
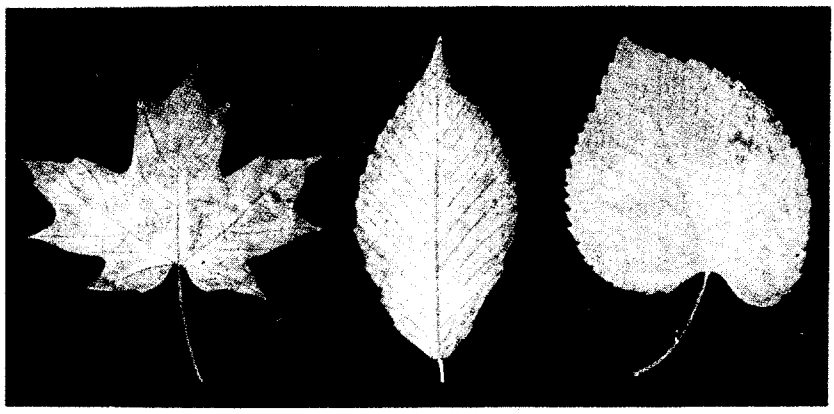


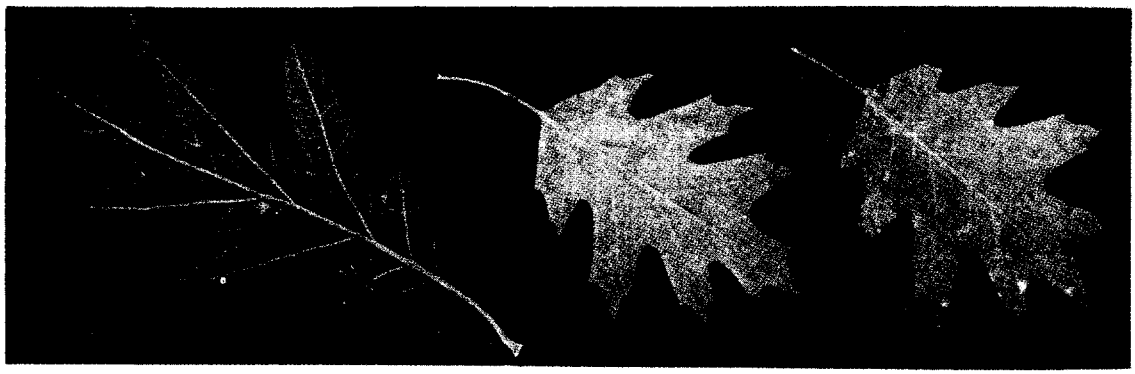
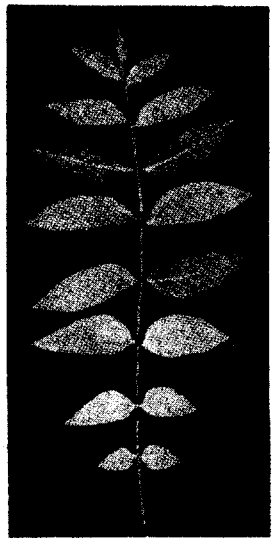

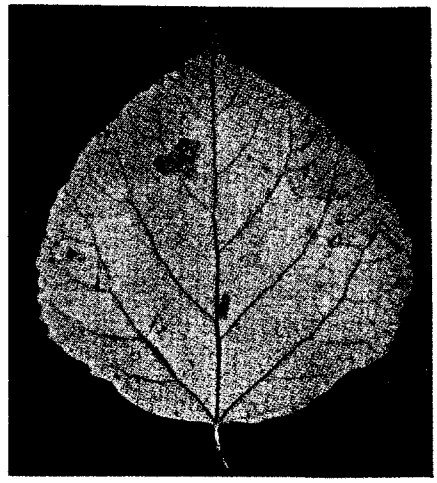

manager's handbook for

BLACK SPRUCE IN THE NORTH CENTRAL STATES

GENERAL TECHNICAL REPORT NC-34

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
Northern white-cedar – GTR-NC-35
Aspen – GTR-NC-36
Oaks – GTR-NC-37
Black walnut – GTR-NC-38
Northern hardwoods – GTR-NC-39

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St. Paul, Minnesota 55108

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1977

Bertsch

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The author has, in certain instances, drawn freely on unpublished information provided by scientists and managers outside his specialty.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.

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

BLACK SPRUCE IN THE NORTH-CENTRAL STATES[1]

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

SILVICAL HIGHLIGHTS

The black spruce[2] type occupies 2 million acres of commercial forest land in the northern Lake States; two-thirds of this total occurs in Minnesota. Black spruce grows mainly on organic soil, where its growth rate is related to the amount of nutrients received from ground water or precipitation. Black spruce grows mainly in pure stands but may also be mixed with tamarack, northern white-cedar, and balsam fir on organic soil and with other conifers and various hardwoods on mineral soil. Black spruce stands are brushy on the best sites, especially on organic soil.

Black spruce stands 40 or more years old have a nearly continuous seed supply because the persistent cones shed seed for at least 4 years after ripening and seed crops seldom fail. Seedling establishment requires a moist seedbed free from competing vegetation. Establishment is generally successful on slow-growing sphagnum moss or where the surface layer is removed by fire or compacted as in skid roads. Vegetative reproduction by layering is common on the poorer sites on organic soil.

Most black spruce stands in the Lake States originated after wildfires and so are, or once were, even-aged. In areas having no major disturbance for a century or more, black spruce stands become uneven-aged because new trees begin to fill in as overstory trees die. However, these new trees grow much faster in open areas than under a living overstory.

The main damaging agents of black spruce are wind, eastern dwarf mistletoe, and impeded drainage. Uprooting or breakage is a problem when older stands are opened by partial cutting because black spruce has a shallow root system and butt rot is common in older trees. Mistletoe, which produces "witches' brooms", is the most serious disease of black spruce. Other pests seldom cause serious damage. Drainage impeded by roads and beaver has killed black spruce or reduced its growth on thousands of acres of organic soil.

MANAGEMENT OBJECTIVES AND NEEDS

The usual objective in managing the black spruce type is to produce a high sustained yield of pulpwood as efficiently as possible without adversely affecting other forest values. For this objective, the type can probably be managed best in fairly large, even-aged stands, similar to virgin stands. Such management should produce stands that are well suited for efficient cultural operations and mechanized harvesting. The poorest sites, however, should be managed mainly for Christmas trees. Although limited, practices to enhance wildlife habitat, water, and esthetics should be applied to the extent they have been developed.

The demand for black spruce pulpwood is expected to remain high, so satisfactory stocking of reproduction needs to be obtained promptly after harvesting. This is usually possible by carrying out the practices recommended here. However, little information exists on the costs and returns of these practices. Relative costs are given for a few alternatives, but most economic decisions will have to be based on the particular situation and the manager's experience and judgment. There is a special need to obtain reproduction after harvesting brushy stands, which occur on the most productive sites. If not stocked early with trees, these areas convert to lowland brush and become difficult and expensive to reforest.

