USDA Forest Service
Research Paper NC-64
1971

William F. Johnston

Management GUIDE For the BLACK SPRUCE type in the Lake States

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

FOREWORD

This management guide applies only to the black spruce forest type in the Lake States where the species grows in pure stands or in mixed stands where it predominates. The guide does not apply to stands where black spruce is an important but not the predominant tree species, such as in the mixed conifer swamp type, the white spruce-balsam fir type, and the jack pine type.

Forests of the black spruce type produce pulpwood and Christmas trees in the Lake States where they occupy 2 million acres of commercial forest land – the largest acreage of the type south of Canada. The most extensive stands are in northern Minnesota, which has two-thirds of the black spruce type in the Lake States. The remainder occurs in Upper Michigan, and to a lesser extent, in northern Wisconsin.

The management practices recommended here are based on research and experience. Unique situations and further research findings may require modification of the recommendations. The forest manager must therefore exercise good judgment in using this guide and must be alert to improved ways of handling the black spruce type.

The author is a Silviculturist for the Station at its Northern Conifers Laboratory in Grand Rapids, Minnesota. The Laboratory is maintained in cooperation with the University of Minnesota. Grateful acknowledgment is due the several industrial, State, and Federal foresters in the Lake States who improved this guide by making helpful review comments.

North Central Forest Experiment Station
D. B. King, Director
Forest Service – U.S. Department of Agriculture
Folwell Avenue
St. Paul, Minnesota 55101

(Maintained in cooperation with the University of Minnesota)

Manuscript approved for publication April 13, 1971.

MANAGEMENT GUIDE FOR THE BLACK SPRUCE TYPE IN THE LAKE STATES

William F. Johnston

SOIL-SITE RELATIONS

The black spruce[1] type is found mainly on organic soil in the Lake States, but it also occurs on mineral soil. Growth rate varies greatly on organic soil sites. Height of dominant trees at 50 years ranges from about 50 feet on the best sites to less than 15 feet on the poorest. Mature stands commonly yield 30 cords per acre on good sites, whereas many stands on poor sites never produce merchantable quantities of pulpwood. Many poor-site stands, however, are harvested for small Christmas trees.

Growth rate on organic soil apparently is related to the amount of nutrients received in ground water flowing from adjacent mineral soil. Thus the best sites are immediately downslope from mineral soil areas. On these sites the soil is usually only a few feet deep, dark brown to blackish, and moderately well decomposed. In contrast, the poorest sites tend to be toward the center and along the lower margin of organic soil areas. On these sites the soil is often several feet deep and topped by a thick accumulation of poorly decomposed, yellowish-brown sphagnum moss.

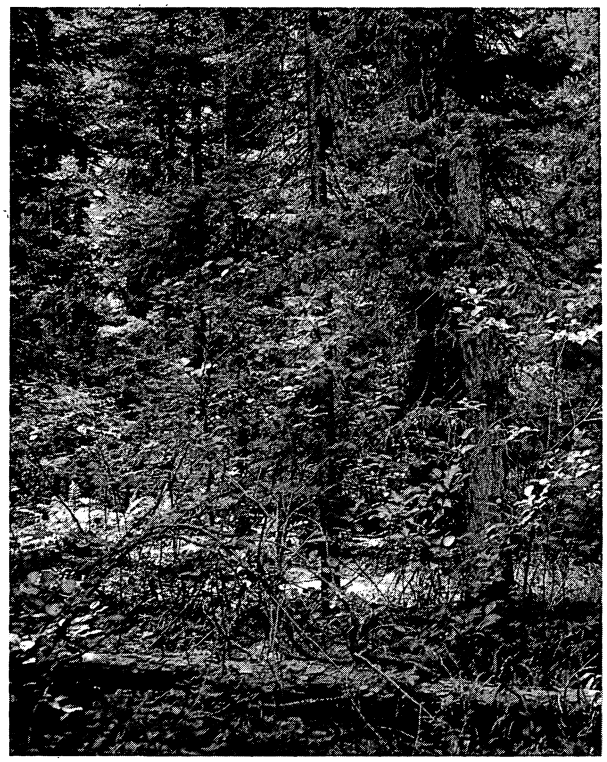
The black spruce type is common on mineral soil only on the Laurentian Shield in northeastern Minnesota and in a few isolated areas of Upper Michigan. Here black spruce grows on gravelly and bouldery loam and on shallow soil over bedrock, where it usually is mixed with other species, but occasionally 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.

