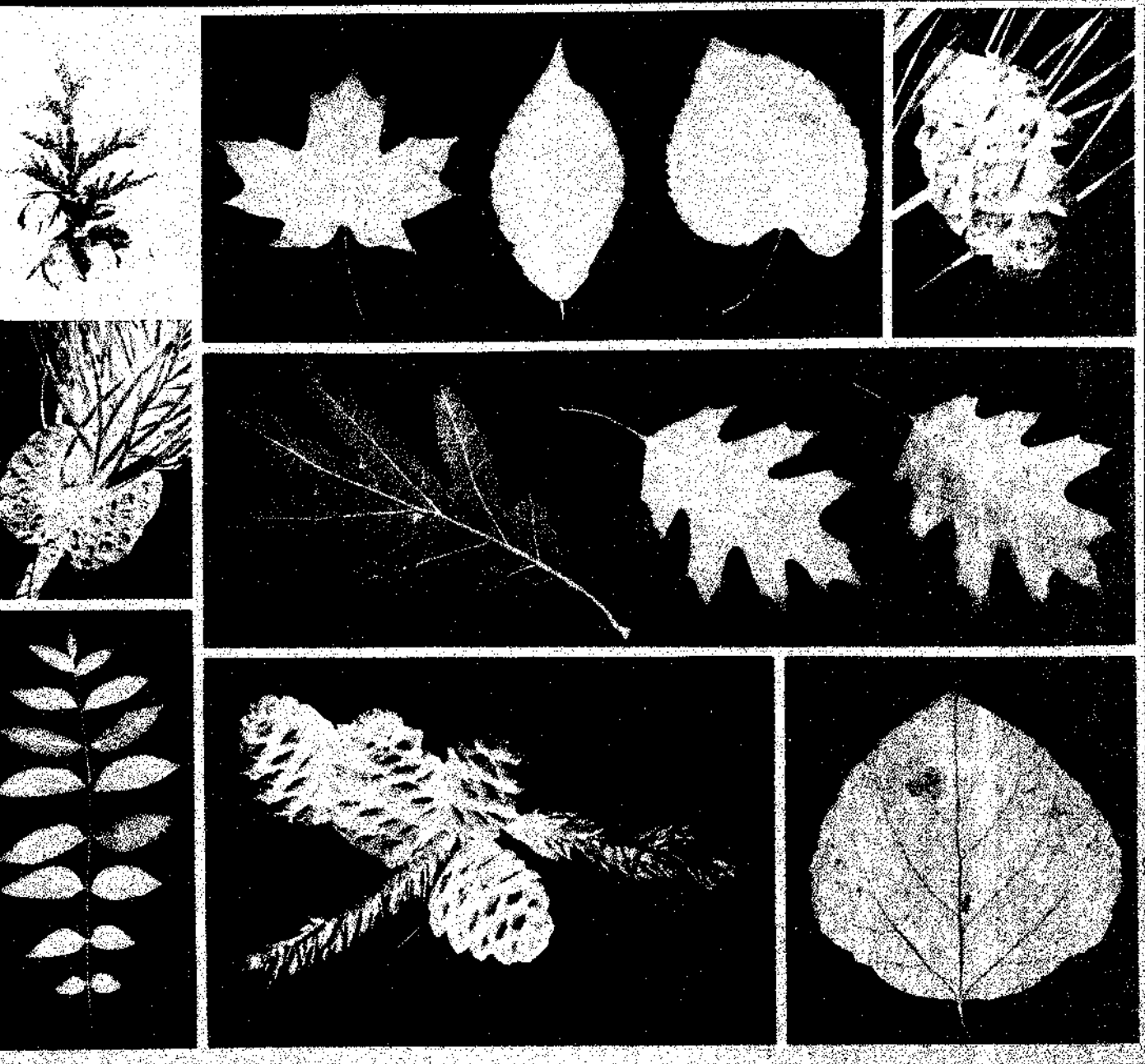
GTR-NC-35



manager's handbook for

NORTHERN WHITE CEDAR IN THE NORTH CENTRAL STATES

GENERAL TECHNICAL REPORT NC-35

NORTH CENTRAL FOREST EXPERIMENT STATION · FOREST SERVICE · U.S. DEPARTMENT OF AGRICULTURE

Other Manager's Handbooks are:

Jack pine – GTR-NC-32
Red pine – GTR-NC-33
Black spruce – GTR-NC-34
Aspen – GTR-NC-36
Oaks – GTR-NC-37
Black walnut – GTR-NC-38
Northern hardwoods – GTR-NC-39

North Central Forest Experiment Station
John H. Ohman, Director
Forest Service – U.S. Department of Agriculture
1992 Folwell Avenue
St. Paul, Minnesota 55108

Manuscript approved for publication August 6, 1976

1977

FOREWORD

This is one of a series of manager's handbooks for important forest types in the north central States. The purpose of this series is to present the resource manager with the latest and best information available on handling these types. Timber production is dealt with more than other forest values because it is usually a major management objective and more is generally known about it. However, ways to modify management practices to maintain or enhance other values are included where sound information is available.

The author has, in certain instances, drawn freely on unpublished information provided by scientists and managers outside his specialty. He is also grateful to the several technical reviewers in the region who made many helpful comments. In particular, Louis J. Verme of the Michigan Department of Natural Resources provided considerable information on deeryard management in the northern white-cedar type.

The handbooks have a similar format, highlighted by a "Key to Recommendations". Here the manager can find in logical sequence the management practices recommended for various stand conditions. These practices are based on research, experience, and a general silvical knowledge of the predominant tree species.

All stand conditions, of course, cannot be included in the handbooks. Therefore, the manager must use technical skill and sound judgment in selecting the appropriate practice to achieve the desired objective. The manager should also apply new research findings as they become available so that the culture of these important forest types can be continually improved.

CONTENTS

NORTHERN WHITE-CEDAR IN THE NORTH CENTRAL STATES

William F. Johnston, *Principal Silviculturist*
Grand Rapids, Minnesota

SILVICAL HIGHLIGHTS

The northern white-cedar[1] type occupies 2 million acres of commercial forest land in the northern Lake States; three-fifths of this total occurs in Michigan. Northern white-cedar grows mainly on organic soil where its growth rate increases as the soil is more decomposed and has more actively moving soil water. White-cedar grows in pure stands but more commonly is mixed with such trees as balsam fir, black spruce, tamarack, and black ash. Northern white-cedar may perpetuate itself in pure stands, whereas other trees seem to gradually replace it in mixed stands, particularly after disturbances. White-cedar lives longer than associated trees, reaching ages of 400 or more years on organic soil sites.

Northern white-cedar produces good seed crops every 3 to 5 years. Germination and early growth are best on moist seedbeds such as rotten wood, compacted moss as in skid roads, and burned soils. Vegetative reproduction by layering is common on organic soil sites. Northern white-cedar can survive in the shade for several years and yet responds well to release at nearly all ages. So, depending on their history, white-cedar stands can be uneven-aged as well as even-aged.