[1] *This handbook supersedes Johnston, William F. 1971. Management Guide for the Black Spruce Type in the Lake States. USDA For. Serv. Res. Pap. NC-64.*

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

KEY TO RECOMMENDATIONS

Recommendations for managing black spruce 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** . . . . . GROW CHRISTMAS TREES
   See "Christmas Trees", p. 10
1. **Site index 25 or more** . . . . . GROW PULPWOOD . . 2
   See "Site Productivity", p. 3
   2. **Stand immature** 3
      See "Rotation", p. 3
   2. **Stand mature** . . . . . CLEARCUT STAND . . 6
      See "Clearcutting Methods", p. 5 and "Wind", p. 9
3. **Black spruce satisfactorily stocked** 4
   See "Intermediate Treatment", p. 4
3. **Black spruce understocked or overstocked** 5
   4. **Spruce severely suppressed by shrubs/hardwoods** . . . . . RELEASE . . 5
      See "Intermediate Treatment", p. 4
   4. **Spruce not or slightly suppressed by shrubs/hardwoods** 5
5. **Witches' brooms absent or inconspicuous** . . . . . CHECK IN 10 YEARS
   See "Dwarf Mistletoe", p. 9
5. **Witches' brooms readily noticeable** . . . . . TREAT INFECTED AREAS
   6. **Witches' brooms absent or inconspicuous** 7
      See "Dwarf Mistletoe", p. 9
   6. **Witches' brooms readily noticeable** . . . . . BROADCAST BURN SLASH (see p. 15) . . 13
7. **Residual stems abundant** 8
   See "Residual Stems", p. 6
7. **Residual stems scarce** 10
   8. **Black spruce a major component** 9
      See "Residual Stems", p. 6
   8. **Black spruce a minor component** . . . . . BROADCAST BURN SLASH (see p. 15) . . 13
9. **Spruce less than 50 years old and in good health** . . . . . SAVE RESIDUAL STEMS
   See "Residual Stems", p. 6
9. **Spruce 50 or more years old, or in poor health** . . . . . BROADCAST BURN SLASH (see p. 15) . . 13
   10. **Brush absent or inconspicuous** 11
      See "Brush", p. 6
   10. **Brush readily noticeable** . . . . . BROADCAST BURN SLASH (see p. 15) . . 13
11. **Sphagnum seedbeds well distributed** 12
   See "Seedbeds", p. 7
11. **Sphagnum seedbeds poorly distributed** . . . . . BROADCAST BURN SLASH (see p. 15) . . 13
   12. **Slash cover light** . . . . . SPREAD SLASH EVENLY, USE NATURAL SEEDING
      See "Slash Cover", p. 7
   12. **Slash cover heavy** . . . . . SKID FULL TREES, USE NATURAL SEEDING; *or*
      BROADCAST BURN SLASH (see p. 15) . . 13
13. **Seed source within range** . . . . . USE NATURAL SEEDING
   See "Clearcutting Methods", p. 5 and "Natural Seeding", p. 8
13. **Seed source out of range** . . . . . USE DIRECT SEEDING
   See "Direct Seeding", p. 9

TIMBER MANAGEMENT CONSIDERATIONS

Controlling Growth

Site Productivity

The black spruce 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 trees at 50 years ranges from about 45 feet on the best sites to less than 15 feet on the poorest. Mature stands on good sites commonly yield 3,000 cubic feet (entire stem) or 30 cords per acre for trees 3.6 inches d.b.h. and larger. In contrast, many stands on poor sites never produce merchantable quantities of pulpwood. (See Appendix for site index curves, yield, and net annual growth of black spruce stands.)

Most organic soil sites are extensive areas on gently sloping glacial lake beds or smaller filled lakes associated with the Laurentian Shield, pitted outwash plains, and moranic areas. On both lake-bed and filled-lake sites, the growth rate of black spruce is related to the surrounding ground water flow system. The best sites occur where the soil water is continuous with the regional ground water system and thus is enriched by nutrients flowing from mineral soil areas. The poorest sites occur where the soil water is "perched" above and thus is separated from this regional system. The fertility of these sites depends mainly on precipitation, which is relatively low in nutrients.

Degree of decomposition and botanical origin of the upper horizons of organic soil are good guides to site productivity, whereas total depth and pH are poor guides by themselves. The best sites have moderately well decomposed organic soil that contains much partially decayed wood and is dark brown to blackish. However, the upper 6 inches may be poorly decomposed sphagnum or other mosses, especially in old stands. The poorest sites have poorly decomposed sphagnum, 2 to 5 feet or more thick, that is yellowish brown.

The growth rate of black spruce 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 value of black spruce pulpwood 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 black spruce type is common on mineral soil only on the Laurentian Shield in northeastern Minnesota and in a few isolated areas of upper Michigan. Here black spruce grows on gravelly and bouldery loam and on shallow soil over bedrock, where it usually is mixed with other species, but occasionally forms a pure type. Growth is best where the slope is gentle and moisture is plentiful, either from a shallow water table or seepage. South of the Shield, black spruce is occasionally found on sandy soil with a high water table.

Rotation

Black spruce stands are usually considered mature and ready to harvest for pulpwood when their mean annual growth in cords peaks. The rotations at which this occurs for trees 3.6 inches d.b.h. and larger can be determined from figure 1 for various stand ages and basal areas. These rotations apply to all site indexes and are similar for cubic feet.

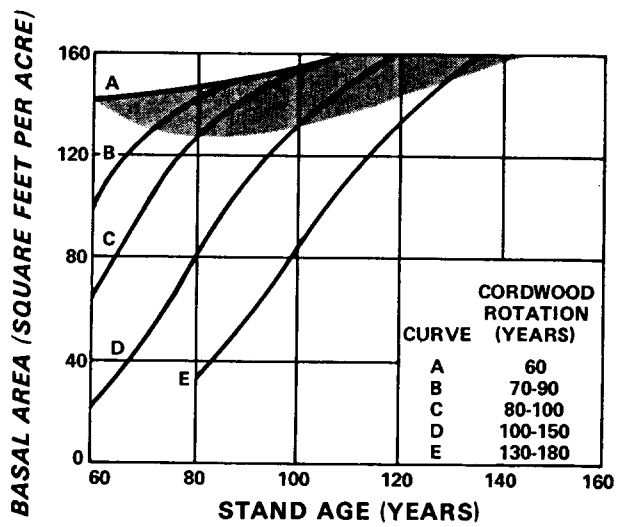


Figure 1. – *Rotations for black spruce stands by stand age and basal area. Adapted from Perala 1971.*

To determine the cordwood rotation for any stand, locate the point where its present age and basal area intersect in figure 1 and then use the following guidelines:

1. If the point is *below* the shaded zone, the stand has not yet reached the recommended rotation. To determine this rotation, select the curve nearest the point and find the rotation range listed for that curve in figure 1. Where the point is between two curves, the rotation range can be determined more precisely by projecting the point upward between the curves and noting at what ages it enters and leaves the shaded zone.

