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Site Preparation Treatments and Their Effects on Establishment and Growth of Tamarack

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Tamarack (*Larix laricina* (Du Roi) K. Koch) is becoming more important as a commercial species in the Great Lakes Region. The native range of tamarack is quite extensive in North America where it exists on poorly drained sites, but also grows well on upland sites. In northern Minnesota, tamarack is a pioneering species primarily found on peatlands where the organic soil is more than 30 cm in depth. It exists as pure and mixed stands with its main associate, black spruce (*Picea mariana* (Mill) B.S.P.) (Johnston 1990). Tamarack can exist on extremely wet sites, but as these sites become mesic, tamarack begins to suffer from competition with more shade tolerant tree species. Natural regeneration of tamarack requires three conditions: abundant light, consistent and adequate amounts of moisture, and a satisfactory seed source (Duncan 1954). Natural seeding is the most common method of regeneration. At around age 40 tamarack begins to produce abundant seed; good seed crops occur every 3 to 6 years (Johnston and Brittain 1983, Duncan 1952). The optimal seedbed is warm moist organic soil with little brush, but *Mnium* mosses may also provide adequate germination conditions (Duncan 1954). Clear-cutting and seed-tree silvicultural systems are currently used to manage tamarack but little information exists on the effectiveness of natural seeding under different harvesting methods. Little research has been conducted on the importance of site preparation for tamarack regeneration (Johnston 1973). Although site preparation in mixed black spruce and tamarack stands provides some evidence that burning of slash increases stocking of tamarack seedlings (Johnston 1971), use of broadcast burning is limited due to fire injury or mortality of residual seed-trees. Full-tree skidding is more commonly used and leaves very little slash distributed on the site.

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This study investigates the effects of site preparation on tamarack regeneration. In particular, we evaluated site preparation as it affects distribution and quality of seedbed types as well as density and initial growth of seedlings.

SITE

Our study area is located on peatlands in Block I, Compartments 108 and 111 (E 1/2, NE 1/4, Sec. 36, T 157 N, R 25 W) Loman District and Block II, Compartment 204 (E 1/2, NE 1/4, Sec. 1, T 156 N, R 25 W) and Compartment 213 (N 1/2, NW 1/4, NE 1/4, Sec. 25, T 68 N, R 27 W) in the Pine Island District of the Big Falls Experimental Forest in northern Minnesota. The average annual rainfall is 64.3 cm and the average annual temperature is 3.7° C. The study area generally fits the site classification V-23 Tamarack-Black Spruce with somewhat lower proportions of tamarack in the overstory (Sims *et al.* 1989). A list of the main associated species is presented in table 1.

METHODS

The study area was laid out in 1979 into six experimental units, each about 1 ha in size. Site preparation treatments were broadcast burning, full-tree skidding, and full-tree skidding with subsequent broadcast burning. Full-tree skidding and broadcast burning were randomly assigned to

Table 1.—*Associated vegetation on tamarack study areas*

Alder	*Alnus* spp.
Bog birch	*Betula pumila*
Blueberry	*Vaccinium angustifolium* Ait.
Calamus	*Acorus calamus*
Sedges	*Carex* spp.
Grasses	*Poa* spp., *Bromus* spp., *Calamagrostis* spp.
Labrador tea	*Ledum groenlandicum* Oeder
Raspberry	*Rubus* spp. Raf.
Willow	*Salix* spp.
Moss	*Sphagnum* spp.

the experimental units. Each unit was labeled according to compartment (108, 111, 204, and 213) and site preparation treatment (S=skid, B=burn, SB=skid-burn).

Stand density and basal area of the mature stand before harvest were sampled by measuring trees more than 9 cm diameter at breast height on four circular plots with a radius of 8 m located systematically in each unit (table 2). Site index was estimated using the height of dominant and codominant trees. Trees 7.5 cm d.b.h. and larger on the skid units were pulled to designated landings as whole trees using a rubber-tired skidder. Slash was burned progressively on landings. The burn-only units were clearcut, removing all trees with a d.b.h of 5 cm and larger. The burn-only units had all slash left evenly distributed and were surrounded by a slash-free alley 7.5 m wide. The units were burned in spring 1980.