The main damaging agents of northern white-cedar are wind, deer and hare, and impeded drainage. The relatively shallow root system of white-cedar makes it susceptible to uprooting where trees are exposed to the wind. Short trees and reproduction are often overbrowsed by deer and hare. Drainage impeded by roads and beaver has killed white-cedar and associated trees on thousands of acres of organic soil.

MANAGEMENT OBJECTIVES AND NEEDS

The assumed objective in managing the northern white-cedar type is to produce at least a moderate sustained yield of merchantable timber as efficiently as possible, while maintaining or increasing the quality and quantity of deeryards and other forest values. Some resource managers may be able to concentrate their efforts on either timber or deeryards. However, most managers will need to consider both because timber management and deeryard management are usually inseparable in the white-cedar type.

Wherever possible, the type should be managed in fairly large, even-aged stands because these are apparently best for both timber production and deeryards, and are well suited for efficient cultural operations and mechanized harvesting. Practices to enhance other wildlife habitat, water, and esthetics are limited, but will be discussed under "Other Resource Considerations" (p. 10), along with practices for managing deeryards.

The demand for *high quality* white-cedar timber is strong, but the type is being undercut in parts of the Lake States because many mature stands do not have enough such timber for a commercial harvest. Thus there is a need to practice more intensive management that will result in merchantable stands. It is especially important to obtain satisfactory reproduction promptly after harvesting on brushy areas. If not stocked early with trees, these areas convert to lowland brush and become difficult and expensive to reforest.

The white-cedar type is also generally valuable for deeryards in the northern Lake States, but some yards

[1] *For scientific names of plants and animals, see Appendix, p. 16.*

support relatively few or no deer at present because of inadequate shelter, browse, or both. More intensive management is needed to restore traditional yards (past and present), and to produce new ones that will have at least a moderate carrying capacity. Although special funds may be available (or necessary) for some areas, most deeryard management will have to be accomplished in conjunction with timber management. This will require careful long-range planning and coordinated action by timber *and* wildlife managers. An adequate sustained amount of deer shelter and browse, in addition to timber, is possible *only* if the white-cedar type is managed so that stands at different stages of development are properly distributed throughout the forest.

The practices recommended here should result in improved management of the white-cedar type, but little information exists on their costs and returns. Relative costs are given for a few alternative practices, but most economic decisions will have to be based on the particular situation and the manager's experience and judgment.

KEY TO RECOMMENDATIONS

Recommendations for managing northern white-cedar stands are given in the following key, which contains a series of alternative statements about various stand conditions. The statements include references to the text where these conditions are discussed. So, with accurate knowledge of a stand, the resource manager can find out the recommended practices.

Starting with the first pair of like-numbered statements, select the one statement that better describes the stand in question and obtain a final recommendation, a partial recommendation plus a number, or a number alone. If a number is given, repeat the selection process until a final recommendation is reached. The overall recommendation is the sum of the partial recommendations arrived at while going through the key.

1. **Site index less than 25** . . . . . MANAGE STAND EXTENSIVELY
   See "Site Productivity", p. 3
1. **Site index 25 or more** . . . . . MANAGE STAND INTENSIVELY . . 2
   2. **Stand immature** . . . . . DO INTERMEDIATE TREATMENT
      See "Rotation", p. 3 and "Intermediate Treatment", p. 4
   2. **Stand mature** 3
3. **Stand small and provides only adequate deer shelter in vicinity** . . . . . OBTAIN/MAINTAIN CLOSED EVERGREEN CANOPY
   See "Deeryards", p. 10
3. **Stand large; or stand small but not used, or others available, for deer shelter** 4
   4. **Associated trees abundant** . . . . . DO PREPARATORY TREATMENT
      See "Preparatory Treatment", p. 5
   4. **Associated trees scarce** . . . . . REPRODUCE STAND BY STRIP CUTTING . . 5
5. **First or intermediate set of strips** . . . . . USE CLEARCUTTING . . 6
   See "Reproduction Cutting", p. 6
5. **Last set of strips** . . . . . USE SHELTERWOOD
   6. **Residual stems abundant** 7
      See "Residual Stems", p. 7
   6. **Residual stems scarce** 9
7. **White-cedar a major component** 8
   See "Residual Stems", p. 7
7. **White-cedar a minor component** 9
   8. **White-cedar less than 50 years old and in good health** . . . . . SAVE RESIDUAL STEMS
      See "Residual Stems", p. 7
   8. **White-cedar 50 or more years old, or in poor health** . . . . . KILL RESIDUAL STEMS . . 9

9. Slash cover light . . . . . SPREAD SLASH EVENLY, USE NATURAL SEEDING
See "Slash Cover", p. 7 and "Natural Seeding", p. 8
9. Slash cover heavy 10
10. Clearcut strips 1 or 2 chains[2] wide . . . . . SKID FULL TREES, USE NATURAL SEEDING
See "Reproduction Cutting", p. 6 and "Slash Cover", p. 7
10. Clearcut strips 3 chains wide . . . . . BROADCAST BURN SLASH, USE NATURAL SEEDING
See "Broadcast Burning Techniques", p. 15

TIMBER MANAGEMENT CONSIDERATIONS

Controlling Growth and Composition

Site Productivity

The northern white-cedar type is found mainly on organic soil in the Lake States, but it also occurs on mineral soil. Growth rate varies greatly; height of dominant white-cedar trees at 50 years ranges from at least 40 feet on the best sites to less than 15 feet on the poorest. Mature, fully stocked stands of pure white-cedar (at least 80 percent) on good sites commonly yield 4,000 merchantable cubic feet or 50 cords per acre for trees 5.0 inches d.b.h. and larger. Much of this volume is in logs and poles, whereas many stands on poor sites produce only small posts. (See Appendix for site index curves and yield of white-cedar stands.)

Degree of decomposition, botanical origin, and natural drainage of the upper horizons of organic soil are good guides to site productivity, whereas total depth is a poor guide by itself. The best sites have moderately to well decomposed organic soil that is derived from woody plants or sedges and is neutral or slightly alkaline. However, the upper 4 inches on these sites may be poorly decomposed sphagnum or other mosses. The best sites have actively moving soil water and are usually near streams or other drainageways. In contrast, the poorest sites have poorly decomposed, acid soil that is derived from plants such as sphagnum moss throughout the whole root zone. These sites have little water movement (except during snowmelt) and are often far from drainageways.

Extensive management is recommended where the site index for white-cedar is less than 25. Stands on such sites are best suited for producing only small posts and deer browse, whereas stands on better sites should be managed to produce larger timber and deer shelter (in addition to posts and browse). Clearcutting in strips at rotation age, and slash disposal to ensure reproduction, are the only silvicultural practices recommended for poor sites (see p. 3, 6, 7).

[2] *One chain = 66 feet.*

The growth rate of white-cedar could undoubtedly be increased on organic soil sites in the Lake States by draining and fertilizing, but specific practices are presently lacking. They have not been developed mainly because the region's extensive upland forests produce sufficient timber, and probably at a higher economic return than lowland forests. However, with the increasing interest in the white-cedar type and the greater demands on land use in upland forests, there may be a need in the future to develop effective and environmentally acceptable ways to drain and fertilize organic soil sites.

