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Site Preparation Treatments and Browse Protection Affect Establishment and Growth of Northern White-Cedar

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Describes the effects of site preparation by fire and skidding on northern white-cedar regeneration. Shows how deer, hare, and rodent browsing impact northern white-cedar.

KEY WORDS: *Thuja occidentalis*, exclosures, burning, skidding, slash.

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Site Preparation Treatments and Browse Protection Affect Establishment and Growth of Northern White-Cedar

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Northern white-cedar (*Thuja occidentalis* L.) is a valuable species in the Lake States not only for its qualities as a forest product but also for its importance as wildlife habitat. This species is especially critical in providing winter yarding and browse for white-tailed deer (*Odocoileus virginianus*) (Verme 1965). The northern white-cedar forest type is found mostly in humid climates characterized by short cool summers (Johnston 1990). Northern white-cedar is shade tolerant and competes well with its associates on rich, swampy sites with actively flowing mineral rich water. Of its common coniferous associates on moist sites, only balsam fir (*Abies balsamea* L.) is more shade tolerant, while black spruce (*Picea mariana* Mill.) and tamarack (*Larix laricina* Du Roi) are less so (Johnston 1990). Important factors controlling reproduction of northern white-cedar are adequate amounts of moisture, warm temperatures, and moderate light levels. Most regeneration occurs by natural seeding and layering. Layering takes place primarily on sites where the seedbed consists of moist organic material and often in areas with abundant sphagnum moss (Nelson 1951). On upland sites, northern white-cedar germinates well on seedbeds where fire has exposed mineral soil but has left some slash on the site. Seedbed conditions are improved by fire on lowland swampy sites when conditions for mosses such as *Heterphyllium, Pleurozium,* and *Brotherela* sp. are improved (Johnston 1990).

A major concern for northern white-cedar management is the lack of sufficient regeneration after harvesting (Johnston 1977). Factors that can hinder reproductive success of northern white-cedar include inadequate seedbeds, competition with faster growing or more shade tolerant associates, and browsing from deer and hares (*Odocoileus virginianus* and *Lepus americanus*) or other rodents (Johnston 1990). Balsam fir can replace northern white-cedar in mixed stands because it is more shade tolerant and because it is not a preferred browse species. Moreover, balsam fir has less stringent seedbed requirements (Frank 1990).

Although decomposing logs can make good seedbeds for cedar (Holcombe 1976), large amounts of cedar slash left on site creates a barrier to seed germination because of its slow decomposition rates and rot resistance (Lanasa 1989). Competition from other shrub or woody species might also reduce northern white-cedar growth and survival in clearcuts (Verme and Johnston 1986). Another important factor in lower survival of northern white-cedar is the level of browsing that occurs. Browsing of seedlings has been attributed mostly to large deer populations, but hare and rodent populations have also been linked to browsing damage (Bookhout 1965).

Research on effective methods to control both balsam fir competition and browsing impacts on northern white-cedar has been lacking. We conducted a study to partly fill this gap by

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investigating (1) the effects of site preparation by fire and skidding on northern white-cedar regeneration and (2) the effects of deer, hare, and rodent browsing on height growth in northern white-cedar. The study is limited by the incomplete nature of measurements taken, but valuable inference can be gained from large differences among the treatments.

SITE

The study area is located on the "Brule Bog" of the Brule River State Forest near Solon Springs, Wisconsin (SE 1/4, NE 1/4, Sec. 8, T45N, R11W). Soil characteristics and site indexes for the study area are presented in table 1. The average annual temperature is 4.4°C, and the average spring (March through June) temperature is 7.5°C. The average annual rainfall is 780 mm, and the average spring rainfall is 226 mm. Conditions during the study period (Spring 1980), were warmer (average temperature = 8.4°C) and drier (rainfall = 156 mm) than normal. Advanced reproduction of balsam fir dominated the understory. The study area generally fits the V-22 Cedar (inc. Mixedwood)/Speckled Alder/Sphagnum site classification (Sims *et al.* 1989). A list of the main associated species is presented in table 2.