During the spring of 1983, the basal area of the adjacent stand seed source for the harvested area was sampled for compartments 213 and 204, using 0.04-ha plots (table 3). Within compartments 108 and 111, 1-m^2 seed traps were placed using 20- by 60-m spacing. Numbers of traps used ranged from six on compartment 111 to four on compartment 108. Seeds were counted in October 1980 and in June and October 1981. Except for compartment 213, the dominant seedbed type present on each treatment unit was determined in 1983 by sampling 48 1-m^2 plots. The seedbed type that supported the most seedlings of tamarack was also recorded on each square meter plot. Seedling density of tamarack and all species was sampled on each treatment in 1992 using the method of non-overlapping triangles (Klier 1969) and recording height (meters) and diameter (millimeters) of sample trees.

Table 2.—*Site characteristics before treatment*

	Compartment					
Characteristic	**108-B**	**108-SB**	**111-B**	**111-S**	**204-S**	**213-B**
Tamarack						
Density (tpha)	99	123	0	0	12	N*
Basal Area/ha (m^2)	1.7	2.6	0	0	0.2	N*
50-year Site Index (m)	9	9	10	9	9	N*
Black spruce						
Density (tpha)	765	259	432	691	543	N*
Basal Area/ha (m^2)	21.5	9.9	20.1	19.4	17.0	N*
50 year Site index (m)	12	11	11	12	12	13

*N=Not measured.

Table 3.—*Seed source basal area and density of Tamarack and Black Spruce adjacent to compartments 213 and 204*

Characteristic	Compartment	
	213-B	204-S
Tamarack density (tpha)	444	247
Tamarack basal area (m^2)	60.6	10.6
Black spruce density (tpha)	12	33
Black spruce basal area (m^2)	0.1	1.2

Our study was exploratory and is limited to a set of case studies. It yields an incomplete, unbalanced, but completely randomized design. Because replication is minimal, little statistical inference can be made. The results are interpreted from large magnitudes of differences observed among treatments and by inference from knowledge of other forest types.

RESULTS

Seed Rain

Seed source density and basal area measurements (table 3) indicated that the seed source was comprised primarily of tamarack downwind about 20 to 50 m from the treatment. Total seed rain averaged nearly nine seeds/m^2 over the 2-year period (table 4). Tamarack had a better seed year in 1980 than in 1981; the former accounted for about 98 percent of tamarack seed over the collection period. However, this finding is partially due to the two seed rain measurements for 1980, which counted all seed released during fall, winter, and spring, compared to the one seed rain measurement for 1981, which captured the seed released during the fall of 1981. Black spruce did not make up a substantial proportion of the incoming seed rain, contributing less than 1 percent of the total seed (table 5).

Seedbed Frequency and Quality

Burn-type Bryophytes (bryophytes other than sphagnum moss) were dominant on each burn treatment, and they were also dominant on the skid-burn treatment, but at a lower frequency than on the burned-only treatments (fig. 1). Leaf litter was the second most common seedbed type on the skid-burn treatment. In contrast, sphagnum moss was the dominant seedbed type on the skid-only treatments.

An estimate of the expected number of tamarack seedlings on each 100 m^2 for each seedbed type was calculated based on the number of tamarack seedlings supported by a seedbed type and the area of that seedbed type for each treatment. This estimate is an indicator of seedbed quality as expressed by seedling density:

Seedbed type	**Seedlings/100 m^2**
Sphagnum moss	113
Burn-type bryophytes	144
Leaf litter	35

Table 4.—*Mean number of tamarack seeds sampled within compartments 108 and 111*

Year	Compartment			
	108-SB	108-B	111-S	111-B
1980*	122,500	95,000	63,300	60,000
1981	2,500	2,500	3,300	0
Total	125,000	97,500	66,600	60,000

* 1980 measurements included seed rain collected in October 1980 and June 1981. Measurements for 1981 included only seed rain collected in October 1981.

Table 5.—*Mean number black spruce seeds per hectare in compartments 108 and 111*

Year	Compartment			
	108-SB	108-B	111-S	111-B
1980*	2,500	2,500	1,667	2,500
1981	0	0	1,667	0
Total	2,500	2,500	3,334	2,500

* 1980 measurements included seed rain collected in October 1980 and June 1981. Measurements for 1981 included only seed rain collected October 1981.