The northern white-cedar type is common on mineral soil in the Lake States mainly on seepage areas and limestone uplands. Growth is usually faster than on organic soil, being best on mineral soil that is calcareous and moist but well drained.

Rotation

The best rotation for growing northern white-cedar varies greatly with site productivity and the management objective. White-cedar stands are usually considered mature and ready to harvest for timber when their mean annual growth for the main product peaks. The rotations at which this occurs for two common units of measurement are as follows:[3]

Site index	Merchantable cubic feet	Board feet
	(Years)	
40 (excellent)	70 to 90	110 to 140
30 (medium)	80 to 100	130 to 160
20 (poor)	100 to 140	130 to 160

These rotations have a range because the mean annual growth has practically the same maximum for a number of years. Therefore, the manager has considerable

[3] *See Appendix for tree dimensions included, site index curves, and timber yield.*

flexibility in selecting a suitable rotation, at least for timber growth. Specific stations are not given for posts or poles because a stand can yield various numbers and sizes of these piece products. However, if the main objective is to grow poles of a certain length, table 2 in the Appendix shows the number of years required on different sites.

White-cedar stands provide an optimum quantity and quality of browse or shelter for deer at different ages, depending on the site, as follows:[4]

Site index	Approximate Age For Optimum: Browse	Shelter
	(Years)	
40	25 to 30	≥ 60
30	30 to 40	≥ 100
20	50 to 70	--[5]

In comparing the timber rotations with those for deer shelter (at the same site indexes), it is obvious that little or no optimum shelter will be provided if the stands are managed to maximize merchantable cubic feet. However, if the rotations are extended to maximize board feet, many years of optimum shelter will be provided except on poor sites. Therefore, in areas where the white-cedar type is important for deer shelter, rotations should generally be at least the minimum ones shown for board feet. (See page 10 for more information on managing deeryards.)

Determining a suitable rotation for *mixed* stands is complicated further because several of the main tree species associated with northern white-cedar require shorter rotations. Balsam fir, aspen (quaking and bigtooth), balsam poplar (balm-of-Gilead), and paper birch should generally be harvested at about 50 years on medium sites, whereas red maple and black ash require at least 100 years to produce saw logs. Whether or not harvesting is done at these rotations will depend on the yield and value of these species. Additional recommendations for handling mixed stands are discussed under "Intermediate Treatment".

Of course, factors other than maximum mean annual growth and deer shelter should be considered in selecting a suitable rotation. The presence of, or risk involved with, some of the damaging agents of white-cedar and associated trees may determine the rotation. For example, mature trees are relatively tall and thus are more susceptible to uprooting or breakage by wind. They also sometimes have butt rot, which can seriously reduce merchantable volume and lead to wind breakage as the stand becomes older.

Intermediate Treatment

Little research or experience is available on managing immature stands of northern white-cedar. Because it is long lived and tolerant to very tolerant of shade, white-cedar should eventually become dominant if there is adequate stocking tall enough to survive deer browsing (about 15 feet). However, intermediate treatment offers an excellent opportunity to improve stand composition and speed up development of both high quality timber and deer habitat. Unfortunately, intermediate treatment often produces little or no immediate return and so it can probably be justified only on the best areas for timber management, or in key deeryards for which special funds are provided.

Despite its shade tolerance, white-cedar reproduction grows best in half to full sunlight. Thus its growth (and proportion) in immature stands can be increased by controlling the usual overtopping shrubs and trees. The degree to which competing vegetation should be controlled depends on the management objectives. Unless white-cedar timber is the only objective, a mixed stand of 50 to 80 percent white-cedar is probably best for multiple-use purposes. Pure white-cedar (at least 80 percent) is often neither practicable nor desirable. For example, a mixture with valuable pulpwood species such as black spruce sometimes makes management more attractive economically.

The best intermediate treatment depends on the composition and merchantability of the competing vegetation. Aerial herbicide spraying is probably the most practical way to kill back overtopping shrubs or hardwoods in young stands. However, little is known about the sensitivity of northern white-cedar to such spraying and so spraying should be tested before being used on a large scale. A low volatile ester of 2,4-D[6] is effective on speckled alder, black ash, aspen, paper birch, and willow; whereas a 50-percent mixture with 2,4,5-T is recommended if red maple and balsam poplar

[4] *Adapted from Verme 1965 and Geyorkiantz and Duerr, 1939, "Volume and yield of northern white cedar in the Lake States," unpublished report on file at North Central Forest Experiment Station, St. Paul, Minnesota.*

[5] *White-cedar does not grow tall enough on poor sites to provide optimum shelter.*

[6] *See Pesticide Precautionary Statement, p. 17.*

are the main species to control. Use a total rate of 3 pounds acid equivalent in at least 4 gallons of water per acre. Spray in early August, or when white-cedar has completed its new growth and yet shrubs and hardwoods are still susceptible.

Herbicide spraying should be done carefully, following all pertinent precautions and regulations. It is particularly important not to contaminate open water with herbicide, so do not spray vegetation around the borders of ponds, lakes, and watercourses. These guidelines will minimize the risk of adverse environmental effects on organic soil sites.

In older stands where northern white-cedar or its main associated trees are merchantable, it may be possible to thin commercially or at little cost. Thinning can improve both timber quality and deer use. If the slash is left so that it is available and not an obstacle, white-cedar and hardwoods cut in *winter* provide browse; deer also have space to move about more easily than in excessively dense, unthinned stands. For optimum deer shelter, deciduous trees (hardwoods and tamarack) should be cut or otherwise killed to obtain a closed canopy of evergreens (mainly white-cedar and black spruce). Balsam fir should be harvested *no later than* 70 years of age because butt rot makes this species especially susceptible to wind breakage after that.

The best available information indicates that middle-aged stands managed for timber can be initially thinned to a residual basal area of 130 square feet per acre and then rethinned every 10 years to at least as low as 90 square feet without affecting growth or mortality. The lighter first thinning is needed to maintain maximum growth. Good diameter growth of white-cedar can apparently be maintained through repeated thinnings that favor dominant and codominant trees. Research findings also indicate that advance tree reproduction and shrubs grow little unless the stand is rethinned to less than 150 square feet per acre (fig. 1).

Therefore, it is generally best not to thin below 150 square feet of basal area per acre. This provides an opportunity to improve the quality of the final harvest and to increase total yield without producing an undesirable undergrowth of balsam fir and shrubs, for example. Such thinning also provides deer shelter ranging from fairly good immediately after thinning to excellent toward the end of the thinning cycle.

Preparatory Treatment

The primary purpose of preparatory treatment is to control associated trees before the final harvest so that

Figure 1. — *Typical stand of northern white-cedar and some black spruce, with an undesirable undergrowth of balsam fir, 10 years after a second thinning to 130 square feet of basal area per acre.*

northern white-cedar will remain predominant in the next stand. Thus associated trees are "scarce" only if their reproduction, especially by vegetative means, will not become predominant. Although they can be easily overlooked, it is important to realize that a few mature trees per acre of certain species sometimes produce many seeds, suckers, or sprouts.

Preparatory treatment, like intermediate treatment, should usually be: (1) aimed at obtaining a mixed stand of 50 to 80 percent white-cedar and (2) limited to stands where intensive management for timber, deer habitat, or both can be justified. Since intermediate treatment tends to reduce the amount of undesirable associated trees, preparatory treatment will have the greatest value in mixed stands that have had no intermediate treatment.