ASSOCIATED VEGETATION

Tamarack, northern white-cedar, and balsam fir are the main tree species associated with black spruce on organic soil in the Lake States; jack pine, quaking aspen, paper birch, and white spruce are the main associates on mineral soil. Black ash, red maple, American elm, balsam poplar, eastern white pine, and red pine are other common tree associates, especially in the transition zone between organic and mineral soil.

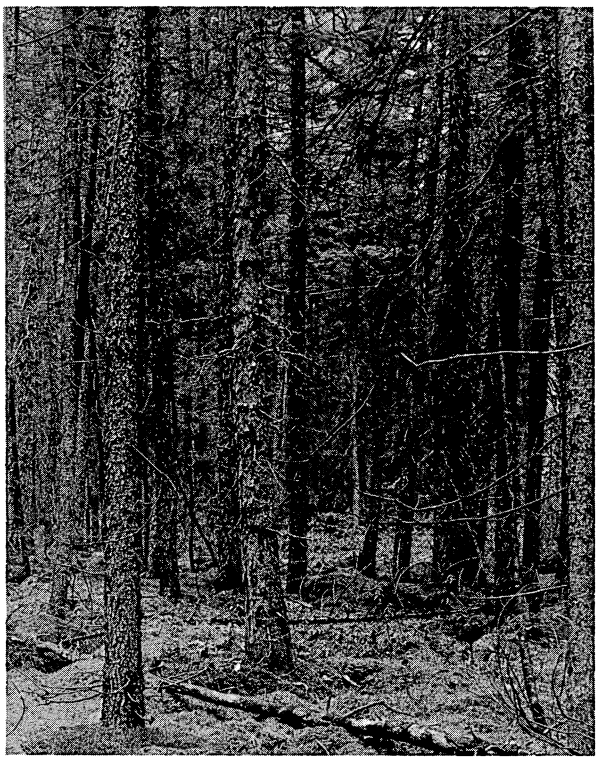
Black spruce stands are bushy on the best sites on organic soil. Tall shrubs such as speckled alder and red-osier dogwood are common, as are grasses and numerous other herbs (fig. 1). The ground cover is a mosaic of various mosses and litter. In contrast, stands on poorer sites have only low shrubs such as Labrador-tea and leather-leaf plus various sedges (fig. 2). Here the ground cover is characterized by feather mosses except on the poorest sites, where sphagnum moss predominates (fig. 3).

[1] *For scientific names of plants mentioned in text see page 12.*



F-517287

Figure 1. — This brushy stand of black spruce is typical of those occupying the best sites on organic soil. As shown here, a conspicuous understory of tall shrubs such as speckled alder is usually present.



F-519898

Figure 2. — 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.

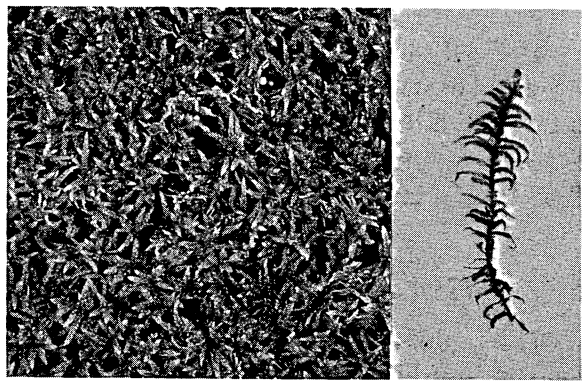
REPRODUCTION

Black spruce is a dependable seeder. 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. A mature stand produces an average of perhaps 200,000 seeds — about ½ pound — per acre per year. Although most of this seed falls in or near the stand, recent reproduction surveys indicate that natural seeding is effective up to 4 chains (1 chain = 66 feet) downwind from the edge of a stand.

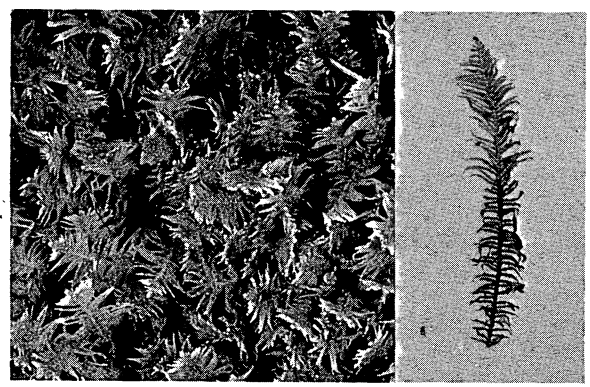
Seedling establishment requires a moist but unsaturated seedbed free from competing vegetation. Establishment is generally successful if the surface layer is: (1) removed, either by fire or machine; (2) compacted, as in a skid road; or (3) composed of living sphagnum moss. Most types of sphagnum moss 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. 3). Thus seedbed conditions are usually much improved by removing or compacting such mosses.