Stands whose basal areas fall well below curve E have poorly stocked overstories that should probably be harvested as soon as possible because these stands would have rotations of 160 to 180 years. Unless a suitable understory remains to form a new stand, black spruce should be rapidly reproduced to full stocking (see p. 2).

2. If the point is *in* the shaded zone, the stand is at the recommended rotation and can be harvested. The range of this rotation is determined the same way as explained in 1.

3. If the point is *above* the shaded zone, the stand is already past the recommended rotation and should be harvested and reproduced as soon as possible.

The rotations recommended here have a range because the mean annual growth has practically the same maximum for a number of years. Therefore, the manager has considerable flexibility in selecting a suitable rotation, at least in terms of growth. Further, figure 1 shows that the rotations are shorter for stands with high basal areas than for those with low basal areas, or that rotations increase as basal area decreases. However, except for excluding trees smaller than 3.6 inches d.b.h., the rotations do not consider tree size. Therefore, excessively dense stands may require longer rotations before yields from merchantable trees are large enough for efficient harvesting.

Of course, factors other than maximum mean annual growth and tree size should be considered in selecting a suitable rotation. The presence of, or risk involved with, some of black spruce's damaging agents, especially wind and dwarf mistletoe, will tend to shorten the rotation (see p. 9). Butt rot, which can lead to wind breakage, becomes common after about 100 years in stands on organic soil. This rot becomes serious enough in stands on mineral soil that their rotation should usually not exceed 70 years. To further help the manager select a suitable rotation for a certain stand, yield and growth at various ages are given in the Appendix by site index and basal area.

Intermediate Treatment

Little research or experience is available on managing immature stands of black spruce. Desirable stand densities for various ages and sites are not known for optimum pulpwood growth under present utilization standards. Thinning of overstocked stands in the sapling and pole stage is not recommended for black spruce due to the low economic return and risk of increasing wind-caused mortality.

In seedling stands a milacre[3] stocking of 60 percent or more is considered satisfactory if the trees are *established* (at least 6 inches tall and healthy). Practical methods do not presently exist for establishing black spruce in understocked stands, except to leave seed-bearing trees so that spruce can gradually reproduce by natural seeding. Seedling stands are probably overstocked when they exceed 10,000 trees per acre. Such stands should be prevented by controlling natural or direct seeding, as discussed on pages 8 and 9.

Although it grows faster in full sunlight, black spruce is tolerant of shade and on most organic soil sites it will eventually grow above competing shrubs or hardwoods. However, slow growth and understocking result when black spruce is severely suppressed by such vegetation for several years, as often happens on the best sites. Under these conditions spruce should be released *before* its growth and ability to respond are reduced too much.

Aerial herbicide spraying is probably the most practical way to kill back overtopping shrubs and hardwoods. A low volatile ester of 2,4-D[4] is effective on speckled alder, black ash, quaking aspen, paper birch, and willow; whereas a 50-percent mixture with 2,4,5-T is recommended if red maple and balsam poplar 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 the new growth of black spruce has hardened off 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

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

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

of ponds, lakes, and watercourses. These guidelines will minimize the risk of adverse environmental effects on organic soil sites.

Controlling Establishment and Composition

Clearcutting Methods

For several reasons mentioned elsewhere in this handbook, clearcutting, or felling of *all* trees, is the best method for harvesting and reproducing black spruce. The shape and size of a clearcut area depend mainly on whether broadcast burning of slash is recommended in the key, size and windfirmness of stand, seed supply, and economic considerations.

If broadcast burning is recommended, its cost per acre can be reduced substantially by clearcutting large patches (40 acres or more) rather than progressive strips. Cost of harvesting and later cultural operations also tends to be lower on such patches than on strips. However, clearcutting of large patches (or entire stands less than 40 acres) should usually be followed by direct seeding (see p. 9), whose cost may offset the above savings. Since it is sometimes difficult to obtain enough seed of acceptable provenance at reasonable cost, the manager should consider carefully whether to clearcut large patches that require direct seeding[5] or progressive strips that are seeded naturally (figs. 2 and 3).

Progressive strips can be applied best in large stands that are windfirm and do not require broadcast burning. The strips should probably be perpendicular to, and progress toward, the prevailing wind direction to maximize seed dispersal and minimize wind damage.

Natural seeding of black spruce can be relied on up to 4 chains (1 chain = 66 feet) from the windward side of a mature stand and up to 2 chains from the leeward side. Thus a strip perpendicular to the prevailing wind direction can be up to 6 chains wide with natural seeding from both sides, or 4 chains wide with seeding only from the windward side. Also, the outer portion of large patches can often be reproduced by natural seeding, thus importantly reducing the area requiring direct seeding.

[5] *Planting may be better on upland sites.*

Stands as small as 20 acres can be clearcut and broadcast burned in strips 3 chains wide if desired. Of course, the shape of such stands may be the main factor in deciding which way to orient the strips. Because harvesting and other costs depend so much on the particular situation, the manager must decide what minimum size of clearcut area is still economical.

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

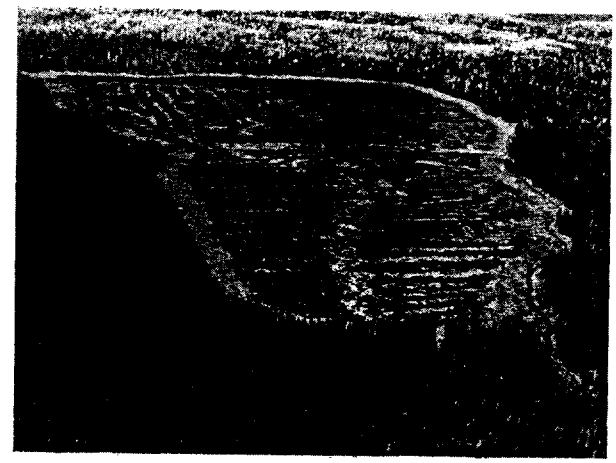


Figure 2. — *This 98-acre patch was clearcut, broadcast burned, and direct seeded. Note the unburned, slash-free alley next to the surrounding forest.*

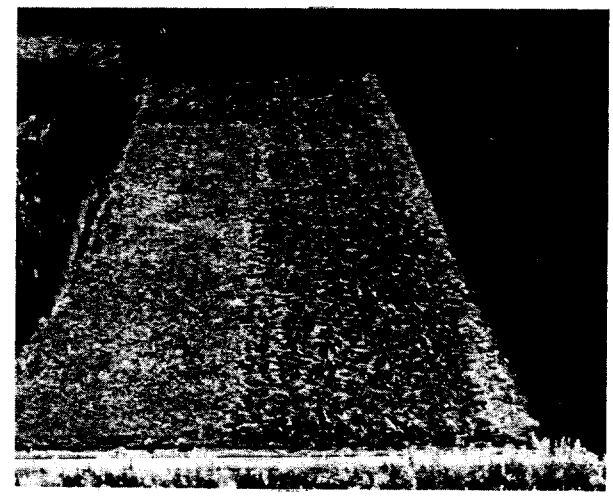


Figure 3. — *These two strips, each about 4 chains wide and 1/4 mile long, were clearcut and broadcast burned 4 years apart; future strips will progress into the mature stand at the right. Note the unburned, slash-free alley next to the stand.*

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 black spruce reproduction. 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.