Preparatory treatment should be done at least 5, and preferably 10, years before reproduction cutting to ensure control of undesirable trees. To minimize the establishment and growth of suckers, sprouts, and seedlings from these trees after treatment, it is apparently important to have a residual basal area of about 150 square feet per acre. Hardwoods are usually more important to control than conifers because they reproduce readily both vegetatively and from seed. Root suckers, such as those of balsam poplar, and stump sprouts are very competitive with white-cedar reproduction. Further, hardwoods (and tamarack) are deciduous and thus provide no winter shelter for deer.

Undesirable trees should be felled if they are merchantable or will provide deer browse; otherwise

they can be controlled by girdling or applying herbicide. Of course, to be effective, browse species must be felled in winter near deer concentrations. Felling or girdling of most or all undesirable trees in a stand should substantially reduce their reproduction by natural seeding, except for aspen and balsam poplar. Wind carries seed of these species long distances, so adequate control of their natural seeding by felling or girdling is probably impractical. However, if the canopy is not opened much, felling or girdling can practically eliminate vegetative reproduction of aspen, balsam poplar, and paper birch because they are intolerant.

Use of herbicide is another way to control vegetative reproduction of hardwoods, especially the more tolerant species such as black ash and red maple. To minimize suckering and sprouting, herbicide should be applied to a frill girdle around the base of uncut trees immediately after full leaf development. An effective herbicide is a low volatile ester of 2,4,5-T at 8 pounds acid equivalent (ae) per 100 gallons of No. 2 fuel oil solution, or the amine salt of 2,4-D or 2,4,5-T at 1 milliliter of a 50-percent water solution per inch of tree diameter. Uncut trees can be killed without girdling by basal spraying with Tordon 155[7] (a combination of picloram and 2,4,5-T) at 10 pounds ae per 100 gallons of fuel oil solution. Fresh hardwood stumps can be wet thoroughly with Tordon 101 (a combination of picloram and 2,4-D) at 5 pounds ae per 100 gallons of water solution to control suckering and sprouting.

Controlling Establishment

Reproduction Cutting

Present knowledge indicates that clearcutting, or felling of *all* trees, is the best way to obtain even-aged stands of northern white-cedar for timber and deeryards. However, unless suitable residual stems are expected (see p. 7), clearcutting must be done in narrow strips (or small patches) because reproduction depends on natural seeding, which has an effective range of only 2 or 3 chains. It may be possible to reproduce white-cedar on large clearcut patches by direct seeding, but this cannot be recommended until current research is completed.

Alternate clearcut strips have been widely used in the white-cedar type in the Lake States, but in most cases the uncut strips remain (fig. 2). These strips may receive inadequate natural seeding if they are clearcut. Therefore, until a better system is developed, a combination of clearcut and shelterwood strips is recommended for harvesting mature stands and reproducing new ones.

[7] *Mention of trade names does not constitute endorsement of the products by the USDA Forest Service.*

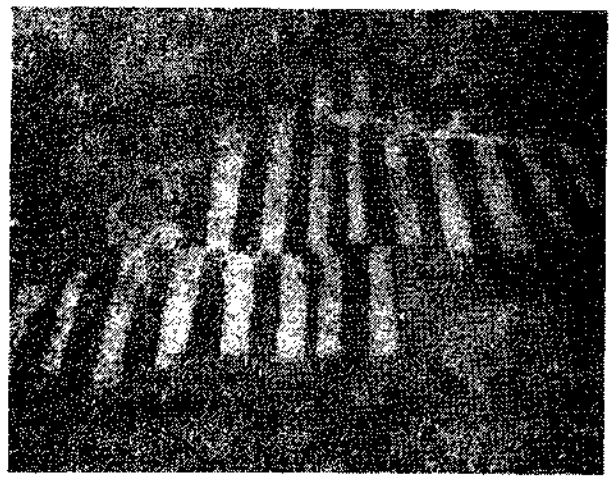


Figure 2. — *Typical large patch with alternate clearcut strips in the northern white-cedar type. Uncut strips must be removed in 10 years or less to minimize overbrowsing of reproduction by deer on the cut strips.*

This combination can be applied either as alternate or progressive strips. If alternate strips are used, one set should be clearcut and the other set cut in two stages (shelterwood). If progressive strips are used, sets of three are suggested — the first two being clearcut and the third one cut in two stages. The first stage or seed cutting of the shelterwood should leave a basal area of 60 square feet per acre in uniformly spaced dominant and codominant trees of the most desirable species. These trees should be selected for good seed production, windfirmness, and timber quality.

Strip orientation has had little study, so strong recommendations cannot be made. Strips that are perpendicular to, and progress toward, the prevailing wind direction should maximize seed dispersal and minimize wind damage. Some information suggests that a northerly exposure is the most favorable for reproducing white-cedar and associated conifers. East-west strips, with subsequent ones progressing southward, would maximize this exposure. However, since the prevailing wind direction in the Lake States is generally from the western quadrant (NW-SW), the manager will often have to compromise in deciding which way to orient strips. The shape and orientation of a stand, especially if small, are other important factors to consider in laying out strips.

Reliable information is also lacking to make strong recommendations on strip width. Clearcut strips should generally vary from 1 chain wide where seed-bearing

trees are short (less than 35 feet) to 2 chains wide where these trees are tall (more than 60 feet). Strips can probably be 1 chain wider and receive adequate seed if they have a mature stand of white-cedar on *both* sides. Since clearcutting is preferred to shelterwood for reproducing white-cedar, shelterwood strips should be only 1 or 2 chains wide to minimize the area they occupy.

The usual reproduction period between removing adjacent clearcut strips, and between seed cutting and final cutting in shelterwood strips, has been about 10 years. However, this period should be shortened or lengthened as needed, depending on results from reproduction surveys (see p. 8). A new even-aged stand can be obtained in less than 10 years or up to 20 years using alternate or progressive strips, respectively. If timber considerations or the risk of overbrowsing call for harvesting or reproducing a stand as rapidly as possible, do seed cutting in the shelterwood strips and remove the alternate or the second set of clearcut strips at the same time. Residual shelterwood trees should adequately seed these clearcut strips, thus substantially shortening the overall reproduction period.

Ways to make new harvest areas look better are discussed under "Esthetics" (p. 11).

Residual Stems

These are trees of any size down to 6 inches tall that are expected to or do survive clearcutting. They may be of any species or age, and of seedling or vegetative origin. Residual stems are "scarce" if they or their reproduction, especially by vegetative means, will not become dense enough to severely suppress reproduction of northern white-cedar or its valuable associate, black spruce. As mentioned under "Preparatory Treatment" (p. 5), it is important to consider the reproductive potential of associated trees, particularly hardwoods.