Vegetative reproduction of black spruce is common on the poorer sites on organic soil where sphagnum moss is the predominant ground cover. Here the moss often grows over segments of the lowest branches and induces the development of adventitious roots. These buried branch segments, or layers, thus result in new trees. Much of the advance growth remaining after clearcutting is of layer origin. Some of these trees grow well, but seedlings are preferred for reproducing black spruce.

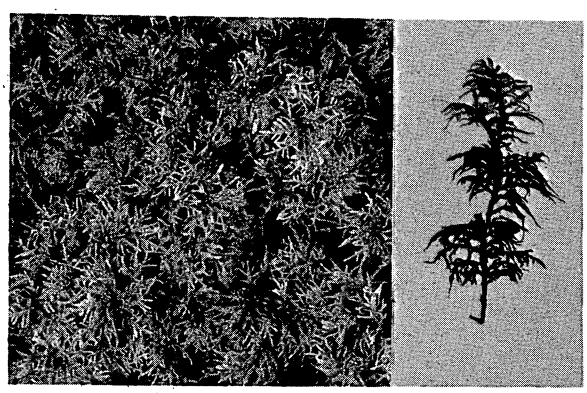
POOR SEEDBEDS: Feather mosses



Calliergonella schreberi

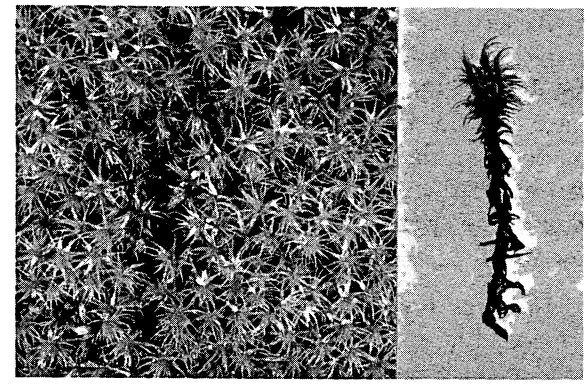


Hypnum crista-castrensis



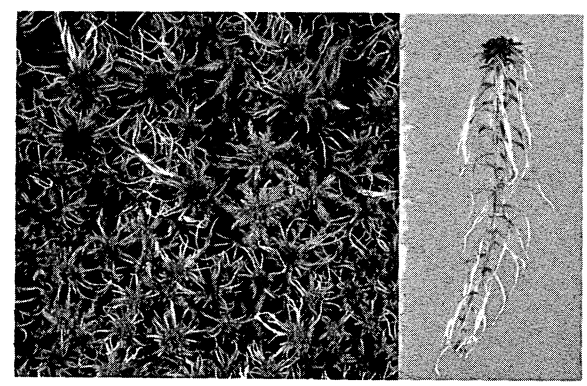
Hylocomium splendens

POOR SEEDBEDS: Dicranum mosses



Dicranum rugosum

GOOD SEEDBEDS: Sphagnum mosses



Sphagnum spp.

F-519899, 519900-519904

Figure 3. — These mosses are common seedbeds in black spruce stands, particularly on nonbrushy sites. All except sphagnum make poor seedbeds because they die and dry out following clearcutting. The photos are all ½ natural size.

STAND DEVELOPMENT

Most black spruce stands in the Lake States are or were once even-aged because wildfires burned periodically in abnormally dry years, long before logging and fire protection began. Black spruce reproduces successfully after a fire because the standing trees retain adequate seed in their cones and the seedlings grow much faster in the open burned area than under a living overstory.

In areas undisturbed by fire for a century or more, black spruce stands become uneven-aged because new trees begin to fill in as overstory trees die. Black spruce is not as tolerant of shade as two of its common competitors, northern white-cedar and balsam fir, and so may be succeeded by them in the absence of fire.

All-aged stands of black spruce are common in the Lake States only on the poorest sites on organic soil. This is probably because such sites have a low fire hazard and the trees are continuously reproduced from layers.