Residual stems should be relied on to reproduce a stand only if relatively young and healthy black spruce 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 black spruce stems remaining after clearcutting are 50 or more years old or have poorly developed crowns. 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, but young seedlings are preferred for reproducing black spruce.

Therefore, residual stems should be saved to reproduce a stand only if: (1) 60 percent or more of the milacres in the clearcut area will contain at least one young and healthy black spruce *after* harvesting and (2) the cost of saving such stems does not exceed the cost of obtaining new spruce reproduction of equal density *and* size. Obviously, the stand must be harvested carefully and slash removed where it covers needed stems.

Residual stems should be killed if suitable black spruce are not present to form a new stand. This is most important where these stems are abundant or will reproduce abundantly after clearcutting. Broadcast burning of slash is an efficient way to kill residual conifers, especially where many are of seedling or sapling size. Burning will also kill back hardwoods, but herbicides are more effective on those that reproduce mainly from suckers or sprouts.

Aerial herbicide spraying should be used if there are many residual hardwoods per acre, whereas scattered trees and stumps should be treated individually. To minimize suckering and sprouting, herbicide should be applied to a frill girdle around the base of uncut hardwoods 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[6] (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.

Brush

Black spruce stands are usually brushy on the best sites on organic soil. An understory of tall shrubs such as speckled alder and red-osier dogwood is typical (fig. 4). In contrast, stands on medium to poor sites are nonbrushy and have only some low shrubs such as Labrador-tea and leather-leaf (fig. 5).

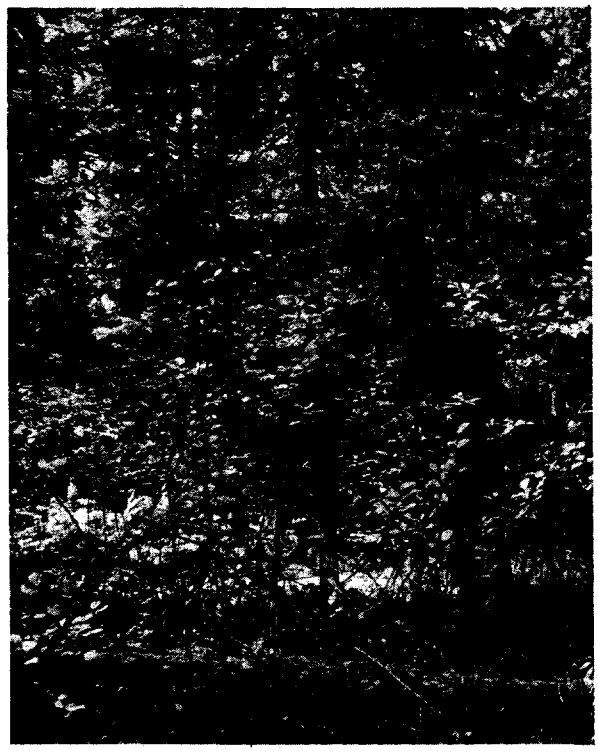


Figure 4. – *This brushy stand of black spruce is typical of those occupying the best sites on organic soil. As shown here, a readily noticeable understory of tall shrubs such as speckled alder is usually present.*

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

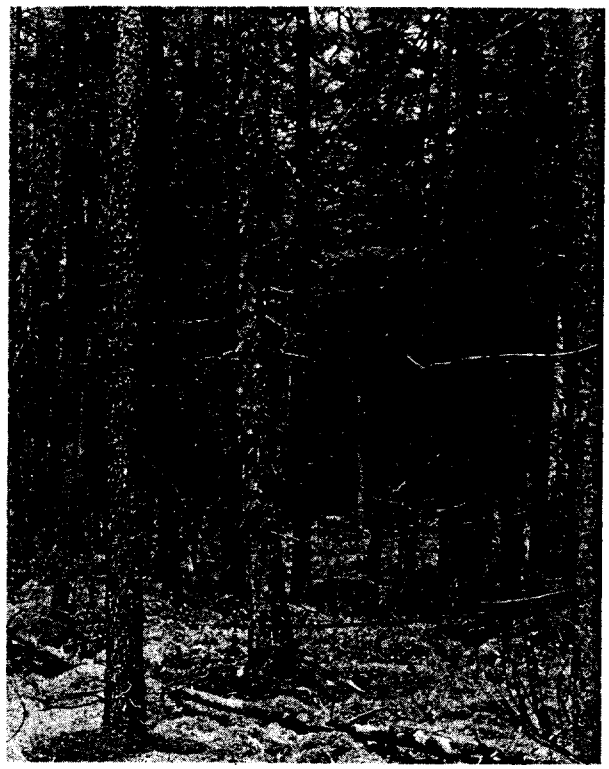


Figure 5. – *This nonbrushy stand of black spruce is typical of those occupying medium to poor sites on organic soil. As shown here, practically no understory is present except for some low shrubs such as Labrador-tea.*

Brush density is difficult to judge because it usually increases greatly after clearcutting. Also, brush is less noticeable when the leaves are off. Therefore, brush should be rated "absent or inconspicuous" only after inspecting the stand carefully – preferably when the leaves are on. Brush that is "readily noticeable" should be controlled because it will probably become dense enough to suppress black spruce reproduction.

Broadcast burning of slash is recommended on brushy sites because it has resulted in good initial establishment of black spruce, especially where ample natural seeding was available. Even so, brush and other competing vegetation, particularly grasses and sedges, overtop many seedlings and reduce their growth within a few years on burn areas. Therefore, black spruce reproduction on brushy sites will usually need release as discussed and prescribed under "Intermediate Treatment" (p. 4).

Seedbeds

Seedling establishment requires a moist but unsaturated seedbed free from competing vegetation. Establishment is generally successful if the surface layer is: (1) removed, either by fire or machine; (2) compacted, as in a skid road; or (3) composed of living sphagnum moss. Most types of sphagnum moss are good seedbeds, although some types outgrow black spruce seedlings and smother them. Other mosses, particularly the feather mosses, dry up and die after clearcutting and become extremely poor seedbeds (fig. 6). Thus seedbed conditions are usually much improved by removing or compacting such mosses.

