea of what 'q' is. But what are the consequences of choosing a 'q' value?



DIFFERENT STRUCTURES
60% RELATIVE DENSITY

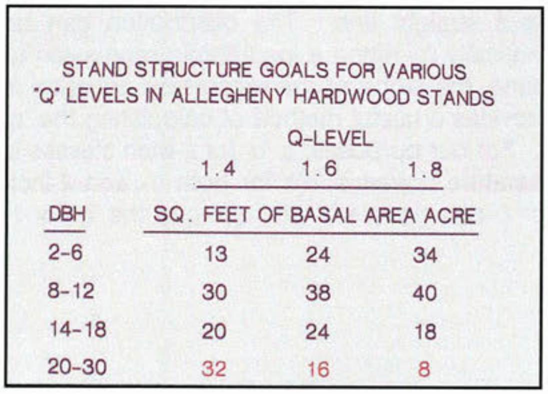
42. Quotients ranging between 1.3 and 2.0 for 2-inch classes have all been recommended for various situations. The lower the 'q', the smaller the difference in number of trees between diameter classes. Stands maintained to a low 'q' have a high proportion of the available growing space devoted to larger, more valuable trees and should theoretically produce somewhat higher sawtimber yields (not necessarily greater total volume yields) than stands maintained to a high 'q'. But maintenance of a low 'q' factor means that excess numbers of small stems that usually develop may have to be removed periodically at some expense.



STAND STRUCTURE GOALS FOR VARIOUS
'Q' LEVELS IN ALLEGHENY HARDWOOD STANDS

	Q-LEVEL		
	1.4	1.6	1.8
DBH	NO. TREES PER ACRE		
2-6	162	312	482
8-12	59	76	83
14-18	22	19	14
20-30	11	6	3
AVG. DIA.	14.6	11.2	9.0

43. For example, consider the numbers of small trees that would be maintained in a stand held at a 'q' of 1.4 versus the number in the same stand if maintained at a 'q' of 1.8. It is obvious that many additional small trees would have to be cut under the 1.4 'q'.



STAND STRUCTURE GOALS FOR VARIOUS
'Q' LEVELS IN ALLEGHENY HARDWOOD STANDS

	Q-LEVEL		
	1.4	1.6	1.8
DBH	SQ. FEET OF BASAL AREA ACRE		
2-6	13	24	34
8-12	30	38	40
14-18	20	24	18
20-30	32	16	8

44. On the other hand, compare the basal area in large sawtimber in the two stands. There is much more basal area in large sawtimber where the 'q' is low.

Optimum structure depends on:

- Product objectives
- Price structure
- Site quality

45. A great deal has been written concerning economic optimization of residual stand diameter distributions under the selection system (see "Selected References"). Several principles emerge. The optimum structure depends on what is optimized: growth of large sawtimber volume, total volume, or total value, for example. It also depends on the price structure: the value premium for large logs, for example. There is evidence that good sites can carry lower 'q's than poor sites, and that strategies are workable that allow for a slow adjustment of the 'q', over several cutting cycles, to an optimum appropriate to site and product objectives.

AIM FOR THE LOWEST 'Q'
THAT'S POSSIBLE
WITH THE EXISTING STAND

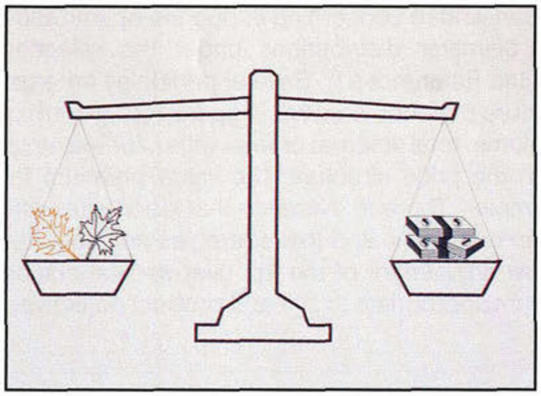
46. This strategy is the one we recommend. As we initiate uneven-age management in a stand, we shoot for the lowest 'q' that seems feasible in terms of markets and money available for cultural work in small trees. The prelogging 'q' level will also be an important factor. In younger, second-growth stands where the existing 'q' level may run over 2.0 and the number of large trees is limited, it would be unrealistic to shoot for a very low 'q'. But in older stands or in stands that have already received several cuts aimed at balancing the diameter distribution, a lower 'q' may be feasible.

ACTUAL
'Q'
MAY CHANGE
OVER TIME

47. When you use the SILVAH computer program, your choice of management goal identifies the 'q' you would like the stand to achieve in the long run. SILVAH automatically adjusts that 'q' during the transition cuts. The actual residual "q" during the period when a stand is first being brought under management may be somewhat higher than the goal 'q' factor. Then you can gradually work toward a smaller 'q' in successive cuts, a process that occurs automatically in the SILVAH computer program.

SILVAH ADJUSTS 'Q'
GOALS TO EXISTING
STANDS

48. That is, with SILVAH, the 'q' of your residual stand reflects a balance between the 'q' of the present stand and the 'q' of the structural goal you have selected. Your structural goal should reflect the visual or aesthetic preferences of management, and will define the target 'q' that SILVAH works towards. But the target will always be modified by the reality of the existing stand, and if you want a stand with many large trees in the long run, but have very few large trees now, SILVAH will adjust accordingly. The distribution of cut practices for manual application of the selection system will achieve this balancing, as well.



49. Although the number of combinations of different maximum tree sizes, residual relative densities, and diameter distributions or 'q' factors is virtually infinite, the final choice of stand structure is really a balancing act between the value of the timber produced and the aesthetic qualities of the managed stand. We have developed two 'prototype' stands from among all these combinations. You are welcome to 'fine tune' your own ideal stand structure, but one of these prototype stands will suffice for the vast majority of situations.

MANAGEMENT GOAL = 3,4

⇩

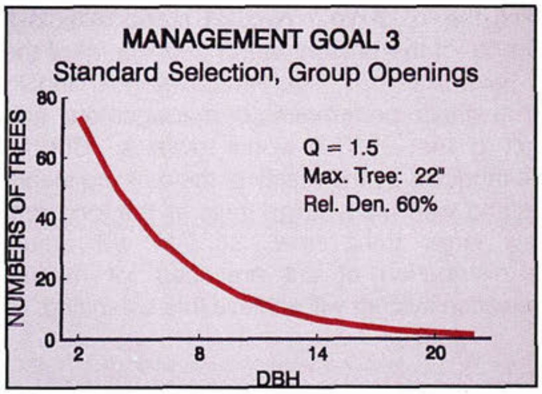
UNEVEN-AGE MANAGEMENT

50. We distinguish between these two stand structures by the management goal associated with each stand. When a landowner specifies a management goal of 3 or 4, even-aged regeneration cuttings of any kind are ruled out for that property.

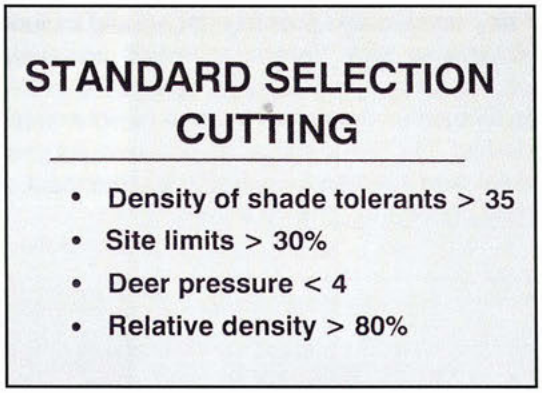
STANDARD SELECTION CUTTING

- **Density of shade tolerants > 35**
- **Management goal = 3**
- **Deer pressure < 4**
- **Relative density > 80%**

51. If the management goal is coded as 3, extremely large trees are not required and maximum timber production possible from uneven-age management is desired. If the target stand also has at least 35 square feet of shade tolerant species to provide seed for new age classes, is under low to medium deer pressure, and has a current relative density that exceeds 80 percent, this goal leads to our standard selection cutting prescription of single-tree and group selection cutting combined.



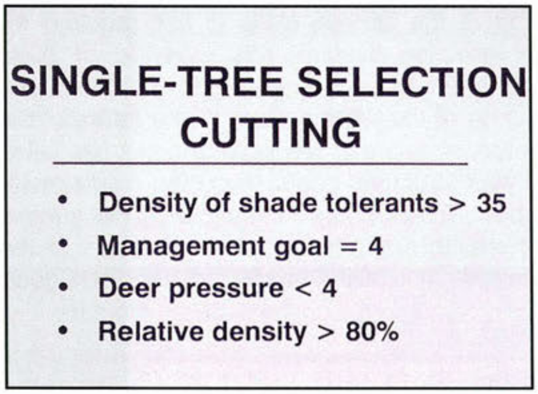
52. The type of residual structure called for by this prescription is illustrated here. A 22-inch maximum tree size is selected as a compromise between desired visual characteristics and timber production, and a 'q' of 1.5 is also selected as a target. Although the single-tree selection between openings will aim for a residual relative density of the traditional 60 percent, the stand average residual density will be closer to 50 percent because of the openings created where whole groups of trees are removed.



STANDARD SELECTION CUTTING

- **Density of shade tolerants > 35**
- **Site limits > 30%**
- **Deer pressure < 4**
- **Relative density > 80%**

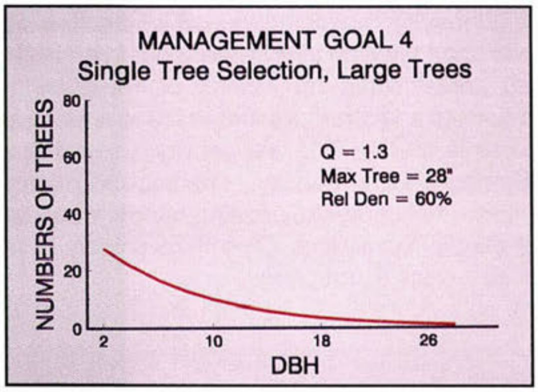
53. This prescription may also be appropriate in stands with site limits detected on over 30 percent of the regeneration inventory plots, depending on management goal. Because continuous overstory cover is maintained, regeneration is never exposed to the drying out of surface soil or the raising of the water table that may occur on some harsh sites after even-aged removals. Here, too, this cutting will only be prescribed if deer pressure is low to medium, if there is a "critical mass" of shade tolerant species, and if the current relative density exceeds 80 percent.



SINGLE-TREE SELECTION CUTTING

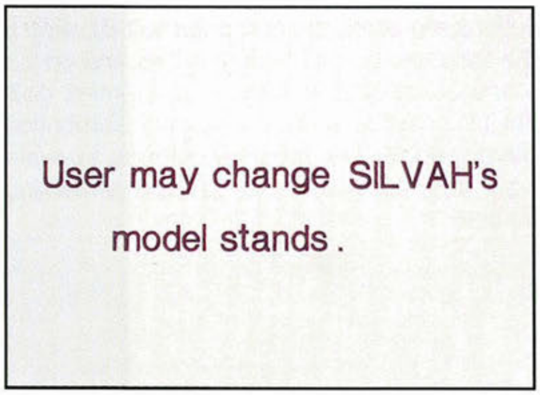
- **Density of shade tolerants > 35**
- **Management goal = 4**
- **Deer pressure < 4**
- **Relative density > 80%**

54. If the management goal is 4, the appearance of a forest of large trees is the primary management concern, and all cutting must help maintain a stand structure that fits that objective. If, in addition to that management goal, a stand has the critical mass of shade tolerant species, is under low to medium deer pressure, and has a current relative density in excess of 80 percent, SILVAH will prescribe strict single-tree selection with a large maximum tree size and low target 'q'.