Table 1.—*Site characteristics and stand conditions before treatment in 1980*

	Burn	Skid	Leave
Soil description			
Total depth (cm)	250-270	220-400	220-320
Texture of mineral substratum	*M	coarse sand to rock	gravel
Organic material	fibric, sapric	fibric, sapric	sapric
Stand Conditions			
Northern white-cedar			
Basal area (m^2/ha)	21.5	33.5	30.7
50-year site index (m)	6	6	6
Balsam fir			
Basal area (m^2/ha)	8.9	7.2	9.0
50-year site index (m)	12	14	14

*M = not measured

Table 2.—*Common associated vegetation on northern white-cedar study areas*

Alder	*Alnus* spp. Miller
Strawberry	*Fragaria* spp. L.
Grasses	*Poa* spp. L., *Calamagrostis* spp. Adans.
Labrador tea	*Ledum groenlandicum* Oeder.
Raspberry	*Rubus* spp. L.
Red osier dogwood	*Cornus stolonifera* L.
Sedges	*Carex* spp. L.
Willow	*Salix* spp. L.
Moss	*Sphagnum* spp.

METHODS

The site preparation treatments included slash removal by broadcast burning (Burn), full-tree skidding (Skid), and a full-tree skidding operation that left slash behind (Leave). These treatments were all compared with an uncut control (Uncut). Site preparation methods were randomly assigned to three completely clearcut units (8,600 m^2) and separated by two uncut, control units (5,665 m^2). Harvesting was completed in the winter of 1979-80; the few residual trees 5 cm diameter at breast height and larger were felled in October 1980. The Skid treatment used a rubber-tired skidder, and slash was burned progressively at the landing. The Leave treatment left slash in place. On the Burn treatment, slash was left evenly distributed between 10-m-wide slash-free alleys and burned in July 1980 under fairly severe conditions. Soil and site conditions were measured in 1979 and 1980 (table 1). Site index was estimated using dominant or codominant northern white-cedar and balsam fir in or near each clearcut unit. The depth and description of organic material were taken near the north and south end of each unit.

Density of northern white-cedar, balsam fir, and black spruce was sampled 3 and 5 years after burning (spring 1983 and fall 1985). New seedlings that established after the harvest and site preparation treatments were distinguished from advanced reproduction for northern white-cedar and balsam fir but not black spruce (Viereck and Johnston 1990). Regeneration from 0.6 m to 2.0 m in height was sampled on fifty 4-m^2 plots for each site preparation and on forty-eight 4-m^2 plots for the uncut control. Reproduction that was less than 0.6 m tall was sampled on 1-m^2 subplots in 1983 and 1985. Seedbeds and associated vegetation were sampled on these same 1-m^2 subplots. Seedbeds were categorized into Sphagnum Moss, Burn-Type Bryophytes (fire succession mosses), Slash, Leaf Litter, and Others (Verme and Johnston 1986). The seedbed type that supported the greatest number of new northern white-cedar seedlings was also recorded on each subplot.

The effects of deer, hare, and rodent browsing on cedar regeneration were examined by establishing exclosures. Hare exclosures (Hare) were 1 m x 1 m in area and 0.76 m in height and made of 5.0-cm-wide mesh poultry netting, which did not exclude rodent browsing. The rodent exclosures (Rodent) were the same dimensions as the hare exclosures but were made of 0.6-cm-wide mesh poultry netting and excluded all browsing. Deer exclosures (Deer) were 1.8 m x 1.8 m in area and 2.4 m high. In November of 1980, each set of exclosures was built in areas with patches of northern white-cedar reproduction except the Burn unit where new seedlings were not yet present. Nearby areas with regeneration patches were selected as controls (Unfenced). Density and height of northern white-cedar reproduction for various combinations of site preparation methods and browsing protection treatments were measured in 1980, 1981, 1983, 1985, and 1990 (table 3).