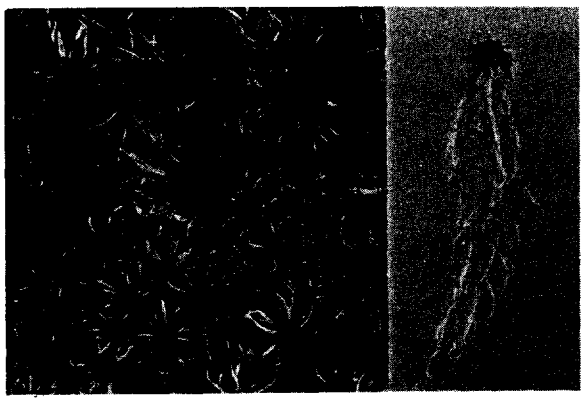
Sphagnum seedbeds are "well distributed" when exposed patches of sphagnum moss occur in at least 60 percent of the milacres in the clearcut area, or at a square spacing not exceeding about 10 feet.

Slash Cover

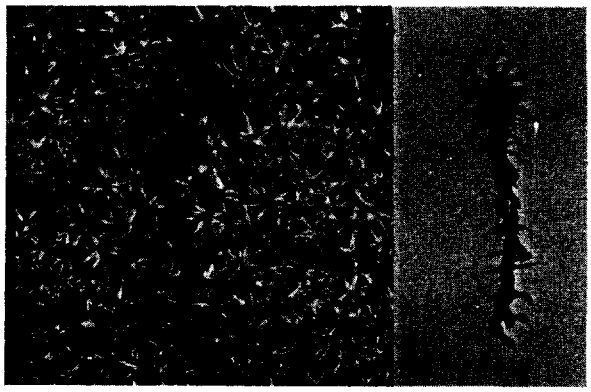
This is "heavy" when slash hinders satisfactory reproduction by burying either suitable residual stems or good seedbeds such as sphagnum moss. Slash cover is also heavy when it creates an important fire hazard. However, the risk of fire is low on most black spruce areas because they do not dry up much and there is little contact with human activities.

Slash should be broadcast burned for all conditions where this is recommended in the key, including where a heavy cover of slash is *already* on the ground. However, if slash cover is the only problem expected, then full-tree skidding can be used. This is because recent research indicates that stands harvested by full-tree skidding, with branches and tops intact, leave only a light cover of slash when felling and skidding are done with reasonable care. 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.

The overall cost of slash disposal should be less by full-tree skidding than by broadcast burning if most trees are merchantable. Skidding should be particularly advantageous on small areas because they have the highest burning cost per acre. Of course, slash disposal is usually not needed in poorly stocked stands when the slash is spread evenly.

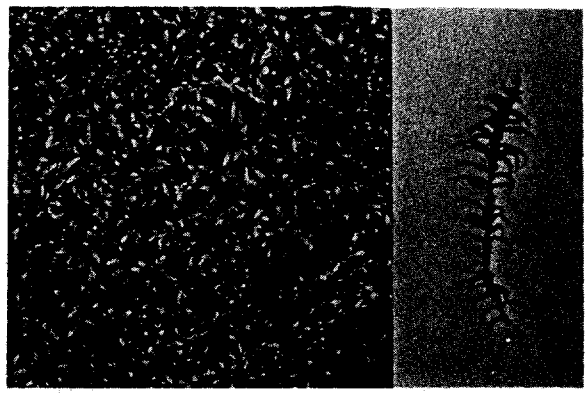


Sphagnum spp.

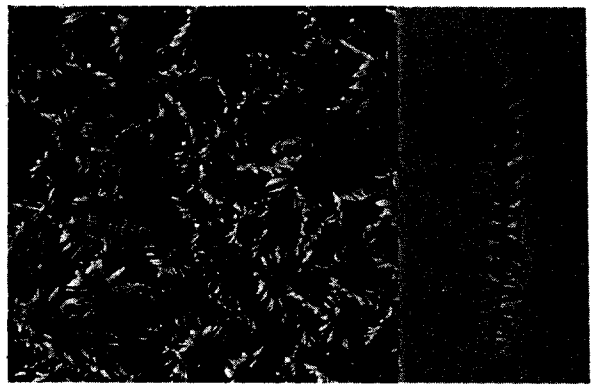


Dicranum polysetum

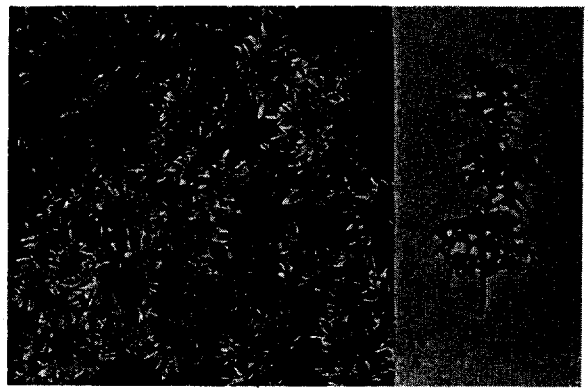
FEATHER MOSSES



Pleurozium schreberi



Ptilium crista-castrensis



Hylocomium splendens

Figure 6. – *These mosses are common seedbeds in black spruce stands, particularly on nonbrushy sites. All except sphagnum make poor seedbeds because they dry up and die after clearcutting. The photos all have the same scale; the individual plants are about 3 inches tall.*

Natural Seeding

Black spruce is a dependable seed producer. A mature stand produces an average of perhaps 200,000 seeds – about 8 ounces – per acre per year. Although most of this seed falls in or near the stand, reproduction surveys indicate that a sufficient amount is dispersed far enough to effectively reforest an adjacent clearcut area of substantial size (see p. 5).

Natural seeding of black spruce, especially on nonbrushy sites, often results in new stands that are too dense for optimum pulpwood growth under present utilization standards. To minimize this problem, the manager should survey the reproduction about 3 years after site preparation and if stocking is satisfactory (see p. 4), the adjacent area (strip or stand) of mature spruce should be clearcut to eliminate further seeding into the new stand. When this cutting removes all mature spruce within seeding range (see p. 5), the area can be seeded artificially after broadcast burning, or perhaps

naturally by seed dispersed before and during full-tree skidding.

Many of the common tree associates of black spruce reproduce on clearcut areas, especially on slash-burned seedbeds. Tamarack reproduces well after broadcast burning on organic soil sites if even a few seed-bearing trees are within 3 chains. Although it is usually outnumbered by black spruce, tamarack grows faster and so will probably be an important component of the new stand. This means that managers who want pure stands of black spruce should harvest or otherwise kill all seed-bearing tamaracks within 3 chains of clearcut areas *before* burning. Seeding from such trees could also be avoided by clearcutting large areas whose interiors are beyond the seeding range of tamarack.

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 tamarack, so it is probably impractical to substantially reduce their natural seeding. Fortunately, aspen and birch are not expected to severely suppress black spruce except on the best sites. Here herbicide spraying may be necessary to release the spruce as discussed and prescribed under "Intermediate Treatment" (p. 4).