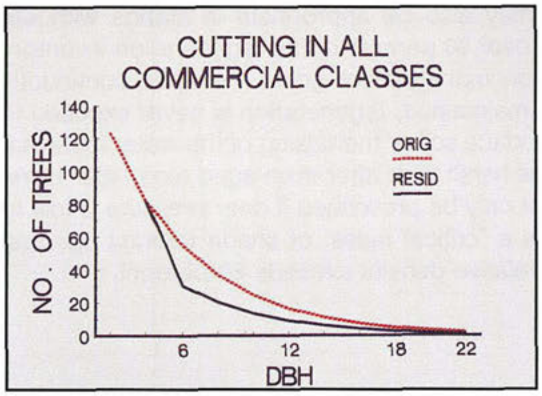
MANAGEMENT GOAL 4
Single Tree Selection, Large Trees

55. This is the target stand for management goal 4. The maximum tree size is 28 inches, the 'q' is 1.3, and the residual relative density is 60 percent. If the 'q' factor of the present stand is appreciably higher than 1.3, SILVAH will adjust the 'q' of the residual for this cut and work toward 1.3 in future cuts.



User may change SILVAH's model stands.

56. These are the basic prescriptions with which SILVAH works. If you are using the computerized version of SILVAH, you may alter the variables that determine the structural goals toward which SILVAH will work. Specifically, you may change the maximum tree size, the 'q,' or the residual relative density for an uneven-age prescription, and SILVAH will do the rest. You may also do these things by hand.


CUTTING IN ALL COMMERCIAL CLASSES

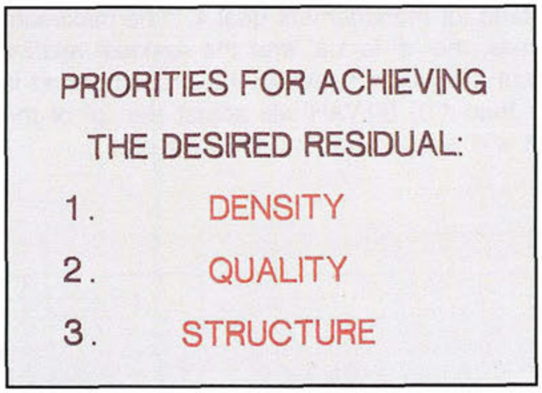
57. The application of any uneven-age prescription should include cutting in all merchantable size classes to avoid unwanted changes in structure. In general, the saplings can be left to thin themselves or to be thinned as they grow into the merchantable size classes. If you find that the saplings greatly exceed your ultimate structural goal, and if money is available for treatment of these stems, you may choose to remove some.


MONITOR

SAPLINGS AND REGENERATION

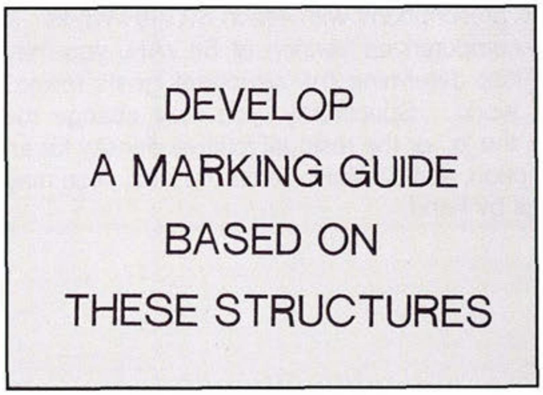
CAREFULLY !

58. Even though cutting in the sapling class is not required for application of the selection system, this class is of great importance. It must be included in any inventory of the stand, because the population of the sapling class IS the future of the stand. When inventory shows that the sapling class has fallen below the levels of your structural goals, the stand may already be in serious trouble. Researchers in Indiana found such a deficiency in stand structure appearing within 16 years of the initiation of selection system in mixed hardwood stands on good sites.


PRIORITIES FOR ACHIEVING THE DESIRED RESIDUAL:

1. DENSITY
2. QUALITY
3. STRUCTURE

59. The basic principles underlying the distribution of a selection cut are the same as those underlying an intermediate cut in an even-age system. Trees are selected for cutting or retention to achieve the desired density and structure and to leave a residual stand of the best possible quality. The first priority is to achieve the desired residual relative stand density. The second priority is to remove as many unacceptable growing stock trees as possible within that density constraint. The third priority is to achieve the desired size-class distribution.


DEVELOP

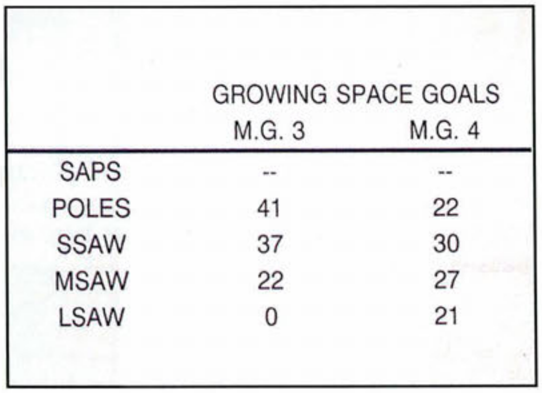
A MARKING GUIDE

BASED ON

THESE STRUCTURES

60. If computer prescriptions are used, the computer will develop a marking guide for the stand based on these priorities and on the residual stand structure associated with the management goal that was chosen. But it is possible to use the manual distribution of cut procedure developed for intermediate cuttings in even-aged stands with very little modification to develop a marking guide for a selection cut.

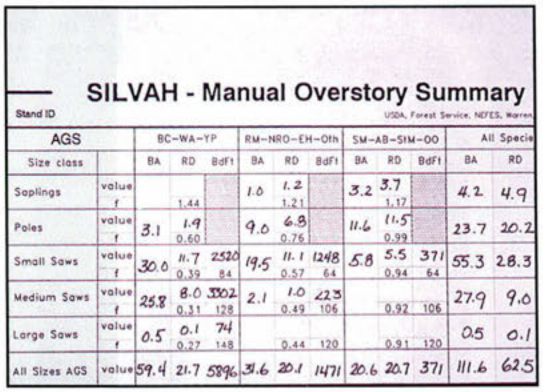
61. Now we review the underlying concepts of a selection cut. Once the basic residual stand structure for the uneven-age management plan has been selected, and the stand has been cruised, we are ready to plan a specific selection cut. We know the structure of the present stand, and the structural goal for the stand. The purpose of the selection cut is to bring the stand closer to that goal, while improving stand quality and maintaining adequate density on the site. This means removing trees that are in excess of the structural goal, except where needed to balance deficiencies, or to improve the overall quality of the stand.



GROWING SPACE GOALS

	M.G. 3	M.G. 4
SAPS	--	--
POLES	41	22
SSAW	37	30
MSAW	22	27
LSAW	0	21

62. Background for the procedures about to be described is given in earlier articles: "Stand Data Summary and Analysis" and "Distribution of Cut." We have characterized the target stand structures by the proportion of the relative density in each of the merchantable size classes. Those are the numbers shown here. For example, in a stand for which we have prescribed a standard selection cut, with a 'q' of 1.5 and a maximum tree size of 22 inches, we would like the relative density of the pole class to be 41 percent of the merchantable residual density. This proportional relationship among the size classes should be the same in any stand with that structural goal.



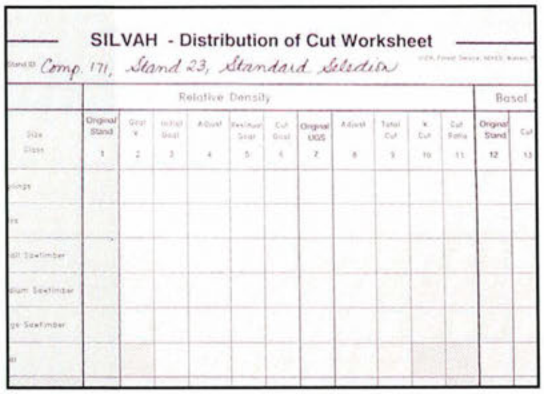
SILVAH - Manual Overstory Summary

Stand ID

USDA, Forest Service, NEFES, Warren

AGS		BC-WA-YP			RM-NRO-EH-Oth			SM-AB-StM-OO			All Specie	
Size class		BA	RD	BdFt	BA	RD	BdFt	BA	RD	BdFt	BA	RD
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			0.76			0.99			
Small Saws	value	30.0	11.7	2520	19.5	11.1	1248	5.8	5.5	371	55.3	28.3
	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
	f		0.31	128		0.49	106		0.92	106		
Large Saws	value	0.5	0.1	74							0.5	0.1
	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

63. Turn to Appendix A as we review the the mechanics of manually planning a selection cut for a stand with a management goal of 3, timber production with continuous high forest cover and some large trees. As with thinning, the first step in distributing a selection cut is to transfer basic stand data from the Manual Overstory Summary forms



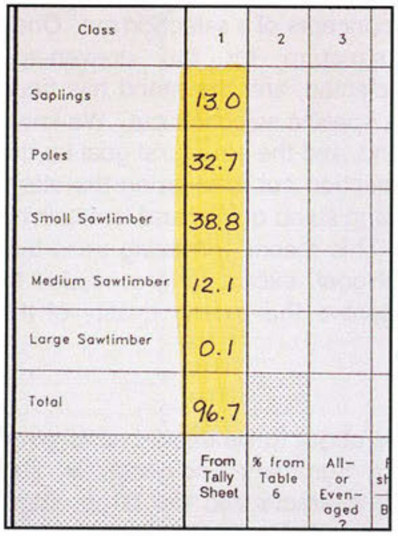
SILVAH - Distribution of Cut Worksheet

Comp. 171, Stand 23, Standard Selection

Relative Density

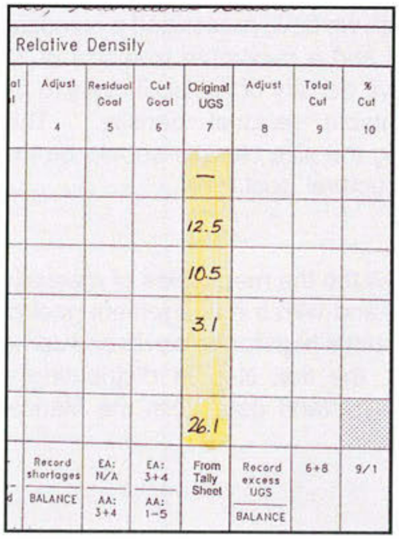
Basal

64. to the Distribution of Cut Worksheet.



Class	1	2	3
Saplings	13.0		
Poles	32.7		
Small Sawtimber	38.8		
Medium Sawtimber	12.1		
Large Sawtimber	0.1		
Total	96.7		
	From Tally Sheet	% from Table 6	All- or Even-aged ?

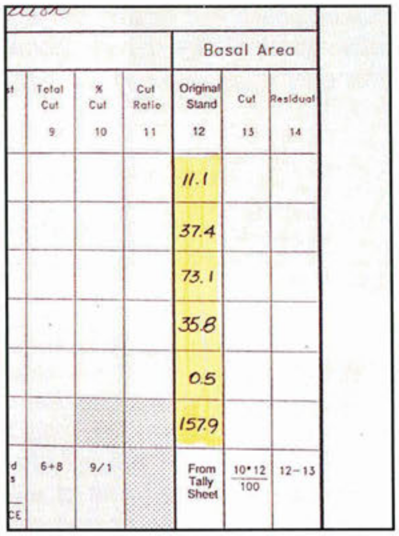
65. Relative stand density is transferred to column 1.