Table 3.—*List of browse exclosure treatments by site preparation methods and year in which height of northern white-cedar seedlings was measured*

	Skid	Leave Slash	Uncut
1980	hare, rodent & unfenced	hare,rodent & unfenced	hare,rodent & unfenced
1981	deer, hare & unfenced	hare & unfenced	hare & unfenced
1983	unfenced	M*	unfenced
1985	deer, hare & unfenced	M*	M*
1990	deer, hare & rodent	hare & rodent	hare & rodent

*M = not measured

RESULTS

Seedbed Frequency and Quality

Dominant seedbed types and frequency on each treatment were recorded in 1983. Burn-type Bryophyte seedbeds dominated the Burn treatment (fig. 1). Sphagnum Moss was the dominant seedbed type on the remaining three treatments. An index of seedbed quality for northern white-cedar was calculated as the number of northern white-cedar seedlings found 3 years after harvest on 100 m^2 of seed bed type:

Seedling density per 100 m^2

Sphagnum Moss	60
Burn-type Bryophytes	11
Leaf Litter	392

The Leaf Litter seedbed type had the highest seedbed quality index, Sphagnum Moss had an intermediate seedbed quality index, and Burn-type Bryophytes had the lowest. However, all seedbed types had enough seedlings to regenerate a fully stocked cedar stand.

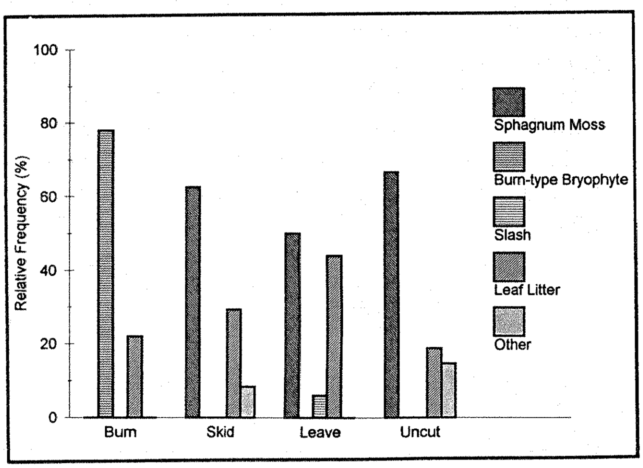

Figure 1.—*Frequency of seedbed types by treatment.*

Northern White-Cedar and Balsam Fir Reproduction

Reproduction measured 3 years after harvest (1983) showed that harvest operations, especially when they included slash treatments, resulted in a loss of well over two-thirds of the advanced cedar reproduction and more than half of the balsam fir reproduction (figs. 2 and 3). Greatest amounts of advanced reproduction for both species were found on the Uncut control. The second highest density of advanced reproduction for cedar was on the Skid site preparation treatment, while the second highest density of advanced reproduction for balsam fir was on the Leave site preparation treatment. Density of new reproduction was also highest on the Uncut control for both species. Among the different site preparation methods, the Burn treatment had the highest density of new northern white-cedar reproduction and the Leave treatment had the highest balsam fir reproduction (figs. 2 and 3). Total density for all species (advanced and new regeneration), including black spruce, was highest on the Uncut control, while the second highest total densities were found on the Leave treatment (fig. 4).

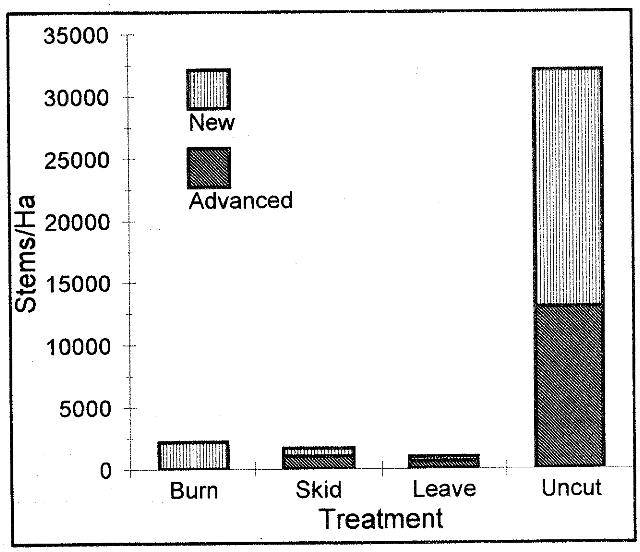

Figure 2.—*Density of advanced and new regeneration of northern white-cedar in 1983.*