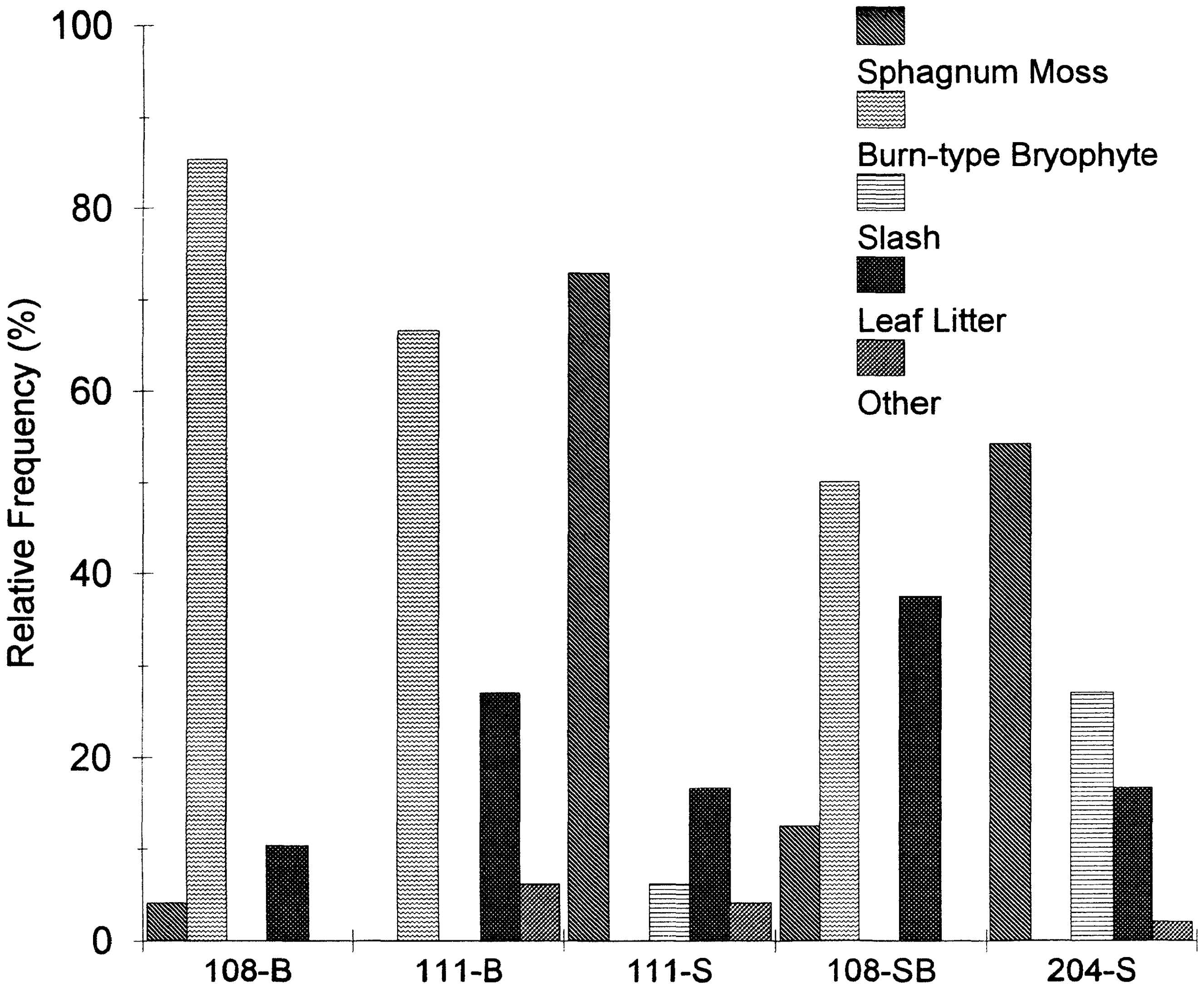

Figure 1.—*Relative frequency of seedbed types in treatment units.*

Density and Initial Growth

The burn-only treatment plots had a higher tamarack density than the skid treatments. The densest tamarack stocking in 1992 (4,800 t/ha) was found in compartment 213-B (fig. 2). The next highest densities were found in the 108-B and 111-B treatments. Black spruce densities were generally highest on two burn treatments (108-B and 213-B) and seem to be about half of the tamarack densities. The average height (fig. 3) and diameter (fig. 4) of tamarack were greatest on the skid treatments except for one burn treatment (213-B), which also had the greatest number of seedlings. Tamarack seedlings were consistently taller and larger in diameter than black spruce on the same plot (figs. 3 and 4).