Residual stems should be relied on to reproduce a stand only if relatively young and healthy white-cedar stems are or will be predominant (at least 50 percent of basal area). Such stems are arbitrarily defined as being less than 50 years old and having well-developed crowns. In contrast, many of the white-cedar stems remaining after clearcutting are 50 or more years old or have poorly developed crowns (for example, from browsing). Old stems also tend to be of layer origin, which often results in poor form. Some old or unhealthy trees may grow satisfactorily after clearcutting and yield much deer browse, but young seedlings are preferred for producing timber and deer shelter. Therefore, residual stems should be saved to reproduce a stand only if: (1) 60 percent or more of the milacres[8] in the clearcut area will contain at least one young and healthy white-cedar *after* harvesting and (2) the cost of saving such stems does not exceed the cost of obtaining new white-cedar reproduction of equal density *and* size. Obviously, the stand must be harvested carefully and slash removed where it covers needed stems.

Residual stems of associated trees should be controlled enough that they or their reproduction will not severely suppress suitable residual stems (or new seedlings) *of white-cedar.* Undesirable trees should usually be felled if they will provide deer browse, otherwise they can be girdled. However, hardwoods should be treated with herbicide where experience indicates they will be a problem. Aerial spraying is recommended where residual hardwoods, especially of seedling or sapling size, are abundant (see p. 4); otherwise trees and stumps should be treated individually (see p. 6). Broadcast burning of slash is an efficient way to kill residual conifers, especially where many are of seedling or sapling size (see p. 15). Burning will kill back hardwoods, but herbicide is more effective on those that reproduce mainly from suckers or sprouts.

Slash Cover

This is "heavy" when slash hinders satisfactory reproduction by burying suitable residual stems or seedbeds (fig. 3, left). A heavy cover of slash is definitely detrimental, but a light cover is more favorable than practically none. Therefore, slash disposal is usually not needed in poorly stocked stands when the slash is spread evenly. Slash cover is also heavy when it creates an important fire hazard. However, the risk of fire is low on most white-cedar areas because they do not dry up much and there is little contact with human activities.

Broadcast burning is the preferred method of slash disposal except, of course, where shelterwood trees are present or residual stems are to be saved. Burning eliminates most slash, completely kills residual conifers, kills back hardwoods and brush, and probably improves seedbed conditions (fig. 3, center). However, because white-cedar has a short seeding range and space is needed for a slash-free alley around the perimeter of the strip, broadcast burning should be limited to strips 3 chains wide. (See Appendix, p. 15 for burning techniques.)

Full-tree skidding *in winter* is recommended for slash disposal on strips less than 3 chains wide. Stands

[8] *A milacre is 1/1,000 acre, usually 6.6 feet square.*

Figure 3. *Typical clearcut areas where slash of northern white-cedar (browsed) and associated conifers was: not disposed of, leaving a "heavy" cover (left); broadcast burned (center); and removed by full-tree skidding (right).*

harvested by full-tree skidding, with branches and tops intact, apparently leave only a light cover of slash when felling and skidding are done with reasonable care (fig. 3, right). All trees should be felled as the harvesting progresses, leaving stumps as low as possible to minimize obstacles that would break off branches and tops during skidding. Also, the trees should be felled into the open rather than into the stand where more breakage would occur. If deer are in the vicinity, skidding of white-cedar and other browse species should be delayed a few days until the browse is eaten.

The overall cost of slash disposal should be less by full-tree skidding than by broadcast burning if most trees are merchantable. This is because skidding of full, merchantable trees by skilled loggers should require little or no extra compensation, whereas burning in strips only 3 chains wide usually has a relatively high cost per acre.

Natural Seeding

Northern white-cedar is a dependable seed producer. It bears good seed crops every 3 to 5 years, with light to medium crops in the intervening years. Adequate seed production starts at about 30 years but is best after 75 years on most sites. Seed dispersal usually starts in September and is fairly complete by November. Practically all of the seed is dispersed by wind. Since white-cedar is usually only 40 to 50 feet tall, the effective seeding range is estimated to be from 2 to 3 chains.

Natural seeding of northern white-cedar, especially on burned organic soil, can result in new stands that are too dense for optimum timber growth or deeryards. To minimize this problem, the manager should survey the reproduction about 4 years after site preparation and if milacre stocking of white-cedar is 60 percent or more, the next set of uncut strips should be removed to eliminate further seeding on the cut strips. Of course, severe browsing and suppression of white-cedar reproduction must be prevented or white-cedar will not become established successfully.

Many of the common tree associates of northern white-cedar reproduce on clearcut areas, especially on slash-burned seedbeds, and some reproduce under a shelterwood. Black spruce and tamarack reproduce well after broadcast burning on organic soil sites if seed-bearing trees are within 3 or 4 chains. Although they may be outnumbered by white-cedar, spruce and tamarack grow faster and so will probably be important components of the new stand. To control natural seeding of black spruce and particularly tamarack, most seed-bearing trees should be harvested or otherwise killed during preparatory treatment (see p. 5). Seeding from spruce and tamarack could also be avoided by clearcutting large patches whose interiors are beyond the seeding range of

these trees. However, this method of controlling composition cannot be recommended until studies under way definitely show that such areas can be successfully reproduced to white-cedar by direct seeding.

Quaking aspen and paper birch not only reproduce well on slash-burned seedbeds on organic soil sites, but also fairly well on unburned seedbeds such as those resulting from full-tree skidding. These trees have much greater seeding ranges than black spruce and tamarack, so it is probably impractical to substantially reduce their natural seeding. Fortunately, aspen and birch are not expected to severely suppress northern white-cedar except on the best sites. Here herbicide spraying may be desirable to release white-cedar as prescribed and discussed under "Intermediate Treatment" (p. 4).

Controlling Damaging Agents

Wind

Breakage and uprooting of trees by wind can be important causes of mortality in older stands of the northern white-cedar type, but the loss has sometimes been overrated. The risk of wind damage is greatest in unmanaged mature stands of mixed composition. For example, balsam fir and black spruce are more susceptible to breakage or uprooting than white-cedar because they are usually taller and balsam fir commonly has butt rot, especially on the drier sites. Both breakage and uprooting occur mainly along stand edges exposed to the prevailing wind and in stands opened up by partial cutting. By using the rotations and cutting methods recommended in this handbook, wind-caused mortality should be minimal.

Deer and Hare

White-tailed deer and snowshoe hare commonly browse northern white-cedar so severely that a stand cannot become established successfully after reproduction cutting. However, as long as white-cedar stands can be established or maintained, browsing is usually considered beneficial to deer and hare – rather than damaging to the reproduction -- because it provides much nutritious food.

The reproduction cutting system recommended earlier (p. 6) should minimize overbrowsing of young white-cedar if large patches (40 acres or more) of mature forest are completely cleared in 10 years or less. This is because: (1) deer and hare tend to avoid large openings, due to the lack of protective cover; (2) openings have deeper snow, which can deter deer in many parts of the northern Lake States; and (3) a great amount of browse is present in large young stands. Further information on how to minimize overbrowsing of white-cedar is discussed under "Deeryards" (p. 10).

Impeded Drainage

Poorly constructed or maintained roads have killed or reduced the growth of northern white-cedar and associated trees on thousands of acres of organic soil in the Lake States by impeding the normal movement of water. Beaver damming of natural watercourses or man-made drainage ditches has similar effects. Also, pipelines carrying natural gas and petroleum will cause damage unless cross drainage is provided.