Relative Density

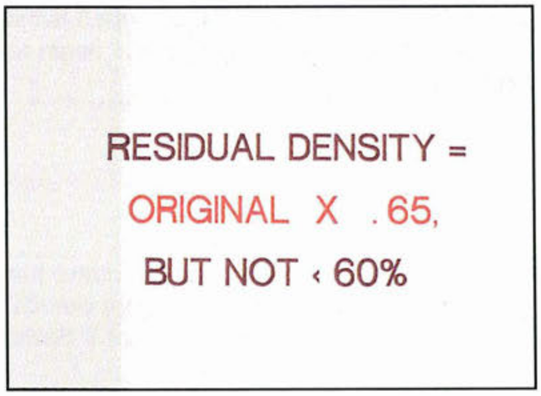
Adjust 4	Residual Goal 5	Cut Goal 6	Original UGS 7	Adjust 8	Total Cut 9	% Cut 10
			—			
			12.5			
			10.5			
			3.1			
			26.1			
Record shortages BALANCE	EA: N/A AA: 3+4	EA: 3+4 AA: 1-5	From Tally Sheet	Record excess UGS BALANCE	6+8	9/1

66. Relative density for UGS only is transferred to column 7. Note that we do not transfer the UGS value for the sapling class, since we will not cut saplings. And the total we record is the total for the merchantable classes.



				Basal Area		
t	Total Cut 9	% Cut 10	Cut Ratio 11	Original Stand 12	Cut 13	Residual 14
				11.1		
				37.4		
				73.1		
				35.8		
				0.5		
				157.9		
d s CE	6+8	9/1		From Tally Sheet	$\frac{10 \cdot 12}{100}$	12−13

67. Basal area for the total stand is transferred to column 12.

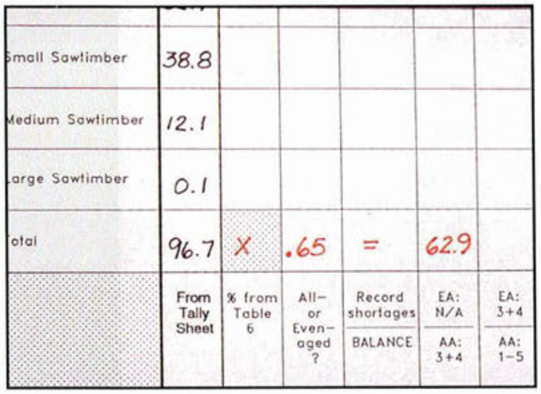


RESIDUAL DENSITY =

ORIGINAL X .65,

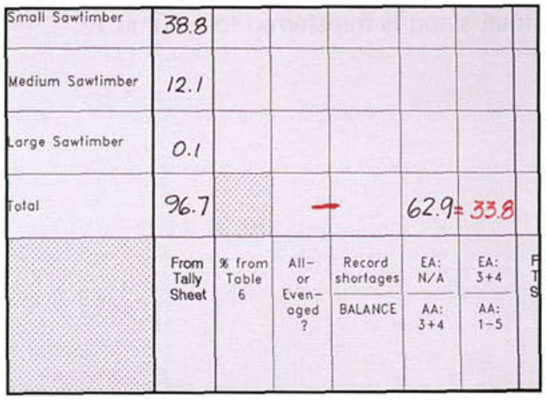
BUT NOT < 60%

68. The desired residual relative density is the relative density of the original stand times 0.65, but not less than 60 percent.



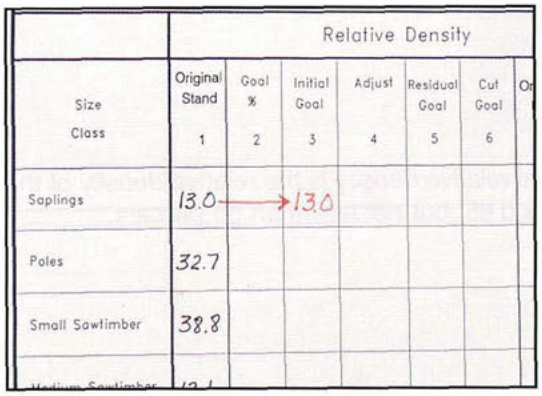
Small Sawtimber	38.8					
Medium Sawtimber	12.1					
Large Sawtimber	0.1					
Total	96.7	X	.65	=	62.9	
	From Tally Sheet	% from Table 6	All- or Even-aged ?	Record shortages BALANCE	EA: N/A AA: 3+4	EA: 3+4 AA: 1−5

69. Record this value in the total row of column 5.



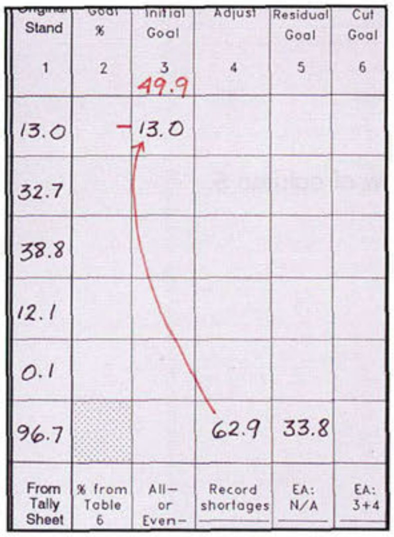
Small Sawtimber	38.8						
Medium Sawtimber	12.1						
Large Sawtimber	0.1						
Total	96.7			−	62.9	= 33.8	
	From Tally Sheet	% from Table 6	All- or Even-aged ?	Record shortages BALANCE	EA: N/A AA: 3+4	EA: 3+4 AA: 1-5	

70. The relative density to be cut is the original stand relative density (total, column 1) minus the residual stand relative density (total, column 5); record this as the cut goal (column 6) in the total row.



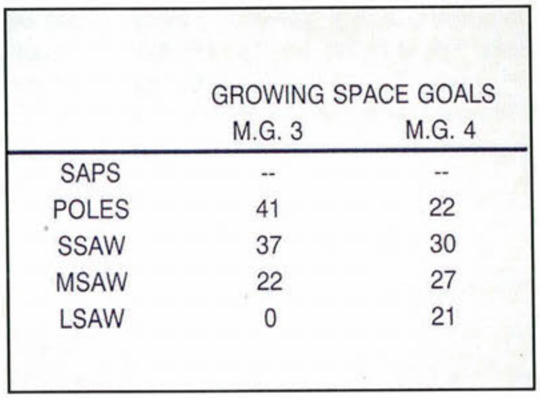
Size Class	Relative Density						
	Original Stand 1	Goal % 2	Initial Goal 3	Adjust 4	Residual Goal 5	Cut Goal 6	
Saplings	13.0 →		13.0				
Poles	32.7						
Small Sawtimber	38.8						

71. We now know the total residual relative density that we would like to have. Because we are not working in the saplings, the entire cut must come from the merchantable sizes. All of the saplings will remain in our residual stand. So, we record the relative density of the sapling class in the sapling row in column 3, just transferring it from column 1. Notice that column 3 is the residual stand, the inverse J-shaped structure that will begin to create a self-sustaining unit.



Stand 1	% 2	Goal 3 49.9	4	Residual Goal 5	Cut Goal 6
13.0		− 13.0			
32.7					
38.8					
12.1					
0.1					
96.7			62.9	33.8	
From Tally Sheet	% from Table 6	All- or Even-	Record shortages	EA: N/A	EA: 3+4

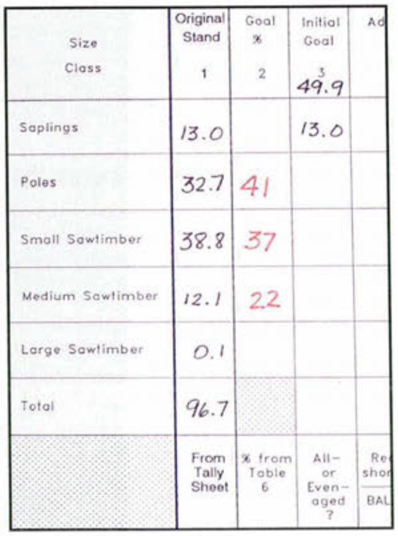
72. To find the residual in the merchantable sizes, we subtract the sapling relative density from the residual stand relative density (total, column 5 minus sapling row, column 3), and jot it down above column 3.



GROWING SPACE GOALS

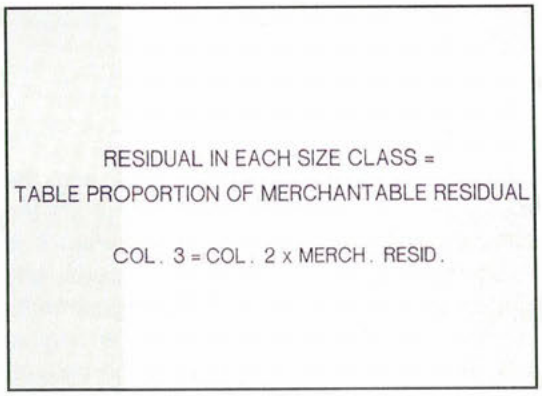
	M.G. 3	M.G. 4
SAPS	--	--
POLES	41	22
SSAW	37	30
MSAW	22	27
LSAW	0	21

73. Use the table in Appendix B to fill in the desired residual structure. Choose the structure appropriate to the prescription. With a management goal of 3, we refer to the line for a Standard Selection Cut. These percentages are 41 percent in the pole class, 37 percent in the small sawtimber class, and 22 percent in the medium sawtimber class. For uneven-age silviculture, these numbers are percentages of the merchantable residual that will be left in each size class. The percentages in the top of this table, for even-aged silviculture, are percentages of the cut.



Size Class	Original Stand 1	Goal % 2	Initial Goal 3 49.9	Ad
Saplings	13.0		13.0	
Poles	32.7	41		
Small Sawtimber	38.8	37		
Medium Sawtimber	12.1	22		
Large Sawtimber	0.1			
Total	96.7			
	From Tally Sheet	% from Table 6	All- or Even-aged ?	Re sho BAL

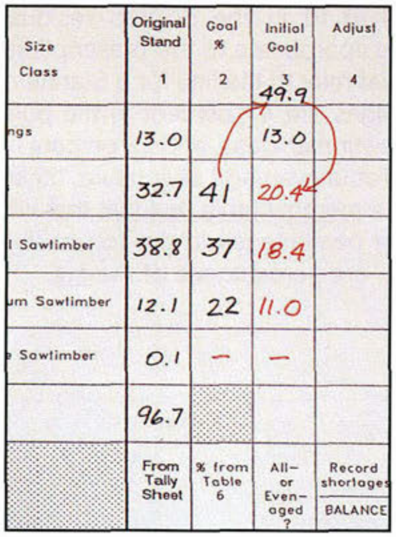
74. Record these values in column 2.



RESIDUAL IN EACH SIZE CLASS =
TABLE PROPORTION OF MERCHANTABLE RESIDUAL

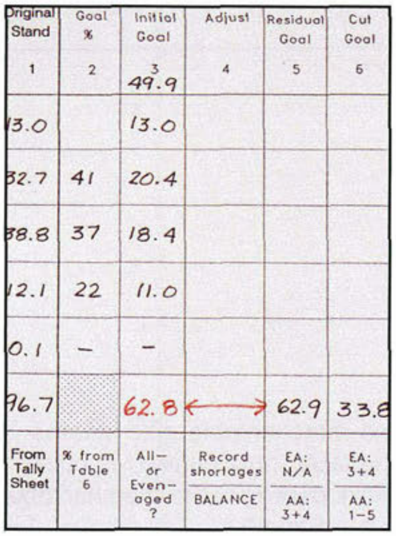
COL. 3 = COL. 2 x MERCH. RESID.