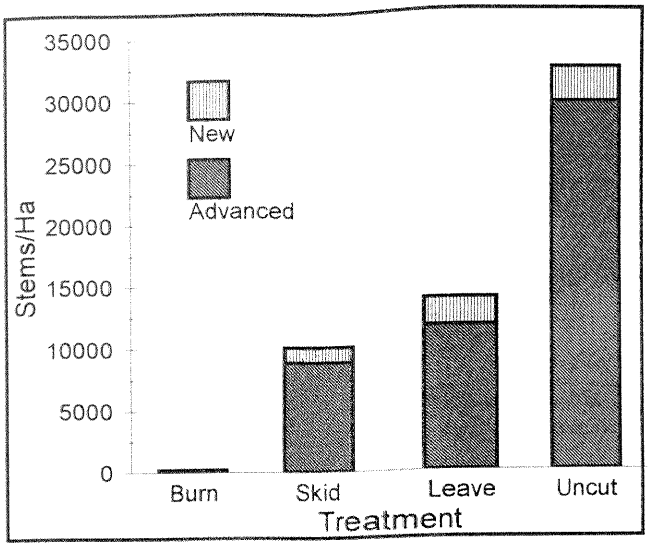

Figure 3.—*Density of advanced and new regeneration of balsam fir in 1983.*

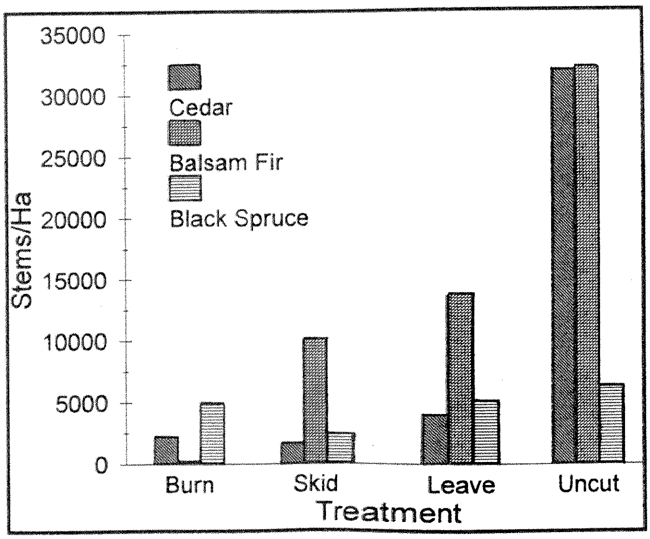

Figure 4.—*Total regeneration density of northern white-cedar, balsam fir, and black spruce in 1983.*

By 1985 most advanced reproduction of northern white-cedar and balsam fir had disappeared or become indistinguishable from new seedlings (figs. 5 and 6), even in the Uncut control. Balsam fir dominated all site treatments, especially the Burn treatment (fig. 7).

When site preparation treatments are compared over the 5-year period, it becomes apparent that the Burn treatment had the highest density of new northern white-cedar reproduction. Only the Leave treatment retained any advanced northern white-cedar regeneration (fig. 6).

Browse Treatments

Height growth of a selected set of seedlings was measured as part of the browse study. The seedling height in the clearcut areas was limited by the height of the Hare and Rodent exclosures (70 cm), presumably because seedlings that outgrew the exclosure were browsed. By age 10, seedlings had reached the exclosure height except in the Uncut unit where they averaged only 20 cm tall (fig. 8). The average height for northern white-cedar seedlings before the exclosures were set up was similar in all site preparation and browsing treatments (fig. 9). The effect of browsing on height was already obvious after 1 year. In 1981, northern white-cedar seedlings in the Hare exclosures were about as tall as in 1980. In the Unfenced controls, seedling height declined by 30 percent compared to seedlings in the fenced treatments in the Leave and Uncut treatments. Height in the Skid treatment was reduced only slightly (figs. 9 and 10). This indication of heavy browsing pressure is supported by observations taken during the 1983 measurements. Northern white-cedar had been almost entirely eliminated on the Unfenced control plots, but they grew and recovered from previous browsing in other exclosures. In 1990, 10 years after harvest and exclosure establishment, no seedlings were found in the Unfenced plots (fig. 8). Height growth in the Deer, Hare, and Rodent exclosures was very similar in all browsing treatments.