DISCUSSION

Seed rain density for tamarack was low within a distance of 20 to 50 m, indicating that seed availability and dispersal at these distances might be of concern in strip clearcuts. Seed dispersal curves for tamarack in Alaska and Minnesota indicate that seedfall drops considerably as distance increases from the seed stand and that as little as 2 percent of seedfall recorded under the stand can be found at a distance of 30 m (Brown *et al.* 1988; Duncan 1954). Despite the low seed rain, all plots received sufficient seed to establish a fully stocked tamarack stand. Even at the lowest density of tamarack, with 1,800 tpha, average spacing of seedlings was 2.4 m in the study area. Less than adequate seed rain for black spruce probably affected the density of black spruce seedlings on most treatments. The lowest density of black spruce was 400 tpha with an average spacing of 5.0 m, which is considered barely adequate stocking (Johnston 1977).

Although all site preparation treatments led to adequate stocking, burning alone was most successful in preparing the site for tamarack germination. The treatment affected black spruce in much the same way except where seed rain was

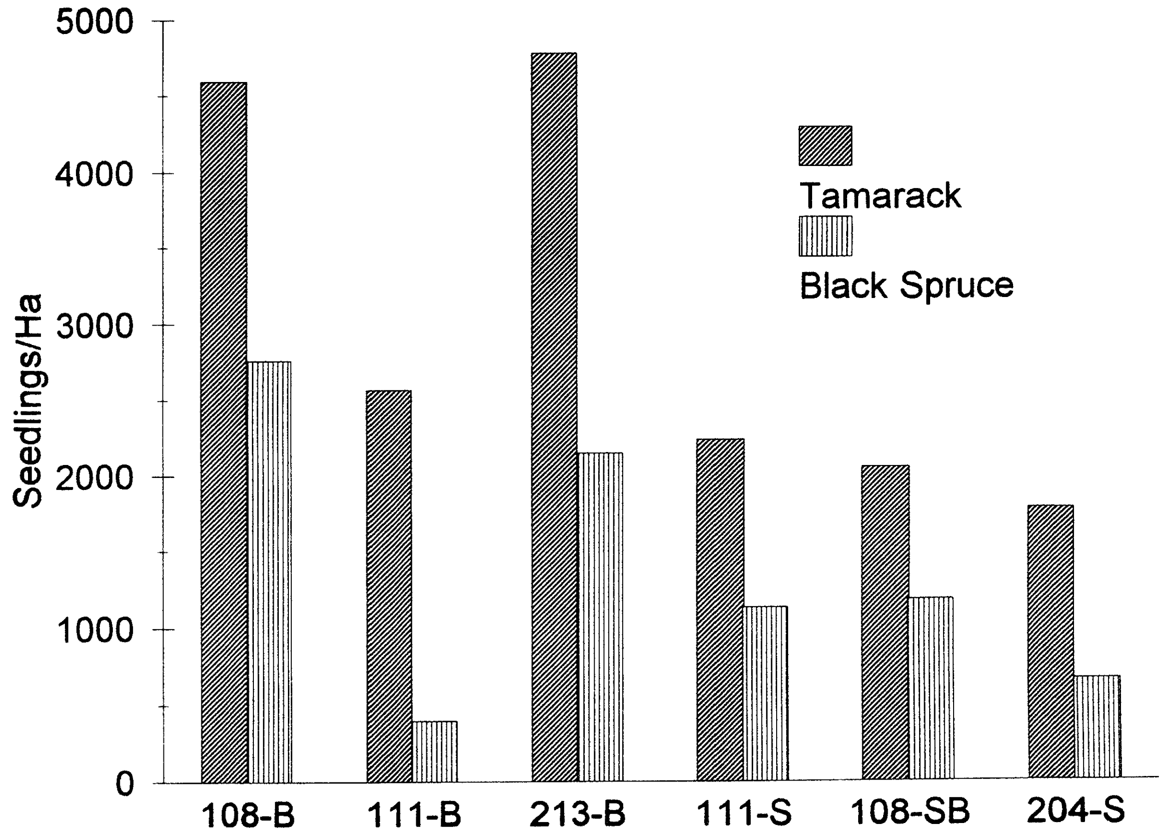

Figure 2.—*Number of tamarack and black spruce seedlings per hectare 12 years after harvest.*