75. The residual goal in each of the merchantable size classes is equal to the percentage from the table, now entered in column 2, times the desired residual relative density in the merchantable classes, the number jotted above column 3.



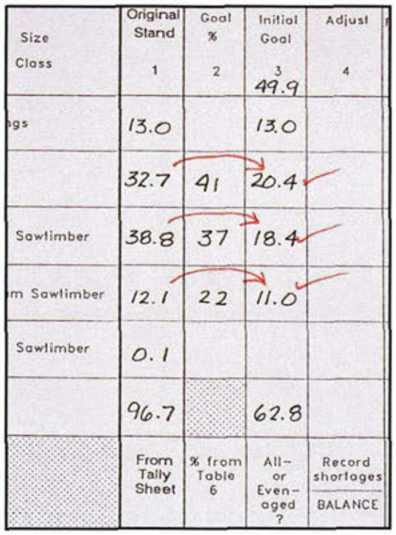
Size Class	Original Stand 1	Goal % 2	Initial Goal 3 49.9	Adjust 4
ngs	13.0		13.0	
	32.7	41	20.4	
l Sawtimber	38.8	37	18.4	
um Sawtimber	12.1	22	11.0	
Sawtimber	0.1	—	—	
	96.7			
	From Tally Sheet	% from Table 6	All- or Even-aged ?	Record shortages BALANCE

76. Enter these values in column 3. For this stand, these values are [20.4] in the pole class, [18.4] in the small sawtimber class, and [11.0] in the medium sawtimber class. The note below column 3 reminds you that these numbers are calculated differently for uneven- and even-aged cuts.



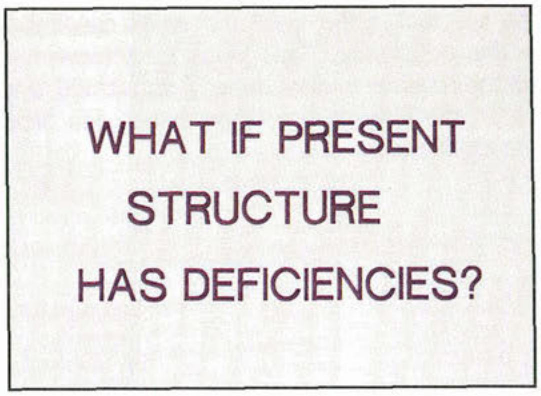
riginal Stand 1	Goal % 2	Initial Goal 3 49.9	Adjust 4	Residual Goal 5	Cut Goal 6
13.0		13.0			
32.7	41	20.4			
38.8	37	18.4			
12.1	22	11.0			
0.1	—	—			
96.7		62.8 ←	→	62.9	33.8
From Tally Sheet	% from Table 6	All- or Even-aged ?	Record shortages BALANCE	EA: N/A AA: 3+4	EA: 3+4 AA: 1–5

77. Sum column 3 and check to see that its total is the same as that in Column 5, within rounding error.



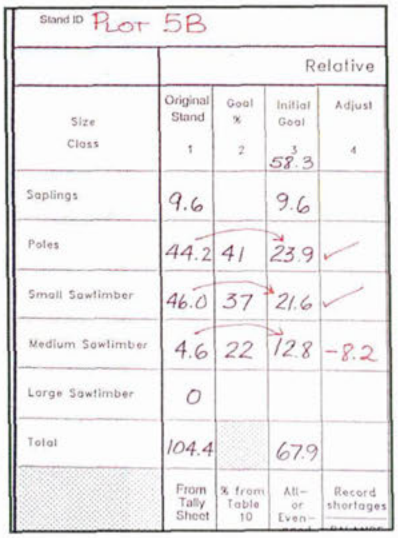
Size Class	Original Stand 1	Goal % 2	Initial Goal 3 49.9	Adjust 4
gs	13.0		13.0	
	32.7	41	20.4	✓
Sawtimber	38.8	37	18.4	✓
m Sawtimber	12.1	22	11.0	✓
Sawtimber	0.1			
	96.7		62.8	
	From Tally Sheet	% from Table 6	All- or Even-aged ?	Record shortages BALANCE

78. Differences between the original stand in column 1 and the desired residual values you have just written in column 3 are the excesses and deficiencies of the stand distribution when it is compared to the desired stand structure. Record any DEFICIENCIES, or negative values, in column 4. No adjustments are required in the sample stand. This means that the original stand structure has no deficiencies compared with the desired residual stand structure.



WHAT IF PRESENT STRUCTURE HAS DEFICIENCIES?

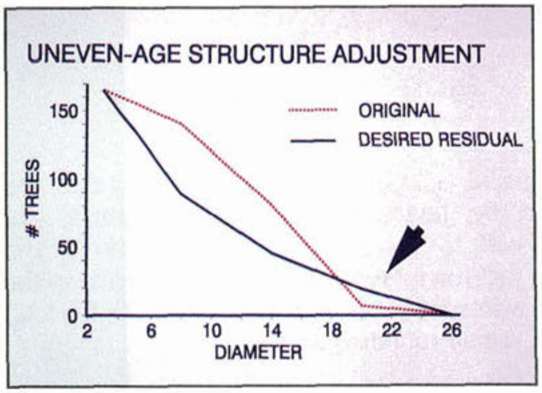
79. For many stands in this transition period from even- to uneven-age management, however, there will be deficiencies, particularly in the sawtimber classes. So we will look at the adjustment procedure--and its meaning--in a stand in that transition.



Stand ID Plot 5B

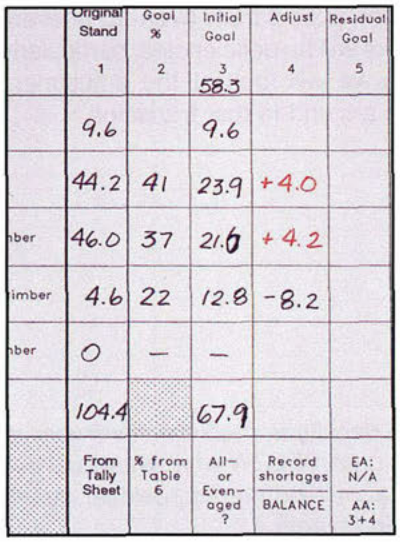
	Relative			
Size Class	Original Stand 1	Goal % 2	Initial Goal 3 58.3	Adjust 4
Saplings	9.6		9.6	
Poles	44.2	41	23.9	✓
Small Sawtimber	46.0	37	21.6	✓
Medium Sawtimber	4.6	22	12.8	-8.2
Large Sawtimber	0			
Total	104.4		67.9	
	From Tally Sheet	% from Table 10	All- or Even-	Record shortages

80. The original or existing relative density in medium sawtimber in this stand is 8.2 relative density units BELOW what we would like to leave in that size class in a well-structured residual stand. This is shown by the negative in column 4.



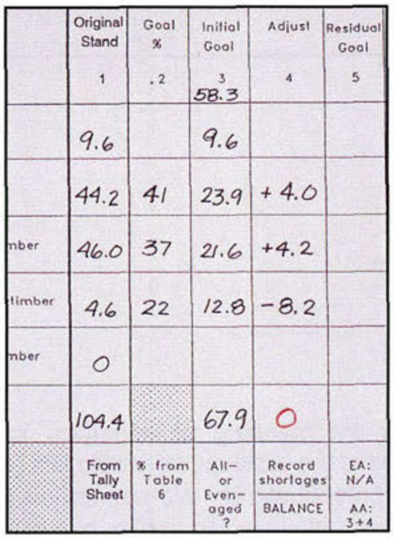
UNEVEN-AGE STRUCTURE ADJUSTMENT

81. This graph helps us visualize the meaning of negatives, or deficiencies. The dotted red line is the residual we would like to leave and the black line is the present stand. We cannot leave the amount of medium sawtimber that we would like to, because it is not there.



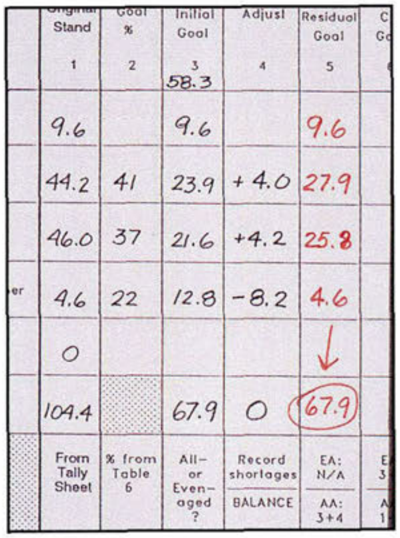
	Original Stand	Goal %	Initial Goal	Adjust	Residual Goal
	1	2	3 58.3	4	5
	9.6		9.6		
	44.2	41	23.9	+4.0	
ber	46.0	37	21.6	+ 4.2	
imber	4.6	22	12.8	-8.2	
ber	0	—	—		
	104.4		67.9		
	From Tally Sheet	% from Table 6	All- or Even- aged ?	Record shortages BALANCE	EA: N/A AA: 3+4

82. So, we increase the residual in the pole and small sawtimber classes to balance this deficiency. This helps to achieve two objectives: we keep the residual relative density we wanted, and we provide "excess" in the smaller size classes that can grow faster and "fill in" the deficiency.



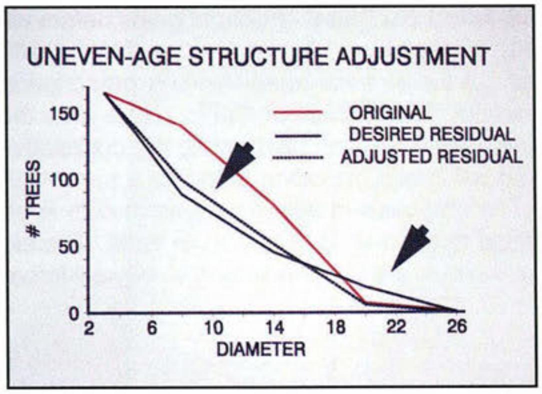
	Original Stand	Goal %	Initial Goal	Adjust	Residual Goal
	1	.2	3 58.3	4	5
	9.6		9.6		
	44.2	41	23.9	+ 4.0	
nber	46.0	37	21.6	+4.2	
timber	4.6	22	12.8	-8.2	
nber	0				
	104.4		67.9	0	
	From Tally Sheet	% from Table 6	All- or Even- aged ?	Record shortages BALANCE	EA: N/A AA: 3+4

83. Be sure that your excesses balance your deficiency. That means that the sum of column 4, with its pluses and minuses, should be zero.

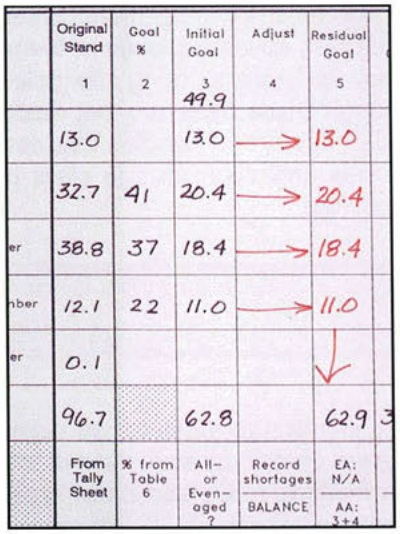


	Original Stand	Goal %	Initial Goal	Adjust	Residual Goal	C Gc
	1	2	3 58.3	4	5	
	9.6		9.6		9.6	
	44.2	41	23.9	+ 4.0	27.9	
	46.0	37	21.6	+4.2	25.8	
er	4.6	22	12.8	-8.2	4.6	
	0				↓	
	104.4		67.9	0	67.9	
	From Tally Sheet	% from Table 6	All- or Even- aged ?	Record shortages BALANCE	EA: N/A AA: 3+4	E 3 A 1

84. Column 5 is the adjusted residual goal. Since column 4 contains your corrections to the theoretical residual in column 3, you calculate the adjusted residual by summing column 3 and column 4. Be sure that the total of column 5 is still equal to the relative density you wanted to leave, already recorded in the total row of that column, within rounding error.