YIELD AND GROWTH

The yield and 10-year net growth of pulpwood in any black spruce stand can be determined given its site index, age, and basal area (tables 1 and 2). Site index is obtained from the

Table 1.—*Yields of black spruce stands in the Lake States by site index, age, and basal area*[1]
(In cords per acre)

Age (years)	Height of dominants and co-dominants (feet)	Basal area per acre (square feet)					
		60	80	100	120	140	160
SITE INDEX 45							
60	51	13.7	18.1	22.4	26.6	30.9	--
80	60	14.8	19.6	24.2	28.8	33.4	37.9
100	66	15.6	20.5	25.4	30.2	35.0	39.7
120	71	16.0	21.1	26.2	31.1	36.1	41.0
140	74	16.4	21.6	26.7	31.8	36.9	41.9
160	76	16.7	22.0	27.2	32.4	37.5	42.6
SITE INDEX 35							
60	40	10.4	13.7	17.0	20.2	23.4	--
80	47	11.3	14.8	18.4	21.8	25.3	28.8
100	51	11.8	15.5	19.2	22.9	26.5	30.1
120	55	12.2	16.0	19.8	23.6	27.4	31.1
140	58	12.4	16.4	20.3	24.1	28.0	31.8
160	60	12.7	16.7	20.6	24.6	28.4	32.3
SITE INDEX 25							
60	28	7.2	9.5	11.7	14.0	--	--
80	33	7.8	10.2	12.7	15.1	17.5	--
100	37	8.2	10.7	13.3	15.8	18.3	20.8
120	39	8.4	11.1	13.7	16.3	18.9	21.5
140	41	8.6	11.3	14.0	16.7	19.3	22.0
160	43	8.7	11.5	14.2	17.0	19.6	22.3

1/ Yields, which include trees 3.6 inches d.b.h. and larger, were obtained from Table 5 of Perala, Donald A., 1971. Growth and yield of black spruce on organic soils in Minnesota. USDA Forest Serv. Res. Pap. NC-56.

Table 2.—*Ten-year net growth of black spruce stands in the Lake States by site index, age, and basal area*[1]

(In cords per acre)

Age (years)	Basal area per acre (square feet)					
	60	80	100	120	140	160
SITE INDEX 45						
60	9.6	9.0	7.4	5.1	2.3	--
80	8.1	8.0	7.0	5.3	3.1	0.5
100	7.1	7.3	6.8	5.6	3.9	1.8
120	6.4	6.8	6.6	5.8	4.6	2.9
140	5.9	6.4	6.5	6.0	5.1	3.8
160	5.5	6.2	6.4	6.1	5.6	4.8
SITE INDEX 35						
60	7.3	6.8	5.6	3.8	1.8	--
80	6.2	6.1	5.3	4.0	2.4	0.4
100	5.4	5.6	5.1	4.2	3.0	1.4
120	4.9	5.2	5.0	4.4	3.4	2.2
140	4.5	4.9	4.9	4.5	3.9	2.9
160	4.2	4.7	4.8	4.6	4.2	3.6
SITE INDEX 25						
60	5.0	4.7	3.9	2.7	--	--
80	4.2	4.2	3.7	2.8	1.6	--
100	3.7	3.8	3.5	2.9	2.0	1.0
120	3.4	3.6	3.4	3.0	2.4	1.5
140	3.1	3.4	3.4	3.1	2.7	2.0
160	2.9	3.2	3.3	3.2	2.9	2.5

1/ Growth, which includes trees 3.6 inches d.b.h. and larger, was obtained from Table 8 of Perala, Donald A., 1971. Growth and yield of black spruce on organic soils in Minnesota. USDA Forest Serv. Res. Pap. NC-56.

stand's average total height and age (fig. 4). The yield of any stand can be projected 10 years by simply adding its net growth (table 2) to its present yield (table 1).

DAMAGING AGENTS

Breakage and uprooting of trees by wind are 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 guide, wind-caused mortality should be minimal.

The most serious pest of black spruce is dwarf mistletoe. Besides causing witches'-broom, it kills many trees and reduces volume growth on others. Dwarf mistletoe is probably best controlled by broadcast burning.

Fortunately, the other pests of black spruce seldom cause serious damage. Needle rusts may discolor and defoliate some trees enough to disqualify them for Christmas trees. Insects such as the spruce budworm, eastern spruce beetle, and certain sawflies occasionally attack

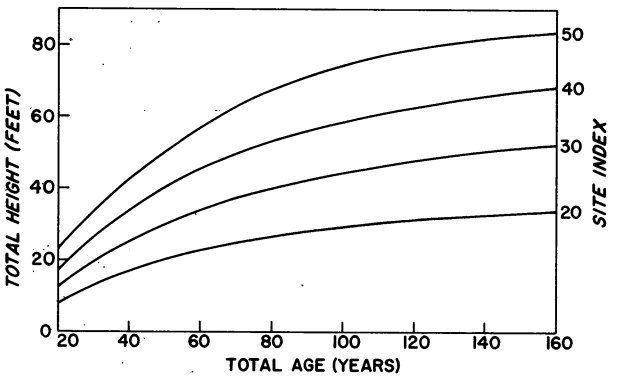


Figure 4. — Site index curves for black spruce stands in the Lake States. (Obtained from Figure 1 of Perala, Donald A., 1971. Growth and yield of black spruce on organic soils in Minnesota. USDA Forest Serv. Res. Pap. NC-56.)

black spruce. Snowshoe hares sometimes debark and browse reproduction, and red squirrels can spoil Christmas trees by clipping off twigs with cones. Black spruce is browsed occasionally by moose but rarely by white-tailed deer.