Direct Seeding

When deciding whether or not to clearcut large areas that require direct seeding, the manager should find out if he can obtain enough seed of acceptable provenance at reasonable cost.

Black spruce has generally been direct seeded at a rate of about 4 ounces (100,000 seeds) per acre to obtain a milacre stocking of at least 60 percent. This has sometimes resulted in overstocking, so 2 to 3 ounces of seed per acre should be adequate on well-prepared sites. However, the manager should check the resulting reproduction success before using this lower rate on a large scale.

The seed need not be stratified but probably should be treated with Arasan, an approved and effective bird repellent and fungicide. Sowing should be done between March and mid-May of the first year following burning. A hand seeder with filler such as fine-textured vermiculite is efficient for seeding small areas. Aircraft or snowmobiles are more efficient for seeding large areas.

Controlling Damaging Agents

Wind

Breakage and uprooting of trees by wind are two of the most important causes of mortality in older stands of black spruce. Wind breakage is more frequent in stands with butt rot, which becomes common after about 100 years on organic soil and 70 years on mineral soil. 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.

Dwarf Mistletoe

Eastern dwarf mistletoe is the most serious disease of black spruce in the Lake States. If it is present, trees will have "witches' brooms", which are easy to identify (fig. 7). Mistletoe significantly reduces volume growth and eventually kills trees, so it should be controlled, especially on the better sites. This can be done by killing infected trees because mistletoe survives only on living trees and it spreads slowly.

Figure 7. – *These readily noticeable witches' brooms are typical of those occurring in black spruce stands that are heavily infected with eastern dwarf mistletoe.*

The following general guidelines are recommended to help the manager control mistletoe:

1. Reproduce and maintain dense stands because infection spreads more slowly and causes less damage in them than in open stands.

2. Clearcut mature stands whether they have mistletoe or not. However, if witches' brooms are readily noticeable, clearcut not only the infected area but also a surrounding isolation strip of black spruce that appears to be *entirely uninfected.* This is to remove latent infections that cannot be seen. The strip should be at least 1 chain (66 feet) wide and 2 chains are preferable if the margins of the infected area are indistinct.

All infected trees, including advance reproduction and especially any tall unmerchantable stems, must be cut or otherwise killed to prevent new reproduction from becoming infected. Broadcast burning of slash on clearcut areas is highly recommended because it is an effective and economical way to kill all residual trees and to prepare the site for black spruce reproduction. (See Appendix, p. 15, for burning techniques.)

3. Small pockets (5 acres or less) of infected trees can arise in immature stands from mistletoe seed carried inadvertently by birds or small mammals. These pockets should be controlled because they gradually enlarge and are a source of seed for starting new pockets, which can eventually merge with older ones. As in mature stands, all trees (including reproduction) should be killed in the infected pocket and surrounding 1- to 2-chain-wide isolation strip. This can be done by cutting but it is desirable to broadcast burn the slash where feasible.

4. Areas treated for mistletoe and those where witches' brooms are inconspicuous or apparently absent should be checked in 10 years to make sure the disease is under control.

Impeded Drainage

Poorly constructed or maintained roads have killed black spruce or reduced its growth 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 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

Fortunately, the other damaging agents of black spruce seldom are serious. Wildfire easily kills black spruce 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. Needle rusts may discolor and defoliate some trees enough to spoil them for Christmas trees. Insects such as the spruce budworm, eastern spruce beetle, and certain sawflies occasionally attack black spruce. Snowshoe hares sometimes debark and browse reproduction, and red squirrels can spoil Christmas trees by clipping cone-bearing branches. Black spruce is browsed occasionally by moose but rarely by white-tailed deer.

OTHER RESOURCE CONSIDERATIONS

Christmas Trees

Extensive stands of black spruce with a site index of less than 25 have supported a sizable Christmas tree industry for several decades, particularly in Minnesota. These Christmas trees, which require special processing to retain their needles, are the top 3 feet of old trees about 20 to 35 feet tall. Since only some trees have suitable tops, the stands are partially cut. Many stands have been cut more than once about 10 years apart when other trees have developed satisfactory tops.

However, harvesting of black spruce Christmas trees has declined greatly in recent years and is now on a limited scale. This is apparently because most of the present stands are no longer producing suitable trees for the market, which requires higher quality than it used to. Therefore, the future of black spruce Christmas trees and how to manage for them are uncertain.

The best indications are that a limited market will continue, but that there is considerable potential to

expand it by producing better quality trees. The specific requirements for such trees would have to be worked out with industry. However, these trees could probably be grown faster and more efficiently if management is concentrated on less extensive areas where the site is somewhat better than in present stands, or is improved by a limited amount of drainage and perhaps fertilization. It is also possible that some of the stands that were cut earlier will produce another crop of Christmas trees in the future.

As in the past, stands that are managed for black spruce Christmas trees in the future should be partially cut about every 10 years. If they are not harvested regularly some trees may become unmarketable. For example, red squirrels can spoil tree form by clipping cone-bearing branches during good seed years. Trees of acceptable quality will usually not be abundant enough to result in overcutting the stand. Since succeeding crops come from the remaining stand, it should be protected as much as possible during each cutting. Fortunately, wind damage is rare because the trees are shorter and more open grown than in pulpwood stands.

Wildlife Habitat

The black spruce type is utilized to some extent by many wildlife species, a few of which are mentioned elsewhere in this handbook. New harvest areas and young stands certainly produce different or more abundant browse and other wildlife food than mature black spruce stands. Therefore, shrubs and hardwoods should not be killed back with herbicide spraying until black spruce reproduction definitely needs release (see p. 4). And even then, all dogwood, willow, quaking aspen, and other hardwoods should not be killed because some mixture of these shrubs and trees with black spruce probably enhances wildlife habitat.

The spruce grouse is of special interest because it depends on the black spruce type for most of its habitat needs. Spruce grouse apparently use noncommercial black spruce sites more than commercial sites, so their habitat may be only moderately affected by timber management. However, spruce grouse habitat can probably be maintained or enhanced on commercial sites by having the following kinds of black spruce stands within compartments of 160 acres or less:

1. Mature stands with high basal areas (more than 150 square feet per acre) are important as display habitat for male grouse in late spring. These stands are characterized by little or no undergrowth and a ground cover of feather moss.
2. Young stands of black spruce 10 to 15 feet tall with dense shrub and herbaceous layers are used by female grouse for cover and feeding before and after nesting. Labrador-tea and leather-leaf are usually the dominant species of the undergrowth and sphagnum moss of the ground cover.
3. Mature spruce stands with moderate basal areas (80 to 100 square feet per acre) and little or no undergrowth, as well as young spruce stands with a dense shrub cover, are used for nesting.
4. Black spruce stands with trees 20 to 60 feet tall and about 150 square feet of basal area per acre are important habitat for both sexes in fall and winter.