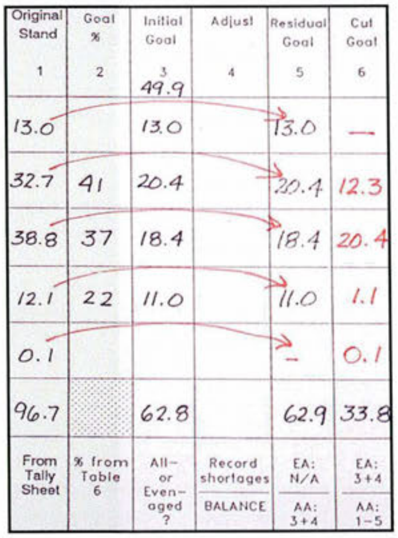


85. What have we done to the stand and to our cut? We have purposely created excesses in the classes immediately below the existing deficiency that can grow and result in a smoother, more desirably structured stand the next time around.



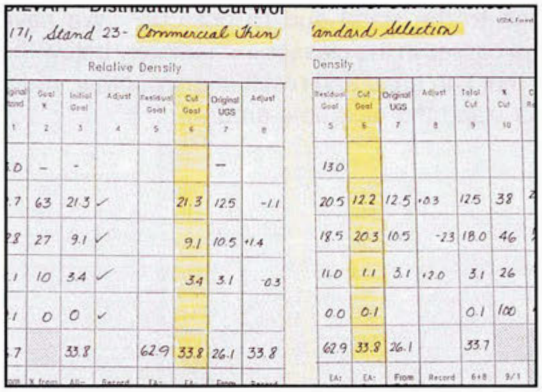
	Original Stand 1	Goal % 2	Initial Goal 3 49.9	Adjust 4	Residual Goal 5	
	13.0		13.0	→	13.0	
	32.7	41	20.4	→	20.4	
er	38.8	37	18.4	→	18.4	
nber	12.1	22	11.0	→	11.0	
er	0.1				↓	
	96.7		62.8		62.9	3
	From Tally Sheet	% from Table 6	All- or Even-aged ?	Record shortages BALANCE	EA: N/A AA: 3+4	

86. Now we shift back to the sample stand, which had no adjustments, and copy the desired residual from column 3 to column 5.



Original Stand 1	Goal % 2	Initial Goal 3 49.9	Adjust 4	Residual Goal 5	Cut Goal 6
13.0		13.0		13.0	—
32.7	41	20.4		20.4	12.3
38.8	37	18.4		18.4	20.4
12.1	22	11.0		11.0	1.1
0.1				-	0.1
96.7		62.8		62.9	33.8
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

87. The cut goal, in column 6, is the present stand minus the desired residual, or column 1 minus column 5.



Distribution of Cut Wor

171, Stand 23- Commercial Thin

Relative Density

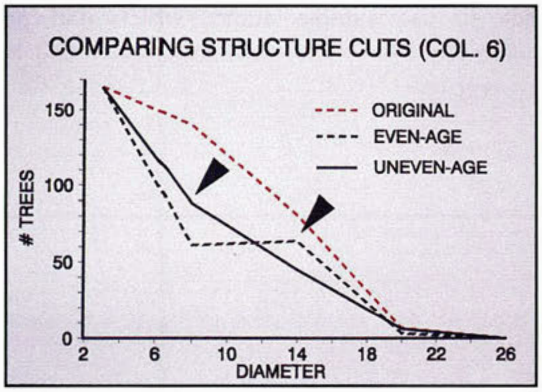
ginal tand 1	Goal % 2	Initial Goal 3	Adjust 4	Residual Goal 5	Cut Goal 6	Original UGS 7	Adjust 8
.0	–	-				—	
.7	63	21.3	✓		21.3	12.5	-1.1
8	27	9.1	✓		9.1	10.5	+1.4
.1	10	3.4	✓		3.4	3.1	-0.3
.1	0	0	✓				
.7		33.8		62.9	33.8	26.1	33.8

andard Selection

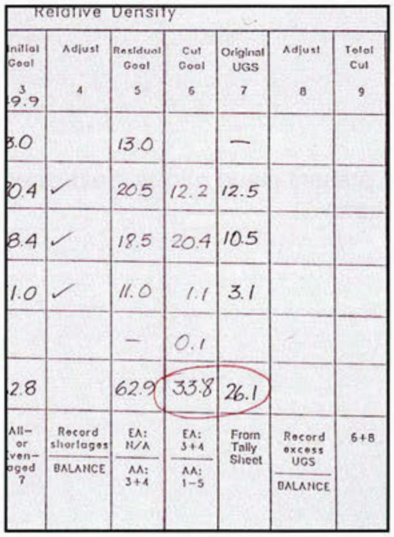
Density

Residual Goal 5	Cut Goal 6	Original UGS 7	Adjust 8	Total Cut 9	% Cut 10
13.0					
20.5	12.2	12.5	+0.3	12.5	38
18.5	20.3	10.5	-2.3	18.0	46
11.0	1.1	3.1	+2.0	3.1	26
0.0	0.1			0.1	100
62.9	33.8	26.1		33.7	
EA:	EA:	From	Record	6+8	9/1

88. The cuts in column 6 reflect our "pure" structural goals before we correct for the quality of the stand. Now compare this cut with the "pure" structural cut for an even-aged thinning prescription (described in the article "Distribution of Cut"). Note that the emphasis in planning a thinning is on distributing the cut relative density in a way that will move the stand along to a more bell-shaped structure. The emphasis in selection system cuts is on structuring the residual to the J-shaped curve we want. The big differences between the cuts are in the pole and small sawtimber size classes.



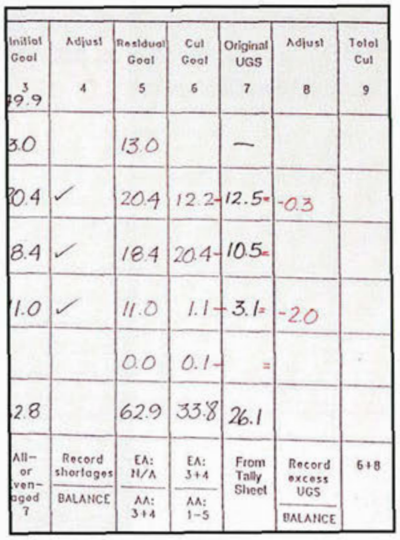
89. The principal value and volume in even-age management comes from the trees that are already largest, so we cut fewer of them. But in uneven-age management we want to bring the poles through to maturity. Even though these trees are not really younger in our transition stands, they are of species that can substitute for a younger age class until such an age class is developed over several cutting cycles.



Relative Density

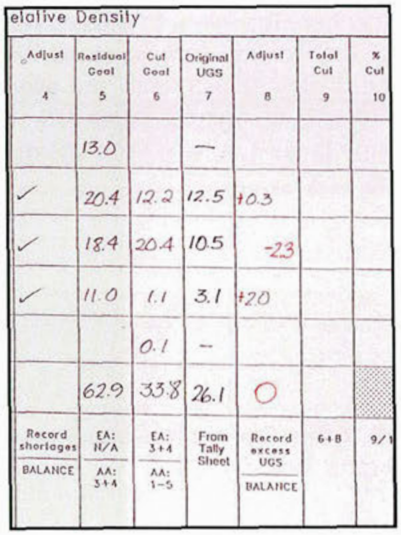
nitial Goal 3	Adjust 4	Residual Goal 5	Cut Goal 6	Original UGS 7	Adjust 8	Total Cut 9
9.9						
.0		13.0		—		
0.4	✓	20.5	12.2	12.5		
8.4	✓	18.5	20.4	10.5		
1.0	✓	11.0	1.1	3.1		
		–	0.1			
2.8		62.9	33.8	26.1		
All- or ven- aged 7	Record shortages BALANCE	EA: N/A AA: 3+4	EA: 3+4 AA: 1–5	From Tally Sheet	Record excess UGS BALANCE	6+8

90. The calculations that remain are identical to those for an even-age cut. We adjust the cut for tree quality, by size class in the stand, then translate the cut to marking ratios and basal area. Be sure that you do not have more merchantable UGS than you can remove in the first cut, by comparing the total of column 7 to the total of column 6.



Initial Goal 3 9.9	Adjust 4	Residual Goal 5	Cut Goal 6	Original UGS 7	Adjust 8	Total Cut 9
3.0		13.0		—		
0.4	✓	20.4	12.2 -	12.5 =	-0.3	
8.4	✓	18.4	20.4 -	10.5 =		
1.0	✓	11.0	1.1 -	3.1 =	-2.0	
		0.0	0.1 -	=		
2.8		62.9	33.8	26.1		
All– or ven– aged 7	Record shortages BALANCE	EA: N/A AA: 3+4	EA: 3+4 AA: 1–5	From Tally Sheet	Record excess UGS BALANCE	6+8

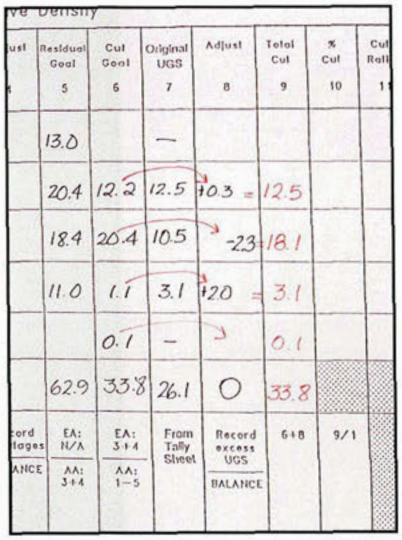
91. In this stand, the total merchantable UGS is less than our cut, so we can make an adjustment to remove all of it. We begin by subtracting column 7 from column 6 and recording negatives, or "UGS being left" in column 8.



elative Density

Adjust 4	Residual Goal 5	Cut Goal 6	Original UGS 7	Adjust 8	Total Cut 9	% Cut 10
	13.0		—			
✓	20.4	12.2	12.5	+0.3		
✓	18.4	20.4	10.5	-2.3		
✓	11.0	1.1	3.1	+2.0		
		0.1	--			
	62.9	33.8	26.1	0		▨
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

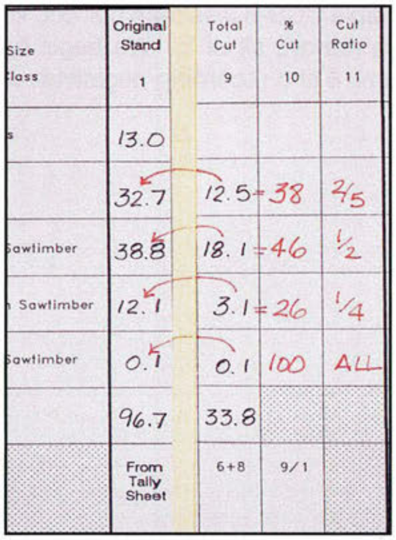
92. We would like to increase the cut in UGS by enough to remove the excesses if we can, so we reverse the sign of these numbers. Then we reduce the cut in classes where the cut (column 6) exceeds the UGS (column 7). Be sure that any adjustment you do make is balanced; that is, that your final values in column 8 sum to zero.