Good fire protection now results in little loss, but wildfire is always a serious potential enemy because black spruce trees are easily killed.

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 man-made drainage ditches has similar effects. 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.

MANAGEMENT OBJECTIVES

The overall objective in managing the black spruce type should be to produce a high sustained yield of pulpwood and other forest values as efficiently as possible. The poorest sites, however, should be managed mainly for Christmas trees under present conditions. Practices to enhance water, wildlife, and scenery are largely unknown in the black spruce type, but these values should not be ignored. Although little is known about how these values are affected by harvesting old stands and growing new ones, the type can probably be managed best in fairly large, even-aged stands, as occurred under virgin conditions.

More specifically, since pulpwood is the main product, the objective should be to manage the type in even-aged stands large enough for efficient, mechanized harvesting. The highest possible sustained yield of water, wildlife, and scenic values will likely be obtained by having pulpwood harvest areas well distributed throughout the forest and over time. The most important specific objective in managing water is to keep normal drainageways open, as noted under Damaging Agents. Wildlife and scenic values can be improved on pulpwood harvest areas by: (1) having their boundaries follow natural site or forest type lines and (2) removing heavy slash cover, particularly by broadcast burning, and otherwise leaving the areas neat. The resulting openings produce different and/or more abundant browse and other wildlife food than mature black spruce stands.

KEY TO RECOMMENDATIONS

Recommendations for managing various black spruce stands are given in the following key, which contains a series of alternative statements accompanied by detailed explanations. So, with accurate knowledge of a stand, the forest manager can find and carry out the correct recommended practice(s).

How to Use the Key

Starting with the first pair of like-numbered statements, select the one statement that better describes the stand in question. Read the accompanying explanation and follow the dotted line to the right where a final recommendation, a partial recommendation plus a number, or a number alone is given. 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.

The Key

1. **Site index 23 or less** ..... GROW CHRISTMAS TREES
   Many stands on such sites can be partially cut for Christmas trees about once every decade (fig. 5). Wind damage is rare because the trees are much shorter and often more open grown than in pulpwood stands. Also, trees of acceptable quality are almost never abundant enough to result in overcutting the stand. If Christmas trees are not harvested about every 10 years some may become unmarketable. For example, additional height growth or twig clipping by red squirrels can spoil tree form. Since succeeding crops come from the remaining stand, it should be protected as much as possible during each cutting.

1. **Site index over 23** ..... GROW PULPWOOD 2

   2. **Stand immature** ..... CUT NO TREES
      Intermediate cutting is not recommended for black spruce due to its low economic return and the risk of increasing wind-caused mortality.

   2. **Stand mature** ..... CLEARCUT STAND 3
      The rotation required to produce pulpwood ranges from about 60 to 130 years. Based on culmination of mean annual growth, rotations would be shorter for stands with high basal areas than for those with low basal areas. Stands on poor sites or with excessive numbers of trees may require rotations up to 130 years before yields or tree sizes are large enough to harvest efficiently. Rotations for stands on mineral soil should not exceed 70 years because butt rot becomes common at this age.

      The shape and size of the area to be clearcut should depend mainly on the long-term cost of harvesting and reproducing either progressive strips seeded naturally, or large patches to entire stands seeded artificially (cf. figs. 6 and 7). Since a stand can usually be managed by more than one method, the overall recommendation for that stand should be determined before deciding what shape and size of area to clearcut.

3. **Dwarf mistletoe scarce** 4
   This means dwarf mistletoe is apparently absent or is established so lightly it will not become a problem during the next rotation.

3. **Dwarf mistletoe abundant** .....
   BROADCAST BURN SLASH (see p. 10) 9
   The clearcut area should include a zone 2 chains (1 chain = 66 feet) *beyond* the margin of the infection center(s).