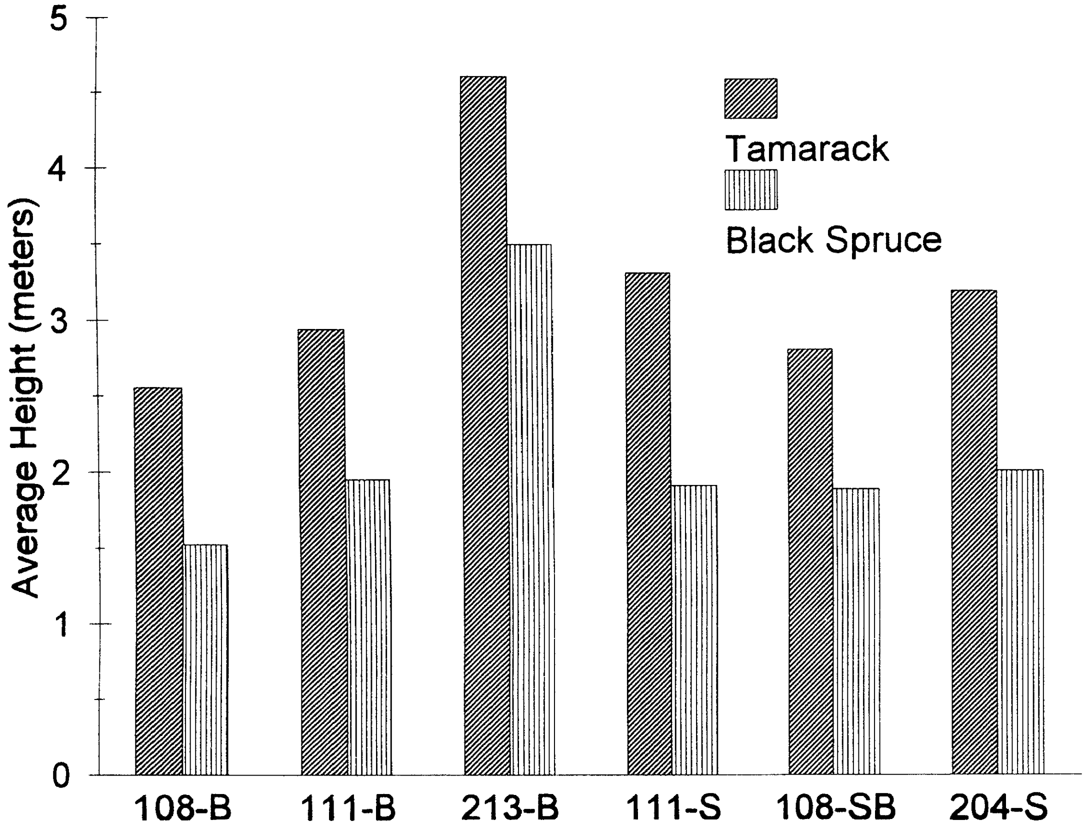

Figure 3.—*Average height of tamarack and black spruce seedlings 12 years after harvest.*

extremely limited. The effect of burning becomes obvious when we compare treatments 111-S and 108-B. Treatment 111-S supported a much lower seedling density, which may be due to differences in seed rain or better slash removal during burning compared to skidding, leading to improved conditions for tamarack establishment (Johnston 1975). Light cover is considered favorable, but heavy shade from slash or other vegetation will hinder tamarack establishment (Duncan 1952). Another reason for the higher tamarack and black spruce densities could be the physical effect fire had on the seedbeds. It is not clear if the Burn-type Bryophytes are merely indicators that seedbed conditions were good or if they provide good seedbed conditions. Burning probably removed the surface organic layer leading to a high proportion of Burn-type Bryophyte. Sphagnum moss can make a good seedbed, but surface drying of the top layer during the growing season may limit the moisture available to the seedling (Duncan 1954). Similar concerns about moisture conditions on moss are expressed for black spruce as well. Other more finely textured mosses like *Mnium* are considered to be better seedbeds than Sphagnum moss (Duncan 1952). Climate data indicate that the annual temperature and precipitation were close to the average for the growing season in 1981 (average rainfall and temperature in 1981 were 62.5 cm and 5.0° C). Thus, in areas where burns are not feasible, full tree skidding seems sufficient to provide good germination conditions for tamarack.

The treatment that led to the highest densities (burn) resulted in the slowest diameter and height growth for tamarack and black spruce. The exception to this trend (compartment 213-B) might be due to higher site quality. This may indicate that good germination conditions are not necessarily good growing conditions. More likely, it indicates that tamarack growth has been reduced by competition in the higher density plots. Thinning studies of other species, such as black spruce on organic soils, indicated growth responses to thinning at similar densities in 7-year-old stands (Burns *et al.* 1996).