ve Density

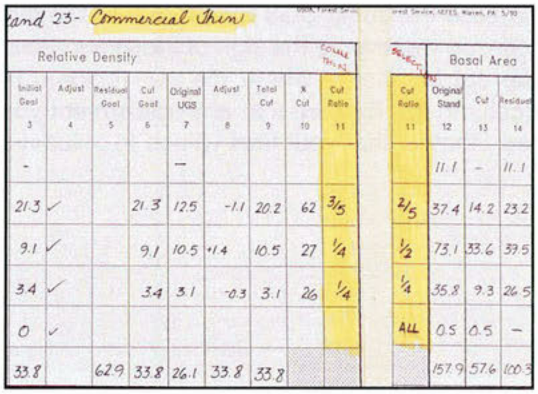
ust	Residual Goal 5	Cut Goal 6	Original UGS 7	Adjust 8	Total Cut 9	% Cut 10	Cut Rati 1
	13.0		—				
	20.4	12.2	12.5	+0.3 =	12.5		
	18.4	20.4	10.5	-2.3 =	18.1		
	11.0	1.1	3.1	+2.0 =	3.1		
		0.1	—		0.1		
	62.9	33.8	26.1	0	33.8	▨	▨
ord tages ANCE	EA: N/A AA: 3+4	EA: 3+4 AA: 1–5	From Tally Sheet	Record excess UGS BALANCE	6+8	9/1	▨

93. The final total cut, column 9, is column 6 plus column 8, or your structural cut plus any quality adjustments. Always check to be sure that this cut does sum to the relative density that you wanted to cut (total row, column 6) after the adjustments.



ize lass	Original Stand 1	Total Cut 9	% Cut 10	Cut Ratio 11
s	13.0			
	32.7	12.5 ÷	38	2/5
awtimber	38.8	18.1 ÷	46	1/2
Sawtimber	12.1	3.1 ÷	26	1/4
awtimber	0.1	0.1	100	ALL
	96.7	33.8		
	From Tally Sheet	6+8	9/1	

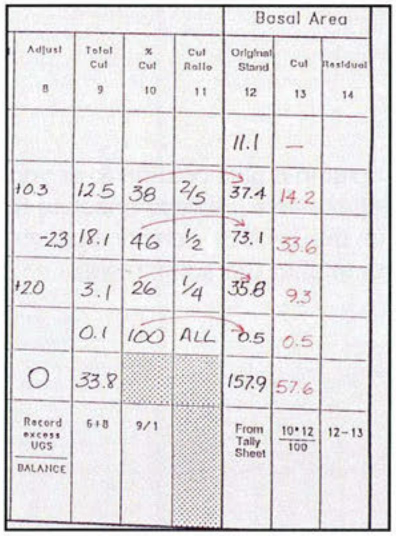
94. Column 10, the percentage cut, is equal to column 9 divided by column 1 times 100, and column 11, the Cut Ratio, is just this percentage translated to an easy-to-remember ratio.



and 23- Commercial Thin

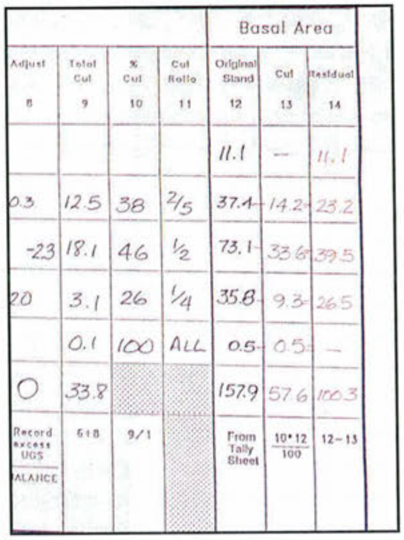
Relative Density								COMMERCIAL THIN	SELECTION	Basal Area		
Initial Goal 3	Adjust 4	Residual Goal 5	Cut Goal 6	Original UGS 7	Adjust 8	Total Cut 9	% Cut 10	Cut Ratio 11	Cut Ratio 11	Original Stand 12	Cut 13	Residual 14
-				—						11.1	–	11.1
21.3	✓		21.3	12.5	-1.1	20.2	62	3/5	2/5	37.4	14.2	23.2
9.1	✓		9.1	10.5	+1.4	10.5	27	1/4	1/2	73.1	33.6	39.5
3.4	✓		3.4	3.1	-0.3	3.1	26	1/4	1/4	35.8	9.3	26.5
0	✓								ALL	0.5	0.5	–
33.8		62.9	33.8	26.1	33.8	33.8				157.9	57.6	100.3

95. This is another opportunity to compare the even- to the uneven-age prescription. You can see that for the sample stand, the comparison still stands after the quality adjustment: the even-age cut takes 3/5 poles, while the uneven-age cut takes 2/5. In the small sawtimber, the even-age takes 1/4, while the uneven-age takes 1/2.



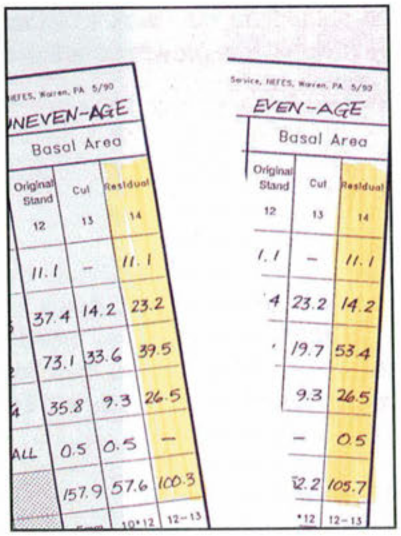
				Basal Area		
Adjust 8	Total Cut 9	% Cut 10	Cut Ratio 11	Original Stand 12	Cut 13	Residual 14
				11.1	—	
+0.3	12.5	38	2/5	37.4	14.2	
-2.3	18.1	46	1/2	73.1	33.6	
+2.0	3.1	26	1/4	35.8	9.3	
	0.1	100	ALL	0.5	0.5	
0	33.8			157.9	57.6	
Record excess UGS BALANCE	6+8	9/1		From Tally Sheet	10•12 / 100	12-13

96. The percentage cut, column 10, times the original basal area, column 12, gives the cut basal area, column 13.



				Basal Area		
Adjust 8	Total Cut 9	% Cut 10	Cut Ratio 11	Original Stand 12	Cut 13	Residual 14
				11.1	—	11.1
0.3	12.5	38	2/5	37.4	14.2	23.2
-23	18.1	46	1/2	73.1	33.6	39.5
20	3.1	26	1/4	35.8	9.3	26.5
	0.1	100	ALL	0.5	0.5	—
0	33.8			157.9	57.6	100.3
Record excess UGS ALANCE	6+8	9/1		From Tally Sheet	10*12 / 100	12−13

97. The original basal area (column 12) minus the cut (column 13) gives the residual basal area (column 14). These residual basal area goals by broad size classes may help markers inexperienced with the selection system make quick prism checks of their progress through the stand.



NEFES, Warren, PA 5/90

NEVEN-AGE

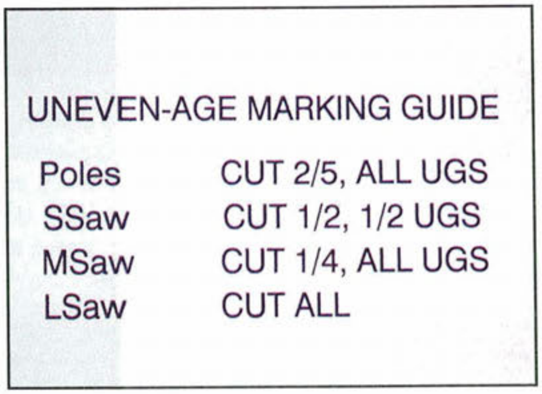
Basal Area		
Original Stand 12	Cut 13	Residual 14
11.1	–	11.1
37.4	14.2	23.2
73.1	33.6	39.5
35.8	9.3	26.5
0.5	0.5	—
157.9	57.6	100.3
	10*12	12−13

Service, NEFES, Warren, PA 5/90

EVEN-AGE

Basal Area		
Original Stand 12	Cut 13	Residual 14
1.1	–	11.1
4	23.2	14.2
	19.7	53.4
	9.3	26.5
	–	0.5
	2.2	105.7
	*12	12−13

98. They also provide a final opportunity to compare the even- and uneven-age cuts. The results here are the same as they were at earlier comparisons, with the principal difference in the residuals in the pole and small sawtimber classes.



UNEVEN-AGE MARKING GUIDE

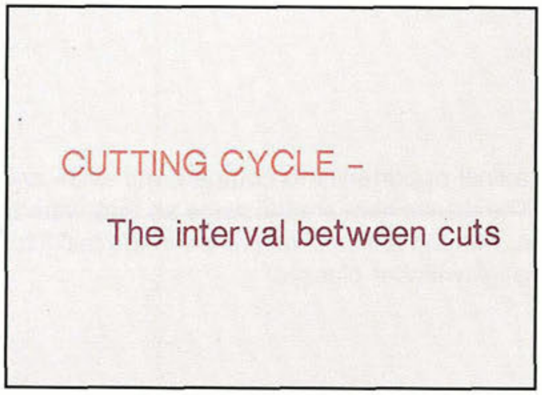
Poles	CUT 2/5, ALL UGS
SSaw	CUT 1/2, 1/2 UGS
MSaw	CUT 1/4, ALL UGS
LSaw	CUT ALL

99. If your quality adjustments have been done in such a way that you know the quality of the cut in each class, this information can be combined with the cut ratios to provide a marking guide.

PLANNING A SELECTION CUT

Management Goal 3

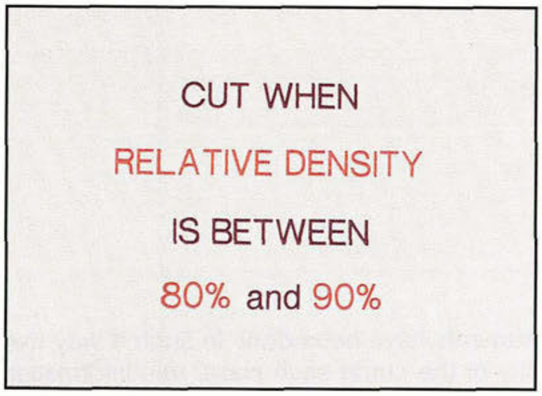
100. Marking according to these ratios, whether calculated by hand or by computer, will help you achieve your objectives for the stand. Your residual stand will be at optimal relative density, will be of better overall quality, and, with each successive cut, will more closely approach the basic structure you have chosen for your management objectives.



CUTTING CYCLE -

The interval between cuts

101. A final decision to be made in implementing uneven-age management for a stand or forest is to choose the cutting cycle for each stand, that is, the interval between cuts. In general, cutting cycles should be shorter on better sites or for stands with low 'q's (a high proportion of the basal area in sawtimber). Stands with long cutting cycles should be cut back to lower residual densities to ensure that individual tree growth conditions remain suitable for most of the cutting cycle.