Therefore, to provide the overall habitat needs of spruce grouse, harvesting of black spruce should be planned carefully so that each compartment will have the kinds of stands just described. This can be done by clearcutting in strips or patches that are well distributed in the compartment and over time. Further, the objective should be to break up extensive, pure stands of black spruce because transition zones with other forest types and some mixture of tamarack seem to benefit spruce grouse. Recording the kind and density of undergrowth in spruce stands during forest inventory would aid the manager interested in coordinating timber and grouse management.

Water

Current research findings indicate that clearcutting black spruce in strips or large patches, or broadcast burning the slash changes the quantity of water little on organic soil sites. 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 of the black spruce 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 either be broadcast burned or removed by full-tree skidding and burned at the landing.

APPENDIX

Yield and Growth

The information presented here enables the manager to estimate the present yield and future growth of any black spruce stand given its site index, age, and basal area. Site index is obtained from the average age (total) and average height (total) of dominant and codominant trees (fig. 8). Yield and growth are given in *total cubic feet* (gross peeled volume of entire stem) (tables 1 and 2) and in *cords* (gross rough volume to a variable top d.i.b. of not less than 3.0 inches) (tables 3 and 4). All values are for trees 3.6 inches d.b.h. and larger. Growth is periodic *net annual* increment, which takes into account ingrowth and mortality.

The yield of any stand can be projected by adding present yield and future growth. However, growth should not be calculated for more than a 10-year period. The following example shows how to use the tables: What is the estimated cubic-foot yield in 5 years of a stand with site index 35, age 140 years, and basal area 110 square feet per acre? First, determine the present yield from table 1; this requires interpolating between the values for 100 and 120 square feet of basal area. So present yield = (2,090 + 2,500) ÷ 2 = 2,295. Second, determine the net annual growth from table 2 and multiply this by 5 to get the total growth for 5 years; (50 + 46) ÷ 2 = 48 and 48 x 5 = 240. Therefore, the stand's yield in 5 years = 2,295 + 240 = 2,535 cubic feet.

The manager should use the yield and growth information in this handbook with caution, especially on mineral soil sites. The site index curves (fig. 8) are based on stands that presumably grew on mineral soil sites and organic soil sites, so these curves should be satisfactory for both kinds of sites. Also, the yields (tables 1 and 3) should be reasonably accurate for both kinds of sites because various basal areas can be used to take care of any differences in stand density. However, the values for growth (tables 2 and 4) should be used with considerable caution on mineral soil sites because these values are based on data from organic soil sites, which may have somewhat different growth rates. For more complete and detailed information on yield and growth, the manager should consult the reference footnoted in the tables.

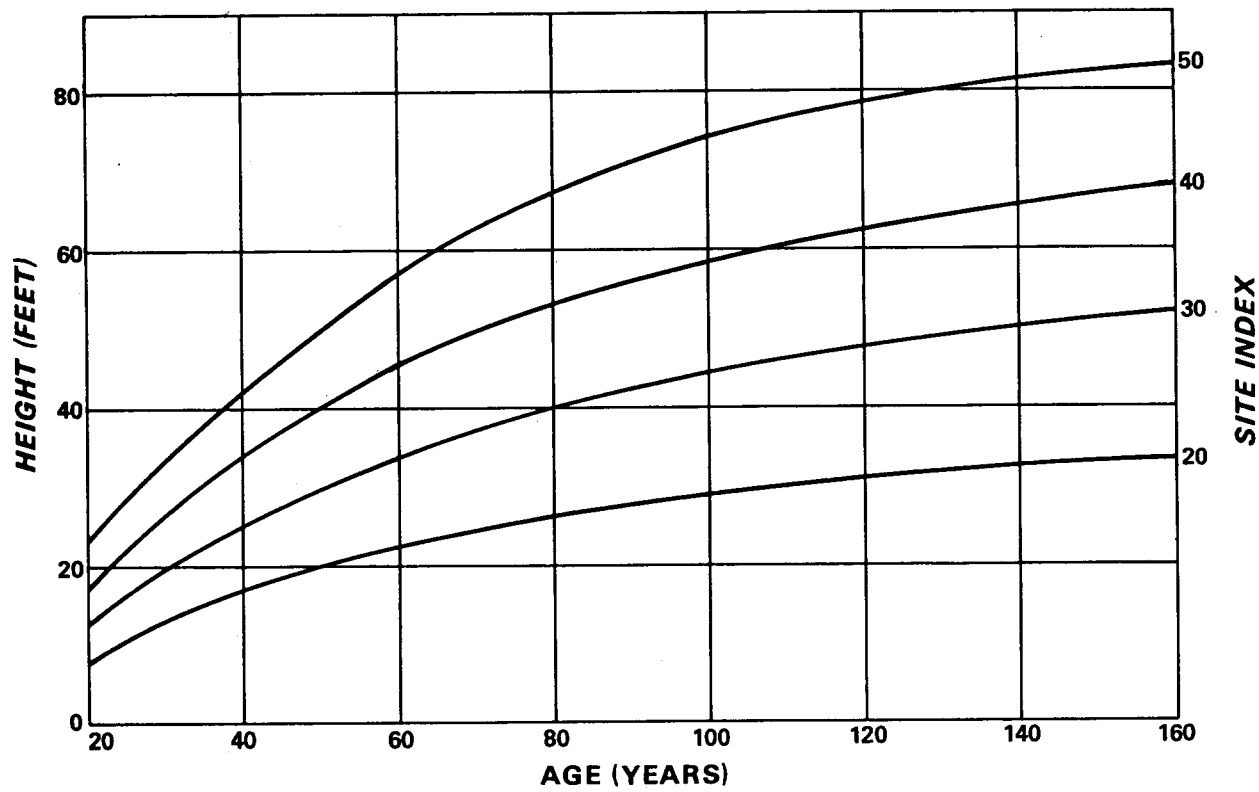


Figure 8. – *Site index curves for black spruce stands. Adapted from Perala 1971.*

Table 1. – *Cubic-foot yield of black spruce stands by site index, age, and basal area*[1]

Age (years)	Height of dominants and co-dominants (feet)	Basal area per acre (square feet) 60	80	100	120	140	160
		Total cubic feet per acre					
SITE INDEX 45							
60	51	1,360	1,800	2,230	2,660	3,090	--
80	60	1,420	1,870	2,320	2,770	3,220	3,660
100	67	1,450	1,920	2,380	2,840	3,290	3,750
120	71	1,470	1,950	2,420	2,880	3,350	3,810
140	74	1,490	1,970	2,440	2,910	3,380	3,850
160	77	1,500	1,980	2,460	2,940	3,410	3,880
SITE INDEX 35							
60	40	1,170	1,540	1,910	2,280	2,650	--
80	46	1,210	1,600	1,990	2,380	2,760	3,140
100	51	1,240	1,640	2,040	2,430	2,820	3,210
120	55	1,260	1,670	2,070	2,470	2,870	3,260
140	58	1,280	1,690	2,090	2,500	2,900	3,300
160	60	1,290	1,700	2,110	2,520	2,930	3,330
SITE INDEX 25							
60	28	950	1,250	1,560	1,860	--	--
80	33	990	1,310	1,620	1,930	2,240	--
100	36	1,010	1,340	1,660	1,980	2,300	2,610
120	38	1,030	1,360	1,690	2,010	2,330	2,660
140	40	1,040	1,370	1,700	2,030	2,360	2,690
160	42	1,050	1,380	1,720	2,050	2,380	2,710

[1]Values are for trees 3.6 inches d.b.h. and larger. Adapted from Perala 1971.