Road-caused damage can be minimized by constructing and maintaining adequate collector and discharge ditches, and by using large culverts that are correctly positioned and maintained. Removal of beaver dams and judicious control of beaver can avert damage to valuable timber, deeryards, and the unsightliness of dying trees. Pipelines should have cross ditches about every 150 feet or less. These ditches can be through the backfill for pipe buried below ground or beneath pipe placed on the surface.

Other Agents

Wildfire easily kills northern white-cedar trees but good fire protection now results in little loss. During very dry periods fires can burn deeply in organic soil and become extremely difficult to put out. Biological agents other than deer and hare also cause damage to white-cedar. Unfortunately, their damage is often not recognized until the trees are cut, or if the damage is recognized, little is known about controlling it. Carpenter ants, both black and red, are the main insect enemies of white-cedar. They frequently attack partially decayed heartwood in living trees. Butt-rot fungi that cause a white stringy rot or a brown cubical rot are common in mature trees on the drier lowland sites. Woodpecker holes are the most common indicator that butt rot is present. Porcupines sometimes cause damage by girdling the stem, and red squirrels frequently eat flower buds and clip cone-bearing branches.

OTHER RESOURCE CONSIDERATIONS

Deeryards

Deeryard management in the northern white-cedar type is affected by the interaction of several factors such as yard size and condition, deer density, winter severity, and availability of browse in and around the yard. These factors vary substantially in different parts of the Lake States and are often difficult or impossible to control. Further, considerable knowledge on managing deeryards in the white-cedar type is based on experience rather than research, because the latter has been done mainly in areas with large yards and deep snow in upper Michigan. So, for these reasons, the present recommendations tend to be general and often cannot be applied directly to the various yarding situations found in the white-cedar type. This means that to obtain desired results the manager must use good judgment and modify the recommendations to fit local conditions.

Whenever possible, deeryard management should be concentrated on areas that have: (1) special importance as traditional or potential yards, (2) deer densities that do not exceed the carrying capacity, (3) a site index of 30 (medium) or higher for northern white-cedar, and (4) enough timber for commercial cutting.

In large deeryards (200 acres or more), the long-range objective should be to organize compartments that contain five age classes each, with 15 to 20 years between classes, in patches of 40 to 160 acres. The size and distribution of these patches should be planned carefully so that adequate deer shelter and browse will always be available on separate patches within each compartment (fig. 4). Cutting of any kind should be done in as many compartments as possible to distribute the deer herd more and to rehabilitate vital yards faster. Of course, northern white-cedar and hardwoods should be cut only during winter to provide deer with browse. Annual cutting is necessary to adequately feed deer where deep snow normally keeps them yarded most of the winter. Such cutting is also desirable where deer can move about more because it tends to attract them away from patches of young white-cedar, which is vulnerable to overbrowsing.

The main objective in small, isolated yards (less than 200 acres) should be to obtain and maintain a closed evergreen canopy for optimum deer shelter. Specific practices for achieving this objective are prescribed and discussed under "Intermediate Treatment" (p. 4).

Figure 4. *This deer is browsing northern white-cedar slash near the edge of a clearcut patch. The dense stand in the background provides excellent shelter.*

Browse is usually scarce in small yards, so removal of hardwoods or northern white-cedar should be done only by cutting during severe winters. This means most browse will have to come from young stands and winter cutting of other forest types in the surrounding area.

In areas where small yards are vital for deer shelter, the rotation can be extended well beyond the longest ones shown on page 3 because northern white-cedar is long lived. Eventually, however, these yards will need to be rehabilitated. Since they are probably too small to handle the series of age classes recommended for large yards, the whole yard should be reproduced as a single even-aged stand by strip cutting (see p. 6). The time when a small yard is cut should be planned carefully so that, if possible, adequate deer shelter will be available elsewhere in the vicinity.

Other Wildlife Habitat

The white-cedar type is utilized to some extent by many wildlife species besides white-tailed deer, a few of which are mentioned elsewhere in this handbook. New openings and young stands certainly produce different or more abundant wildlife food than mature white-cedar stands. For example, young stands should support substantial populations of snowshoe hare and their accompanying predators as soon as the tree crowns begin to close. Therefore, shrubs and hardwoods should not be killed back with herbicide spraying unless the growth or proportion of white-cedar reproduction definitely needs

to be increased (see p. 4). And even then, all stems should not be killed because a mixture of shrubs and hardwoods with white-cedar and other conifers probably enhances wildlife habitat in general.

Some trout streams have their source in areas occupied by the northern white-cedar type or they pass through such areas. So, to keep the water cool, areas cleared for new stands should probably: (1) have an uncut border between them and the streams, (2) not exceed 40 acres each, and (3) total only a small proportion of the surrounding watershed.

Water

Current research findings indicate that clearcutting lowland conifers in strips or large patches, or broadcast burning the slash changes the quantity of water little. However, if a stream flows from or through a clearcut area, the water will have a higher concentration of certain nutrients for a few years with or without burning. Whether or not this increase in nutrients will have an important effect downstream, especially in lakes, is still unknown.

Esthetics

The manager can minimize the impact of harvesting on the esthetic appeal (fig. 5) of the northern white-cedar type by: (1) having harvest boundaries follow natural site or forest type lines and (2) removing heavy slash cover and otherwise leaving harvest areas neat. Slash can be removed by full-tree skidding and burned at the landing, or broadcast burned in the case of wide clearcut strips (see p. 7). Of course, as mentioned earlier, skidding of browse species should be delayed a few days if deer are in the vicinity.

Figure 5. *The unusual bark and foliage patterns of northern white-cedar are esthetically appealing to many forest users, including hikers, snowshoers, and ski tourers.*

APPENDIX

Yield

Usable information on yield of northern white-cedar is limited and that on growth is practically nonexistent. Yield in a few common units or products can be determined for any fully stocked (normal), even-aged stand given its site index and age (tables 1 and 2). Site index is obtained from the average age (total) and average height (total) of dominant and codominant trees (fig. 6).

Volumetric yield can be estimated for a stand with less than full stocking because volume is proportional to basal area. Therefore, volumes in table 1 should be reduced by the percentage that the stand's basal area is less than the basal area in table 1.