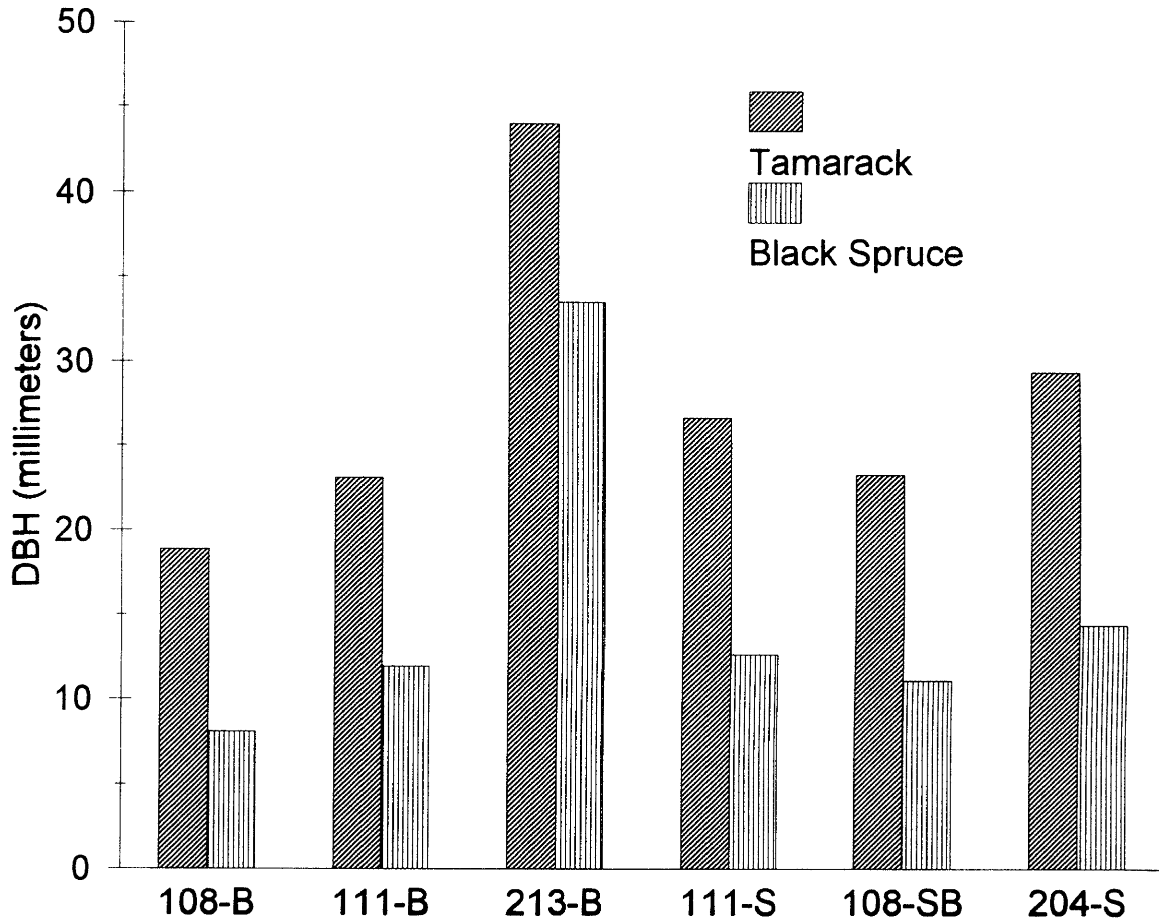

Figure 4.—*Diameter at breast height of tamarack and black spruce seedlings 12 years after harvest.*

CONCLUSION

Both site preparation treatments (burning and skidding) resulted in germination rates adequate to establish fully stocked tamarack stands. The burn treatments altered the seedbed and increased the proportion of Burn-type Bryophytes. The highest tamarack densities coincided with the presence of Burn-type Bryophytes. When burning is not possible, full tree skidding can provide adequate seedbeds. The higher density in the burn treatment resulted in greater competition between the seedlings. The slower growth rates on the burn treatments compared to the skid treatments suggest the need for earlier thinning in higher density tamarack stands.

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KEY WORDS: tamarack, site preparation, seedbed, peatland, burning.