Table 2. – *Net annual cubic-foot growth of black spruce stands by site index, age, and basal area*[1]

Age (years)	Basal area per acre (square feet) 60	80	100	120	140	160
	Total cubic feet per acre					
SITE INDEX 45						
60	92	85	68	44	16	--
80	76	74	64	48	26	--
100	66	67	62	50	34	14
120	59	62	60	52	41	25
140	54	58	59	54	46	34
160	50	56	57	55	50	43
SITE INDEX 35						
60	78	73	58	38	14	--
80	65	64	55	41	22	--
100	56	58	53	43	29	12
120	50	53	51	45	35	21
140	46	50	50	46	39	29
160	43	48	49	48	43	37
SITE INDEX 25						
60	64	59	48	31	--	--
80	53	52	45	33	18	--
100	46	47	43	35	24	10
120	41	43	42	36	28	17
140	37	41	41	38	32	24
160	35	39	40	39	35	30

[1]Values are for trees 3.6 inches d.b.h. and larger. Adapted from Perala 1971.

Table 3. – *Cordwood yield of black spruce stands by site index, age, and basal area*[1]

Age (years)	Height of dominants and co-dominants (feet)	Basal area per acre (square feet)					
		60	80	100	120	140	160
		Cords per acre					
SITE INDEX 45							
60	51	14	18	22	27	31	--
80	60	15	20	24	29	33	38
100	67	16	20	25	30	35	40
120	71	16	21	26	31	36	41
140	74	16	22	27	32	37	42
160	77	17	22	27	32	38	43
SITE INDEX 35							
60	40	10	14	17	20	23	--
80	46	11	15	18	22	25	29
100	51	12	16	19	23	26	30
120	55	12	16	20	24	27	31
140	58	12	16	20	24	28	32
160	60	13	17	21	25	28	32
SITE INDEX 25							
60	28	7	10	12	14	--	--
80	33	8	10	13	15	18	--
100	36	8	11	13	16	18	21
120	38	8	11	14	16	19	22
140	40	9	11	14	17	19	22
160	42	9	12	14	17	20	22

[1]Values are for trees 3.6 inches d.b.h. and larger. Adapted from Perala 1971.

Table 4. – *Net annual cordwood growth of black spruce stands by site index, age, and basal area*[1]

Age (years)	Basal area per acre (square feet)					
	60	80	100	120	140	160
	Cords per acre					
SITE INDEX 45						
60	1.0	0.9	0.7	0.5	0.2	--
80	.8	.8	.7	.5	.3	--
100	.7	.7	.7	.6	.4	0.2
120	.6	.7	.7	.6	.5	.3
140	.6	.6	.6	.6	.5	.4
160	.6	.6	.6	.6	.6	.5
SITE INDEX 35						
60	0.7	0.7	0.6	0.4	0.2	--
80	.6	.6	.5	.4	.2	--
100	.5	.6	.5	.4	.3	0.1
120	.5	.5	.5	.4	.3	.2
140	.4	.5	.5	.4	.4	.3
160	.4	.5	.5	.5	.4	.4
SITE INDEX 25						
60	0.5	0.5	0.4	0.3	--	--
80	.4	.4	.4	.3	0.2	--
100	.4	.4	.4	.3	.2	0.1
120	.3	.4	.3	.3	.2	.2
140	.3	.3	.3	.3	.3	.2
160	.3	.3	.3	.3	.3	.2

[1]Values are for trees 3.6 inches d.b.h. and larger. Adapted from Perala 1971.

Broadcast Burning Techniques

Research and experience in northern Minnesota and upper Michigan have shown that black spruce slash, whether pure or mixed with slash of associated conifers, can be broadcast burned safely, effectively, and economically 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 a recommended practice (see p. 2), the area involved must be located and harvested in such a way that it can be burned safely and efficiently. The main requirements for setting up and conducting a successful broadcast burn are:

1. Locate burn area 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 burn area smooth and reasonably straight to avoid control problems resulting from sharp angles.
3. Cut all unmerchantable trees near the edge of the burn area.
4. Plan cutting and skidding so as to distribute the slash evenly, thus ensuring that the fire will spread over the entire burn area.
5. Leave a slash-free alley about 1/2 chain wide around the perimeter of the burn area.
6. Burn slash within a 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 away from adjacent timber to avoid serious crown scorch or mortality. If the burn area is completely surrounded by timber or the desired wind direction is uncommon, then use center firing when the wind speed is only 0 to 5 miles per hour.

Black spruce slash has been broadcast burned successfully under a wide range of conditions. However, research and experience indicate that burning severe enough to kill back brush or improve nonsphagnum seedbeds requires drier and hotter conditions than burning to just consume slash or kill residual trees, which simultaneously eradicates dwarf mistletoe. Most burning has been done under the following conditions:

Time or weather variable	Burns in general	Severe burns
Time of year	May to October	July to August
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 must be severe enough to expose mineral soil if natural or direct 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 5/9 (°F-32) or $\frac{°F-32}{1.8}$.

Common and Scientific Names of Plants and Animals

Plants

Common name	*Scientific name*
Alder, speckled	*Alnus rugosa*
Ash, black	*Fraxinus nigra*
Aspen, quaking	*Populus tremuloides*
Birch, paper	*Betula papyrifera*
Dogwood, red-osier	*Cornus stolonifera*
Fir, balsam	*Abies balsamea*
Labrador-tea	*Ledum groenlandicum*
Leather-leaf	*Chamaedaphne calyculata*
Maple, red	*Acer rubrum*
Mistletoe, eastern dwarf	*Arceuthobium pusillum*
Moss:	
Dicranum	*Dicranum polysetum*
Feather	Main species are: *Hylocomium splendens*, *Pleurozium schreberi*, *Ptilium crista-castrensis*
Sphagnum	*Sphagnum* spp.
Poplar, balsam	*Populus balsamifera*
Rust, needle	*Chrysomyxa* spp.
Spruce, black	*Picea mariana*
Tamarack	*Larix laricina*
White-cedar, northern	*Thuja occidentalis*
Willow	*Salix* spp.

Animals

Beaver	*Castor canadensis*
Beetle, eastern spruce	*Dendroctonus obesus*
Budworm, spruce	*Choristoneura fumiferana*
Deer, white-tailed	*Odocoileus virginianus*
Grouse, spruce	*Canachites canadensis*
Hare, snowshoe	*Lepus americanus*
Moose	*Alces alces*
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.

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