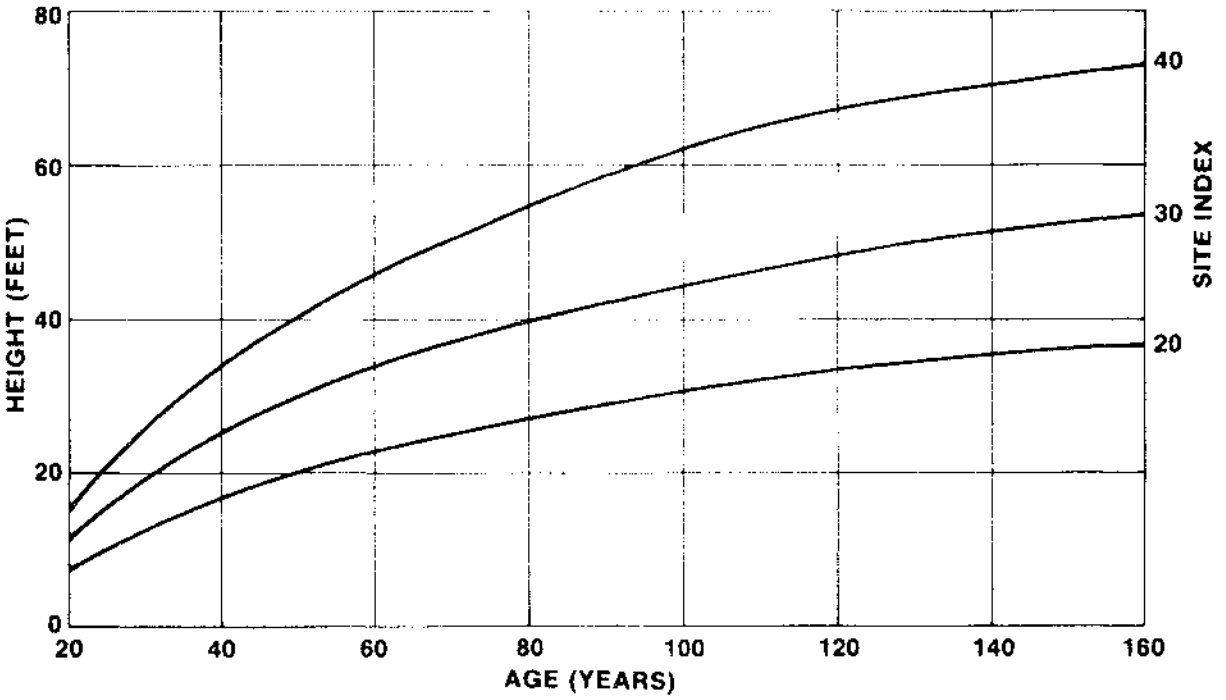


Figure 6. – *Site index curves for northern white-cedar stands. Adapted from Gevorkiantz and Duerr, 1939, "Volume and yield of northern white cedar in the Lake States", unpublished report on file at North Central Forest Experiment Station, St. Paul, Minn.*

Table 1. -- *Yield per acre of fully stocked, even-aged stands of northern white-cedar by site index and age*[1]

Age	Height of dominants and codominants	Trees 0.1 inch d.b.h. and larger				Merchantable volume		
		Average d.b.h.	Number	Basal area	Total volume			
Years	*Feet*	*Inches*		*Square feet*	*Cubic feet*[2]	*Cubic feet*[3]	*Cords*[4]	*Board feet*[5]
SITE INDEX 40								
60	47	6.2	850	180	3,490	2,460	31	2,840
80	56	8.7	470	195	4,200	3,540	45	9,540
100	64	10.7	320	200	4,700	4,180	53	15,600
120	69	12.4	250	205	5,040	4,560	58	19,900
140	72	13.6	210	210	5,270	4,800	61	22,790
160	75	14.5	180	215	5,420	4,950	63	24,410
SITE INDEX 30								
60	35	4.5	1,550	170	2,600	1,440	18	230
80	41	6.2	860	180	3,240	2,480	31	2,460
100	46	7.7	580	190	3,670	3,100	39	6,000
120	50	8.9	450	195	3,960	3,480	44	9,220
140	53	9.8	380	200	4,160	3,720	47	11,570
160	55	10.4	340	200	4,280	3,860	49	13,000
SITE INDEX 20								
60	22	3.0	3,120	155	1,690	280	4	--
80	26	4.2	1,740	170	2,180	1,120	14	120
100	29	5.2	1,180	175	2,500	1,700	22	740
120	32	6.0	930	180	2,720	2,050	26	1,680
140	34	6.5	790	185	2,860	2,280	29	2,590
160	35	6.9	720	185	2,960	2,410	30	3,220

[1]Values (except cords) adapted from Gevorkiantz and Duerr (1939) "Volume and yield of northern white-cedar in the Lake States", unpublished report on file at the North Central Forest Experiment Station, St. Paul, Minn. Values in the original report were for site indexes 41, 31, and 19; 40, 30, and 20 are shown here for convenience because the respective values are practically the same.

[2]Gross peeled volume of entire stem.

[3]Gross peeled volume between stump (height equal to d.b.h., in inches) and fixed top d.i.b. of 4 inches for trees 5.0 inches d.b.h. and larger.

[4]Gross rough volume obtained by dividing merchantable cubic-foot volume by 79, the assumed number of cubic feet of wood (inside bark) per cord.

[5]Volume (Scribner) between stump (height equal to d.b.h., in inches) and fixed top d.i.b. of 6 inches for trees 9.0 inches d.b.h. and larger.

Table 2. *Poles and additional 7-foot posts in trees 4.0 inches d.b.h. and larger for fully stocked, even-aged stands of northern white-cedar by site index and age*[1]

Age (years)	Number of poles per acre, by length (feet)									Number of posts per acre
	All	16	20	25	30	35	40	45	50	
SITE INDEX 40										
60	530	270	40	150	70	--	--	--	--	280
80	415	80	30	120	170	15	--	--	--	335
100	310	10	20	65	160	40	15	--	--	380
120	250	--	10	30	50	65	55	40	--	310
140	210	--	5	15	30	50	50	55	5	290
160	180	--	--	10	20	35	45	60	10	265
SITE INDEX 30										
60	105	--	95	10	--	--	--	--	--	1,205
80	530	270	170	80	10	--	--	--	--	155
100	465	145	115	165	35	5	--	--	--	285
120	405	85	10	235	60	15	--	--	--	250
140	360	55	--	200	70	30	5	--	--	250
160	325	40	--	165	75	35	10	--	--	200
SITE INDEX 20										
60	5	5	--	--	--	--	--	--	--	650
80	75	75	--	--	--	--	--	--	--	885
100	180	70	80	30	--	--	--	--	--	735
120	245	5	180	60	--	--	--	--	--	630
140	275	--	190	85	--	--	--	--	--	525
160	280	--	190	90	--	--	--	--	--	530

[1]Values adapted from Gevorkiantz and Duerr, 1939, "Volume and yield of northern white cedar in the Lake States", unpublished report on file at the North Central Forest Experiment Station, St. Paul, Minnesota. Values in the original report were for site indexes 41, 31, and 19; 40, 30, and 20 are shown here for convenience because the respective values are practically the same.

Broadcast Burning Techniques

Initial research and experience in upper Michigan and related work in northern Minnesota indicate that northern white-cedar slash, whether pure or mixed with slash of associated conifers, can be broadcast burned safely and effectively on organic soil sites. So burning on such sites should be successful throughout the Lake States after resource managers gain some local experience.