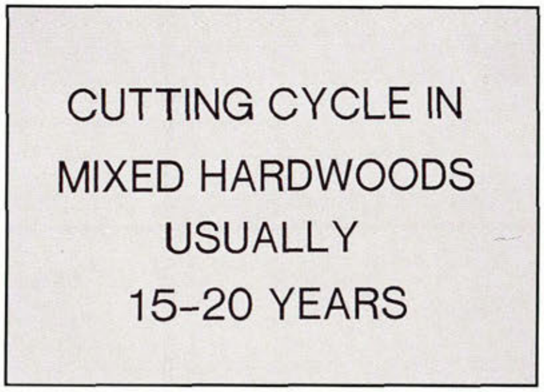
CUT WHEN

RELATIVE DENSITY

IS BETWEEN

80% and 90%

102. These general rules arise because timing of cuttings should be based on the projected growth rate and the time it takes to return to average maximum density. Cutting is usually economically feasible after the stand returns to 80 percent relative density, and should generally not be delayed beyond 90 percent relative density.



CUTTING CYCLE IN

MIXED HARDWOODS

USUALLY

15-20 YEARS

103. In cherry-maple stands that have been cut back to 60 percent relative density, it requires about 15 years to return to 80 percent relative density, 20 years to return to a relative density of 85 or 90 percent. So, cutting cycles of 15 to 20 years will be appropriate for most Allegheny hardwood stands. This timing is also appropriate for most oak and oak transition stands.

MARKING RATIOS

HELP WITH 'NEW'

PRESCRIPTIONS

104. Few of us--and few of the markers who actually implement our prescriptions--have much experience with the selection system. But as described in "Marking Ratios and the SILVAH System", marking ratios can help implement prescriptions that are unfamiliar.

TO HELP MARKERS:

- Broad size classes
- Quality data
- Prism self-checks
- Training plots

105. On the White Mountain National Forest, researchers developed aids for markers that they found worked well. Their prescriptions were presented in terms of large size classes, as ours are. They showed the approximate proportion of poor-quality stems in each cutting class. They asked the markers to check the structure of the leave stands fairly regularly with a prism during marking to ensure that the structure goals were being met, and they established some training plots for markers to practice the different prescriptions.

IN GROUPS, MARK

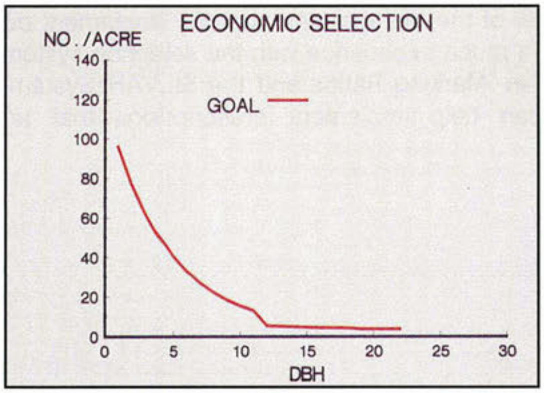
TREES DOWN TO 1"

106. A few special considerations apply when individual tree selection is being combined with the removal of groups of trees, as in Management Goal 3. In between groups, the marking procedure and guidelines are the same as those for a strict individual-tree selection cut. But experience and judgment are required for the recognition of potential groups: if two or more larger trees that would normally qualify for removal are rather close together, and if ample seed source or advance regeneration of the desired intermediate and intolerant species exists in the nearby residual, then a group removal may be considered. All trees down to 1 inch should be marked by whatever convention is appropriate to the organization.

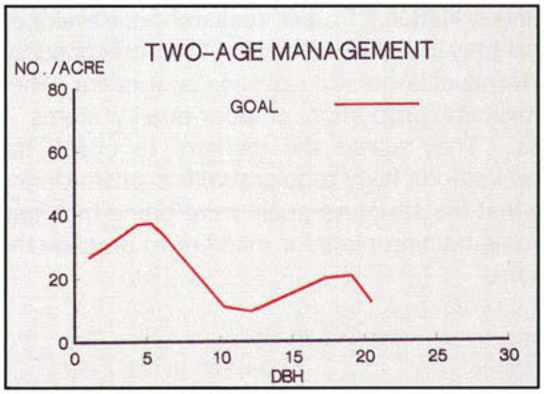
NEW TECHNIQUES

ARE NEEDED

107. We have already alluded to the increased attention being paid to uneven-age management, and maintenance of continuous forest cover, by foresters who work in areas of heavy public use and with private nonindustrial landowners. New techniques are needed to manage forest lands to meet all the objectives of their various constituencies. So, I will briefly mention two modifications of traditional uneven-age management that we are studying. We have installed each of these treatments in three different forest stands, a total of six plots as of 1993, and we are following the growth and regeneration in these trials carefully.



108. The treatment we call economic selection differs from single-tree and group selection only in that there is no cutting below 12 inches d.b.h. That is, pulpwood cutting is not required. A structural goal based on 'q' is established and used to control cuts, and density is reduced to about 60 percent after each treatment. This may be more realistic for private landowners, or areas where there is no pulp market. We will have to watch the stands that have been treated in this way for several years before we know how growth and yield of such stands compare with stands that are managed down through the pole class.



109. The treatment that we call two-age management is another alternative that may prove important in types with shade-intolerant species. The concept is to maintain two age classes on a particular site, with their ages one-half rotation apart. For example, in Allegheny hardwoods, with an 80 year rotation, we would initiate this treatment by harvesting the oldest and biggest trees, leaving a relative density of perhaps 35 to 40 percent. A new age class would grow up in the openings created by this radical cutting. Twenty years later, we would thin both age classes. At 40 years, we would harvest the remnant of the residual stand and thin the new age class, leaving, again, 35 to 40 percent density and initiating a new age class. Only time will tell if this fosters the development of shade intolerant species without ever completely removing high forest cover.

Selection System Stands

SELECT & HANDLE

WITH CARE !

110. The increasing multiple-use demands on the forest resource are requiring us to develop greater flexibility and diversity in our "toolkits". Selection-system silviculture can be a valuable tool for certain stands. Those close to high-use corridors or recreation sites may benefit from this system. Those with an existing pool of tolerant species whose site limitations might put productivity at risk in the harsh conditions following even-aged removal may also thrive under a variant of this system. But the most precise overstory prescriptions will not get tolerant regeneration through the pressure of a heavy deer herd, nor will such prescriptions make fern, grasses, or other interfering understory plants disappear. So we recommend that selection system be used with care in its application, and with special care in the selection of stands that will truly prosper under this system.

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APPENDIX A

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			0.76			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		4 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	1/(3-4) 14.5	2/3 13.7	2125.1 1	2158.4 2	31.5	157.9 3	96.7	8847

SILVAH - Distribution of Cut Worksheet

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

Stand ID

	Relative Density											Basal Area		
Size Class	Original Stand 1	Goal % 2	Initial Goal 3 49.9	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		13.0		13.0		N/A					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		6.3		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	$\frac{10*12}{100}$	12-13

APPENDIX B.--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 50% 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 75% of original density in large saws and adjust other sizes proportionally.

[4] In all-age cuts, all existing sapling density is retained.

Source: 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.

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Summary

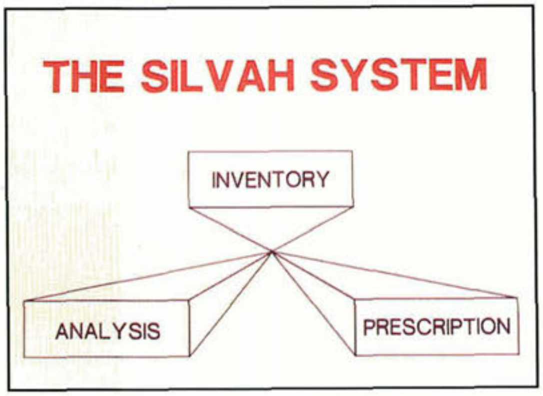
David A. Marquis

SILVICULTURE

TRAINING

1. This series of articles on "Quantitative Silviculture for Hardwood Forests of the Alleghenies" has summarized both the scientific background and the practical guidelines that constitute the SILVAH stand analysis and prescription system. These papers are based on lectures given during periodic training sessions at the Kane Experimental Forest, Northeastern Forest Experiment Station, near Kane, PA.

   In the training sessions and articles, we have tried to provide a systematic and objective procedure that forest land managers can use to make silvicultural decisions in hardwood forests of the Allegheny region.



THE SILVAH SYSTEM

INVENTORY

ANALYSIS

PRESCRIPTION

2. The SILVAH system involves a three-step process: stand inventory, analysis, and prescription. We have discussed the processes in detail. In the actual training session, we illustrate this approach using several sample stands.

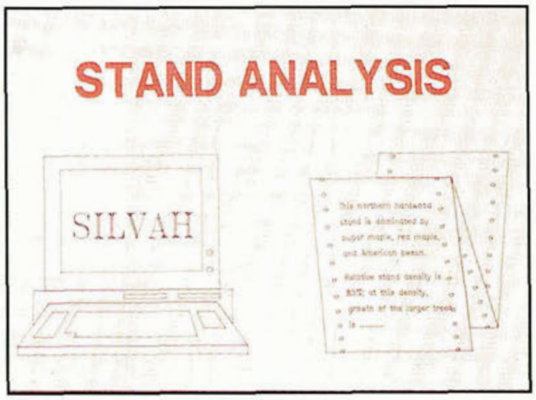
3. The first step is an inventory--a stand examination--during which we collect data on the overstory using a wedge prism to obtain basal area by species, diameter class, quality, and other attributes.

4. We also collect data on the understory, to estimate the amount and nature of advance reproduction,

5. the density of undesirable plants such as fern and grass,

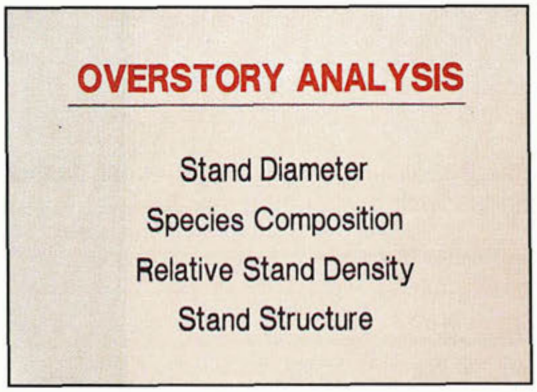
6. or woody undesirables such as striped maple, beech, sassafras, and dogwood

7. or site limiting soil conditions.



STAND ANALYSIS

8. in the <u>second</u> step, the data collected are used to analyze the stand, to determine the present stand condition, the need for thinning or regeneration, and the potential response to each of these possible treatments.



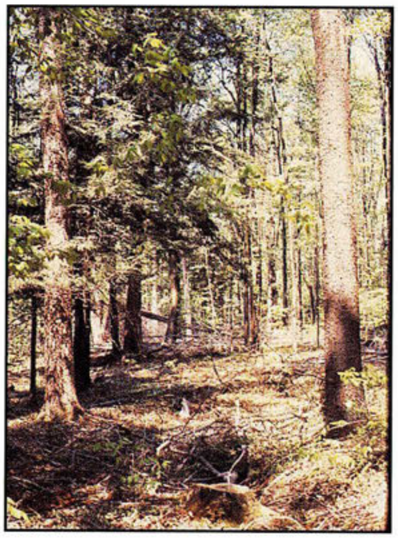
OVERSTORY ANALYSIS

Stand Diameter
Species Composition
Relative Stand Density
Stand Structure

9. Specifically, the overstory data are used to determine the stand diameter, species composition, relative stand density, and stand structure. These parameters provide insight into how the stand originated and developed, how close it is to maturity, whether it needs thinning to speed it along toward maturity, and whether any cutting would provide volumes and sizes of products that would make an economically feasible cut.

10. The understory data provide information on the potential of the stand to regenerate should a decision be made to harvest the overstory.