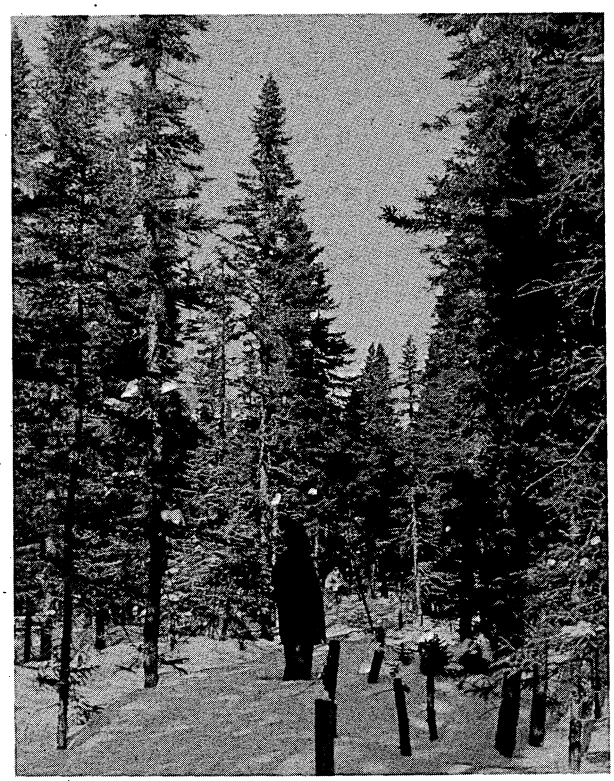
   4. **Residual black spruce stems abundant** 5
      This means enough stems are present to form a new stand or to reduce the growth of new reproduction.

   4. **Residual black spruce stems scarce** 6

5. **Residual stems young and fast growing** ..... SAVE RESIDUAL STEMS
Residual stems should be saved to reproduce the stand only if: (1) 60 percent or more of the milacres[2] in the clearcut area will contain at least one, young, fast growing stem *after* harvesting and (2) the cost of saving such stems does not exceed the cost of obtaining new reproduction of equal size. Obviously, the stand must be harvested carefully and slash removed where it covers needed stems.

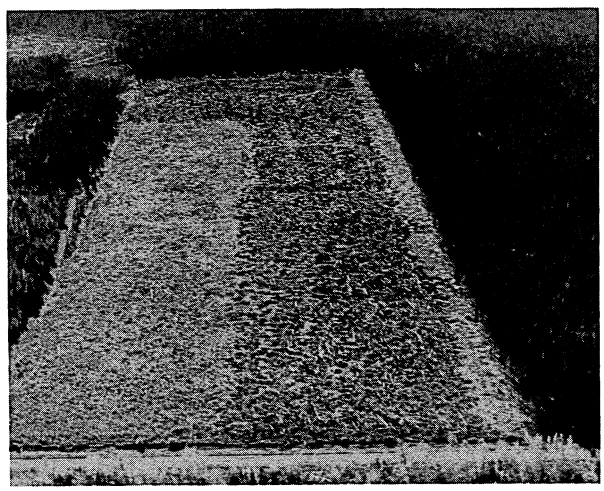
5. **Residual stems old and slow growing** .....
BROADCAST BURN SLASH (see p. 10) 9

[2] *A milacre is 1/1000 acre or about 44 square feet.*



F-519905

Figure 5. — This stand of black spruce is typical of those on poor sites that have been partially cut for Christmas trees. Note the stumps of harvested trees in the foreground.



F-519897

Figure 6. — These two strips, each about 4 chains wide and ¼ 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.

F-519147

Figure 7. — This 98-acre patch was clearcut, broadcast burned, and direct seeded. Note the unburned, slash-free alley next to the surrounding forest.

6. **Brush scarce** 7
This means brush is absent or will not become dense enough to reduce the growth of reproduction. In deciding whether brush is scarce or not (cf. figs. 1 and 2), it is important to realize that brush density usually increases greatly after clearcutting.

6. **Brush abundant** BROADCAST BURN SLASH (see p. 10) 9

7. **Sphagnum seedbeds well distributed** 8
This means patches of sphagnum suitable for seedling establishment occur in at least 60 percent of the milacres in the clearcut area, or at a square spacing not exceeding about 10 feet.

7. **Sphagnum seedbeds poorly distributed** .....
BROADCAST BURN SLASH (see p. 10) 9

8. **Slash cover light** 9
This means slash (expected or actual) will not hinder satisfactory reproduction or be an important fire hazard. Stands with low yields and those harvested by the full tree system, for example, may leave only a light cover of slash.