If burning is planned (see "Key," p. 2, 3), strips 3 chains wide must be located and harvested in such a way that they can be burned safely and efficiently. The main requirements for setting up and conducting a successful broadcast burn on a clearcut strip are:

1. Locate strip on *undrained* organic soil to avoid deep ground fires that are difficult and expensive to put out. Unless burning is essential for site preparation, slash should be removed by full-tree skidding near drained organic soil, such as along ditches, and near upland sites. Burning near drained organic soil should be done only after the surface soil has been wet down thoroughly. A mineral soil firebreak should be constructed near upland sites.
2. Make edges of strip smooth and reasonably straight to avoid control problems resulting from sharp angles.
3. Cut all unmerchantable trees in the strip.
4. Plan cutting and skidding so as to distribute the slash evenly, thus ensuring that the fire will spread over the entire strip.
5. Leave a slash-free alley about 1/2 chain wide around the perimeter of the strip.
6. Burn slash the first or second year after harvesting.
7. Burn when conditions will ensure consumption of most slash less than 1 inch in diameter (see below).
8. Burn when the wind direction is parallel to the strip to avoid serious crown scorch or mortality. If this direction is uncommon, then use center firing when the wind speed is only 0 to 5 miles per hour.

Burning on organic soil sites will probably be most successful in July and August of the first year or in May of the second year. Research and experience indicate that burning severe enough to kill back residual hardwoods and shrubs or to improve moss seedbeds requires drier and hotter conditions than burning to just consume slash or kill residual conifers. Most burning has been done under the following conditions:

Time or weather variable	Burns in general	Severe burns
Time since rain $\geq$ 0.1 inch	3 to 10 days	$\geq$7 days
Minimum relative humidity	30 to 60 percent	$<$45 percent
Maximum air temperature	60° to 90° F	$\geq$80° F
Maximum wind speed	5 to 15 mph	5 to 15 mph

On mineral soil sites, broadcast burning should probably be severe enough to expose mineral soil if natural seeding is planned. However, local conditions and experience may indicate that mechanical ground preparation such as scarification is more efficient than burning.

Metric Conversion Factors

To convert	*to*	*Multiply by*
Acres	Hectares	0.405
Board feet[1]	Cubic meters	0.005
Board feet/acre[1]	Cubic meters/hectare	0.012
Chains	Meters	20.117
Cords[1]	Cubic meters	2.605
Cords/acre[1]	Cubic meters/hectare	6.437
Cubic feet	Cubic meters	0.028
Cubic feet/acre	Cubic meters/hectare	0.070
Degrees Fahrenheit	Degrees Celsius	[2]
Feet	Meters	0.305
Gallons	Liters	3.785
Gallons/acre	Liters/hectare	9.353
Inches	Centimeters	2.540
Miles	Kilometers	1.609
Miles/hour	Meters/second	0.447
Number/acre	Number/hectare	2.471
Ounces	Grams	28.350
Ounces/acre	Grams/hectare	70.053
Pounds	Kilograms	0.454
Pounds/acre	Kilograms/hectare	1.121
Pounds/gallon	Kilograms/liter	0.120
Square feet	Square meters	0.093
Square feet/acre	Square meters/hectare	0.230
Tons	Metric tons	0.907
Tons/acre	Metric tons/hectare	2.242

[1]The conversion of board feet and cords to cubic meters can only be approximate; the factors are based on an assumed 5.663 board feet (log scale) per cubic foot and a cord with 92 cubic feet of solid material.

[2]To convert °F to °C, use the formula $\frac{5/9\ (°F-32)}{1.8}$ or $\frac{°F-32}{1.8}$.

Common and Scientific Names of Plants and Animals

Common name	*Scientific name*
Plants	
Alder, speckled	*Alnus rugosa*
Ash, black	*Fraxinus nigra*
Aspen:	
Bigtooth	*Populus grandidentata*
Quaking	*Populus tremuloides*
Birch, paper	*Betula papyrifera*
Fir, balsam	*Abies balsamea*
Fungus, butt-rot:	
White stringy	*Poria subacida*
Brown cubical	Main species are: *Polyporus balsameus*, *Polyporus schweinitzii*
Maple, red	*Acer rubrum*
Moss, sphagnum	*Sphagnum* spp.
Poplar, balsam	*Populus balsamifera*
Spruce, black	*Picea mariana*
Tamarack	*Larix laricina*
White-cedar, northern	*Thuja occidentalis*
Willow	*Salix* spp.
Animals	
Ant, carpenter:	
Black	*Camponotus pennsylvanicus*
Red	*Camponotus ferrugineus*
Beaver	*Castor canadensis*
Deer, white-tailed	*Odocoileus virginianus*
Hare, snowshoe	*Lepus americanus*
Porcupine	*Erethizon dorsatum*
Squirrel, red	*Tamiasciurus hudsonicus*

PESTICIDE PRECAUTIONARY STATEMENT

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

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

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment if specified on the container.

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

Do not clean spray equipment or dump excess spray material near ponds, streams, or wells. Because it is difficult to remove all traces of herbicides from equipment, do not use the same equipment for insecticides or fungicides that you use for herbicides.

Dispose of empty pesticide containers promptly. Have them buried at a sanitary land-fill dump, or crush and bury them in a level, isolated place.

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

LITERATURE CITED AND OTHER REFERENCES

Arend, John L., and Eugene I. Roe. 1961. Releasing conifers in the Lake States with chemicals. U.S. Dep. Agric., Agric. Handb. 185, 22 p.

Benzie, John W. 1963. Cutting methods in mixed conifer swamps. Upper Michigan. USDA For. Serv. Res. Pap. LS-4, 24 p. Lake States For. Exp. Stn., St. Paul, Minnesota.

Boelter, Don H., and Gordon E. Close. 1974. Pipelines in forested wetlands: cross drainage needed to prevent timber damage. J. For. 72:561-563.

Foltz, Bruce W., and William F. Johnston. 1968. Gross basal area growth of northern white-cedar is independent of stand density over a wide range. USDA For. Serv. Res. Note NC-61, 4 p. North Cent. For. Exp. Stn., St. Paul, Minnesota.

Fowells, H. A., ed. 1965. Silvics of forest trees of the United States. U.S. Dep. Agric., Agric. Handb. 271:679-685.

Johnston, William F. 1972. Balsam fir dominant species under rethinned northern white-cedar. USDA For. Serv. Res. Note NC-133, 4 p. North Cent. For. Exp. Stn., St. Paul, Minnesota.

Johnston, William F. 1975. Reproducing lowland conifer forests. J. For. 73:17-20.

Michigan State University. 1976. Proceedings of national northern white cedar conference, Escanaba, Michigan. April 24, 1975. 36 p. Michigan State Univ., Coop. Ext. Serv.

Nelson, Thomas C. 1951. A reproduction study of northern white cedar. 100 p. Michigan Dep. Conserv., Game Div.

Shipman, R. D., and E. P. Farrand. [1975.] Forest resources and herbicides: a guide to control of undesirable woody plants. Pennsylvania State Univ., Coll. Agric., Ext. Serv., Univ. Park, Pennsylvania. Spec. Circ. 206, Nat. Resour. Ser., 13 p.

Stoeckeler, Joseph H. 1967. Wetland road crossings: drainage problems and timber damage. USDA For. Serv. Res. Note NC-27, 4 p. North Cent. For. Exp. Stn., St. Paul, Minnesota.

Thornton, Philip L. 1957. Problems of managing Upper Michigan's coniferous swamps. J. For. 55:192-197.

Verme, Louis J. 1965. Swamp conifer deeryards in northern Michigan, their ecology and management. J. For. 63:523-529.

Printed on recycled paper