11. It provides information that helps predict whether clearcutting will result in good reproduction,



12. whether we can increase the numbers of advance seedlings in stands where they are lacking through shelterwood cutting without running into interference from undesirable plants,

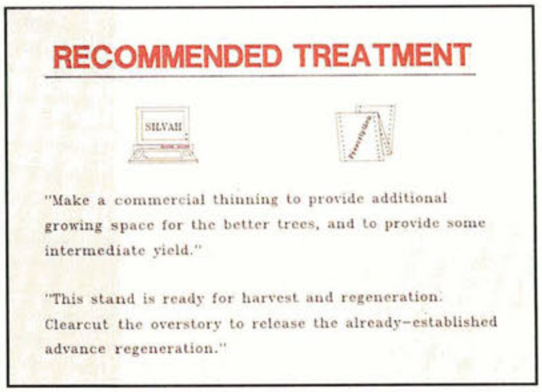
13. and whether reproduction is likely to fail under either method unless we are willing to invest in such treatments as

14. herbicide control of undesirables,

15. fencing to exclude deer,

16. fertilization to speed growth of seedlings and get them above the reach of deer quickly, or

17. planting to augment natural reproduction.

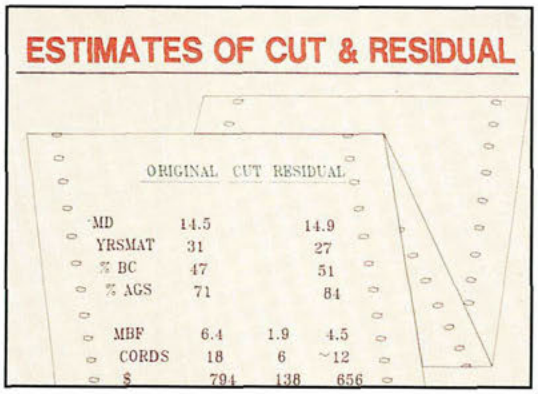


RECOMMENDED TREATMENT

"Make a commercial thinning to provide additional growing space for the better trees, and to provide some intermediate yield."

"This stand is ready for harvest and regeneration. Clearcut the overstory to release the already-established advance regeneration."

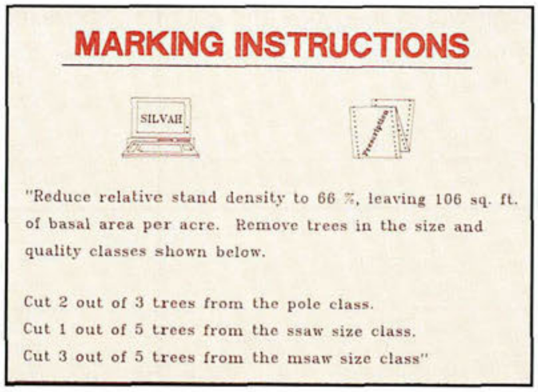
18. In the third step, the information gained from the analysis is used to decide on a course of action. A prescription outlining the work to be done in the stand is written.



ESTIMATES OF CUT & RESIDUAL

	ORIGINAL	CUT	RESIDUAL
MD	14.5		14.9
YRSMAT	31		27
% BC	47		51
% AGS	71		84
MBF	6.4	1.9	4.5
CORDS	18	6	~12
$	794	138	656

19. If a cutting is prescribed, the prescription includes estimates of the cut and residual stands that will result,

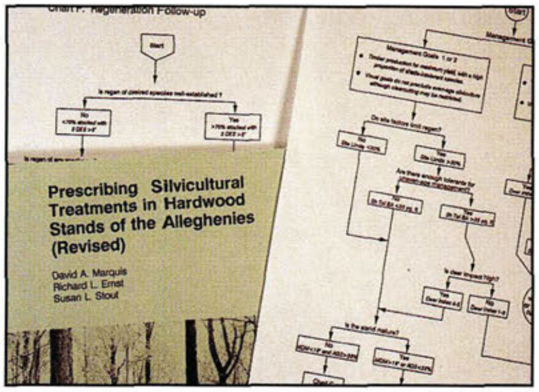


MARKING INSTRUCTIONS

"Reduce relative stand density to 66 %, leaving 106 sq. ft. of basal area per acre. Remove trees in the size and quality classes shown below.

Cut 2 out of 3 trees from the pole class.
Cut 1 out of 5 trees from the ssaw size class.
Cut 3 out of 5 trees from the msaw size class"

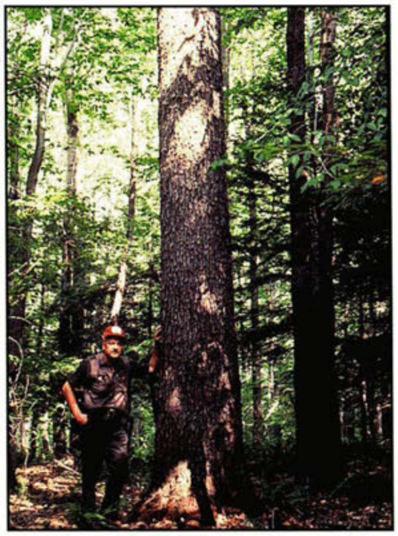
20. and a plan for distribution of that cut among species groups, quality classes, and size classes. This provides the stand marker with the information needed to ensure that the residual density and structure will actually accomplish the goals specified by the prescription.



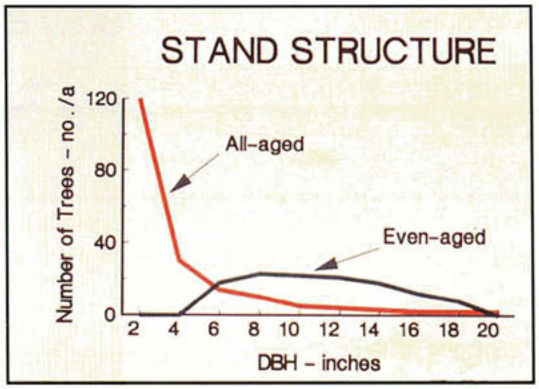
Prescribing Silvicultural Treatments in Hardwood Stands of the Alleghenies (Revised)

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

21. The system of stand inventory, analysis, and prescription that we have presented relies heavily on numerical guides to help decide the when, where, how, and how much. These guides must not be used in blind faith, since they represent only our best judgment at the present time; they will undoubtedly be improved and modified as research data accumulate. Furthermore, no guide can ever be perfect and complete for all of the many possible circumstances that you are likely to encounter.

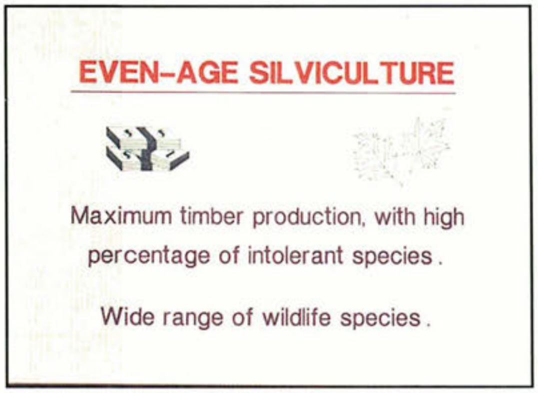


22. So our guides must always be used in combination with a full measure of professional judgment. Nevertheless, we feel that these guides do provide a more objective technique for prescribing stand treatments than has previously been available. We hope that these guides will reduce the amount of subjective judgment required and produce results that are silviculturally sound and consistent--not only from stand to stand but also from person to person, as well.



STAND STRUCTURE

23. We also hope that we have refreshed your memory on the theory behind both all-age and even-age silviculture and their application in Allegheny hardwood, northern hardwood, and oak types.



EVEN-AGE SILVICULTURE

Maximum timber production, with high percentage of intolerant species.

Wide range of wildlife species.

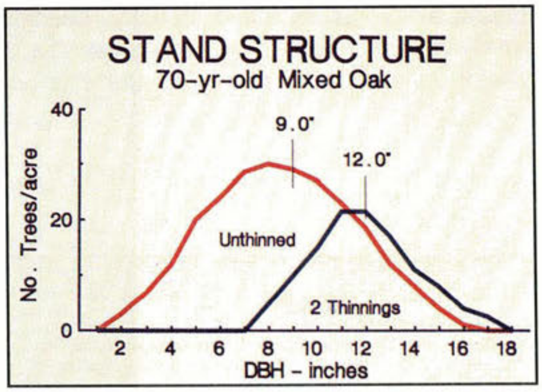
24. Even-age silviculture is used where the landowners' goals call for maximum timber production, because even-age silviculture favors the fast-growing, high-value, shade-intolerant species.

25. The goal under even-aged silviculture is to maximize growth and value,

26. by thinning in such a way as to provide for rapid growth of the best trees without reducing total stand growth, and without subjecting trees to loss in quality due to taper, slower pruning, or forking.

27. Normally this means cutting stands back to about 60 percent of average maximum density.

28. Such thinnings should generally occur from below,



29. so that the stand is moved along toward maturity as rapidly as possible. Although intermediate cuts may not be possible unless they provide a reasonable profit, we must remember that this is not the primary purpose of such thinnings, and that any cut made in such a way as to delay rotations, reduce final values, or increase regeneration difficulties is actually working in opposition to our long- term goals under even-age management.

30. Although circumstances may sometimes force you to modify treatments from this theoretical ideal, you should be fully aware of the consequences of that modification on future stand condition and ultimate yield. In many instances, a no cut prescription is better than one that reduces stand diameter and composition of desired species.

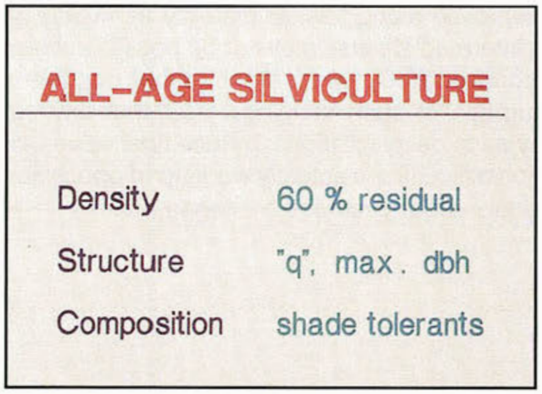
31. And, of course, when the stand finally reaches maturity, our goal is to harvest it and reproduce a new one by means that will provide full stocking of desirable mixed species composition.

ALL-AGE SILVICULTURE

Continuous forest cover
to meet visual goals.

Late sucession wildlife species.

32. All-age silviculture is an alternative in stands that contain shade tolerant species, and where management goals make continuous high forest cover desirable for visual reasons, or to favor particular wildlife species.



ALL-AGE SILVICULTURE

Density	60 % residual
Structure	"q", max. dbh
Composition	shade tolerants

33. With all-age silviculture, we regulate stand density, species composition, and stand structure, much as we did with even-age silviculture. The major difference is simply in the type of structure used.

34. We hope the information presented in this series will be useful to forest land managers in the Allegheny forest region, and that the SILVAH system will serve as an example of a quantifiable approach to silvicultural decisionmaking that could be adapted for use in many other forest regions. We are anxious to improve and extend this system, and we welcome any comments or suggestions.

Marquis, David A., ed. 1994. **Quantitative silviculture for hardwood forests of the Alleghenies.** Gen. Tech. Rep. NE-183. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 376 p.

A collection of lectures from the annual silviculture training sessions designed to explain and demonstrate the silvicultural prescription system to practicing foresters.

Headquarters of the Northeastern Forest Experiment Station is in Radnor, Pennsylvania. Field laboratories are maintained at:

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