8. **Slash cover heavy** 9
BROADCAST BURN SLASH (see p. 10) 9

9. **Seed source within range** ..... USE NATURAL SEEDING
If the clearcut area is surrounded by a mature stand of black spruce, natural seeding can be relied on up to 4 chains from the windward side of the area and up to 2 chains from the leeward side. Thus a strip perpendicular to the prevailing wind direction (the recommended orientation) 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. A milacre stocking of 60 percent within 2 to 4 years after cutting is considered satisfactory reproduction.

9. **Seed source out of range** ..... USE DIRECT SEEDING
Black spruce is generally direct seeded at a rate of about ¼ pound (100,000 seeds) per acre to obtain a milacre stocking of at least 60 percent. Seed need not be stratified but should be treated with approved repellents for birds and rodents, and then sown between March and mid-May of the first year following burning or cutting. A hand seeder with filler such as sawdust is efficient for seeding small areas. Snowmobile or aerial seeding is more efficient for large areas.

BROADCAST BURNING TECHNIQUES

Research and experience in north-central Minnesota have proven that black spruce slash can be broadcast burned safely, effectively, and economically on organic soil sites. Burning on such sites should be equally successful in Michigan and Wisconsin after forest managers gain some local experience.

If burning is recommended in the key, the stand must be harvested in such a way that the resulting clearcut area can be burned safely and efficiently. The main requirements for setting up and conducting a successful broadcast burn are:

1. Make sides of clearcut area smooth and reasonably straight.

2. Leave a slash-free alley about ½ chain wide between the slash-covered area and the surrounding area (figs. 6 and 7).

3. Distribute the slash as completely and evenly as possible inside the slash-covered area.

4. Cut all unmerchantable trees near the edge of the slash-covered area.

5. Burn slash within a year after harvesting.

6. Burn when the fire will consume most slash but not cause a control problem.

Burning has been successful from June to October, with about half the burns occurring in August. Burning has usually been done 3 to 10 days since 0.1 inch of rain, and when minimum relative humidity was 30 to 60 percent, maximum air temperature 60° to 90° F., and maximum wind speed 5 to 15 miles per hour. Burning to kill back brush or improve non-sphagnum seedbeds requires drier and hotter conditions than burning to just consume slash or kill residual trees, which simultaneously eradicates dwarf mistletoe. Experience indicates this more severe burning usually requires at least 7 days since rain, relative humidity less than 45 percent, and an air temperature of at least 80° F.

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.

SUGGESTED REFERENCES

Fowells, H. A. ed. 1965. Silvics of forest trees of the United States. U.S. Dep. Agri., Agr. Handb. 271: 288-298.

Heinselman, Miron L. 1963. Forest sites, bog processes, and peatland types in the Glacial Lake Agassiz region, Minnesota. Ecol. Monogr. 33: 327-374.

Heinselman, M. L. 1958. Wind-caused mortality in Minnesota swamp black spruce in relation to cutting methods and stand conditions. Soc. Amer. Forest. Proc. 1957: 74-77.

Heinselman, M. L. 1959. Natural regeneration of swamp black spruce in Minnesota under various cutting systems. U.S. Dep. Agr., Prod. Res. Rep. 32, 22 p.

Irving, F. D., and French, D. W. 1971. Control by fire of dwarf mistletoe in black spruce. J. Forest. 69: 28-30.

Johnston, William F. 1968. Lowland brush in clearcut spruce swamps develops from residual vegetation — not from invasion. J. Forest. 66: 566-567.

Johnston, William F. 1971. Broadcast burning slash favors black spruce reproduction on organic soil in Minnesota. Forest. Chron. 47: 33-35.

Larson, Hubert, and Jamrock, Eugene. 1969. Snowmobile seeding. Tree Planters' Notes 19 (4): 1-3.

Lundgren, Allen L. 1961. Investment opportunities in regenerating black spruce are greatly affected by site. USDA Forest Serv., Lake States Forest Exp. Sta. Tech. Note 611, 2 p.

Perala, Donald A. 1971. Growth and yield of black spruce on organic soils in Minnesota. USDA Forest Serv. Res. Pap. NC-56, 16 p. N. Cent. Forest Exp. Sta., St. Paul, Minn.

Stoeckeler, Joseph H. 1967. Wetland road crossings: drainage problems and timber damage. USDA Forest Serv. Res. Note NC-27, 4 p. N. Cent. Forest Exp. Sta., St. Paul, Minn.

Vincent, A. B. 1965. Black spruce: A review of its silvics, ecology and silviculture. Can. Dep. Forest. Pub. 1100, 79 p.

COMMON AND SCIENTIFIC NAMES OF PLANTS MENTIONED IN TEXT

Common name	Scientific name
Alder, speckled	*Alnus rugosa* (Du Roi) Spreng.
Ash, black	*Fraxinus nigra* Marsh.
Aspen, quaking	*Populus tremuloides* Michx.
Birch, paper	*Betula papyrifera* Marsh.
Dogwood, red-osier	*Cornus stolonifera* Michx.
Elm, American	*Ulmus americana* L.
Fir, balsam	*Abies balsamea* (L.) Mill.
Labrador-tea	*Ledum groenlandicum* Oeder
Leather-leaf	*Chamaedaphne calyculata* (L.) Moench
Maple, red	*Acer rubrum* L.
Mistletoe, dwarf	*Arceuthobium pusillum* Peck
Mosses:	
Feather	Main species are: *Calliergonella schreberi* (BSG.) Grout, *Hylocomium splendens* (Hedw.) BSG., *Hypnum crista-castrensis* Hedw.
Sphagnum	*Sphagnum* spp.
Pines:	
Jack	*Pinus banksiana* Lamb.
Red	*Pinus resinosa* Ait.
Eastern white	*Pinus strobus* L.
Poplar, balsam	*Populus balsamifera* L.
Rust, needle	*Chrysomyxa* spp.
Spruces:	
Black	*Picea mariana* (Mill.) B. S. P.
White	*Picea glauca* (Moench) Voss
Tamarack	*Larix laricina* (Du Roi) K. Koch
White-cedar, northern	*Thuja occidentalis L.*

SOME RECENT RESEARCH PAPERS OF THE NORTH CENTRAL FOREST EXPERIMENT STATION

Proceedings of the Ninth Lake States Forest Tree Improvement Conference, August 22-23, 1969. USDA Forest Serv. Res. Pap. NC-47, 34 p. 1970.

A Water Curtain for Controlling Experimental Forest Fires, by Von J. Johnson. USDA Forest Serv. Res. Pap. NC-48, 7 p., illus. 1970.

Wilderness Ecology: A Method of Sampling and Summarizing Data for Plant Community Classification, by Lewis F. Ohmann and Robert R. Ream. USDA Forest Serv. Res. Pap. NC-49, 14 p., illus. 1971.

Predicting Lumber Grade Yields for Standing Hardwood Trees, by Charles L. Stayton, Richard M. Marden, and Glenn L. Gammon. USDA Forest Serv. Res. Pap. NC-50, 8 p. 1971.

Tables of Compound-Discount Interest Rate Multipliers for Evaluating Forestry Investments, by Allen L. Lundgren. USDA Forest Serv. Res. Pap. NC-51, 142 p. 1971.

Ecological Studies of the Timber Wolf in Northeastern Minnesota, by L. David Mech and L. D. Frenzel, Jr. (Editors). USDA Forest Serv. Res. Pap. NC-52, 62 p., illus. 1971.

Pest Susceptibility Variation in Lake States Jack-Pine Seed Sources, by James P. King. USDA Forest Serv. Res. Pap. NC-53, 10 p., illus. 1971.

Influence of Stand Density on Stem Quality in Pole-size Northern Hardwoods, by Richard M. Godman and David J. Books. USDA Forest Serv. Res. Pap. NC-54, 7 p., illus. 1971.

The Dynamic Forces and Moments Required in Handling Tree-length Logs, by John A. Sturos. USDA Forest Serv. Res. Pap. NC-55, 8 p., illus. 1971.

Growth and Yield of Black Spruce on Organic Soils in Minnesota, by Donald A. Perala. USDA Forest Serv. Res. Pap. NC-56, 16 p., illus. 1971.

ABOUT THE FOREST SERVICE . . .

As our Nation grows, people expect and need more from their forests — more wood; more water, fish, and wildlife; more recreation and natural beauty; more special forest products and forage. The Forest Service of the U.S. Department of Agriculture helps to fulfill these expectations and needs through three major activities:

- Conducting forest and range research at over 75 locations ranging from Puerto Rico to Alaska to Hawaii.
- Participating with all State forestry agencies in cooperative programs to protect, improve, and wisely use our Country's 395 million acres of State, local, and private forest lands.
- Managing and protecting the 187-million acre National Forest System.

The Forest Service does this by encouraging use of the new knowledge that research scientists develop; by setting an example in managing, under sustained yield, the National Forests and Grasslands for multiple use purposes; and by cooperating with all States and with private citizens in their efforts to achieve better management, protection, and use of forest resources.

Traditionally, Forest Service people have been active members of the communities and towns in which they live and work. They strive to secure for all, continuous benefits from the Country's forest resources.

For more than 60 years, the Forest Service has been serving the Nation as a leading natural resource conservation agency.