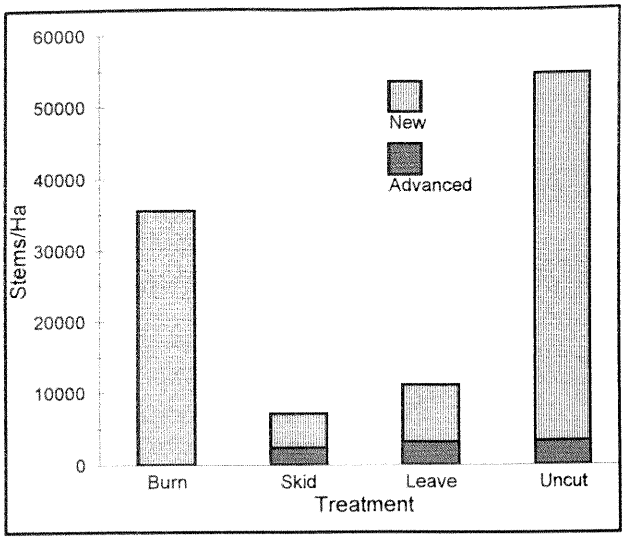

Figure 5.—*Density of advanced and new regeneration of balsam fir in 1985.*

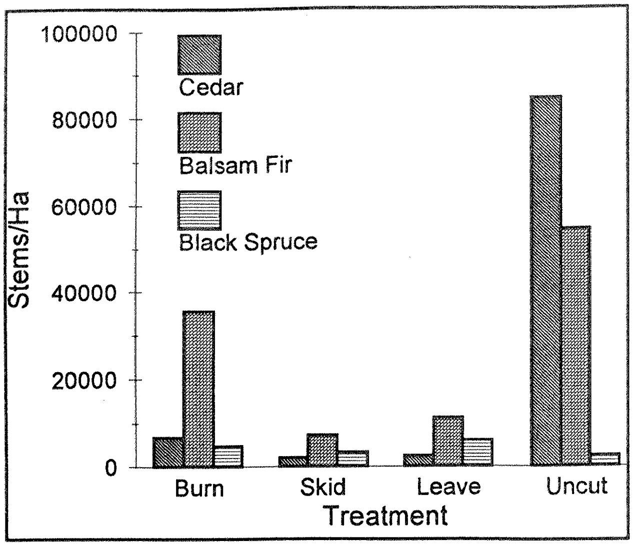

Figure 7.—*Total regeneration density of northern white-cedar, balsam fir, and black spruce in 1985.*

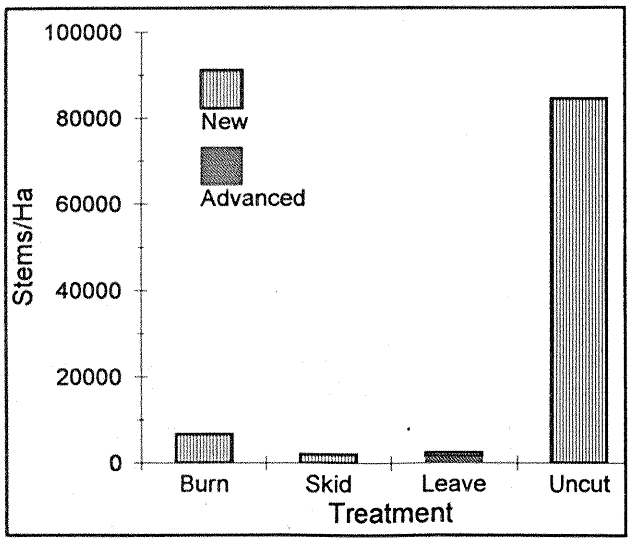

Figure 6.—*Density of advanced and new regeneration of northern white-cedar in 1985.*

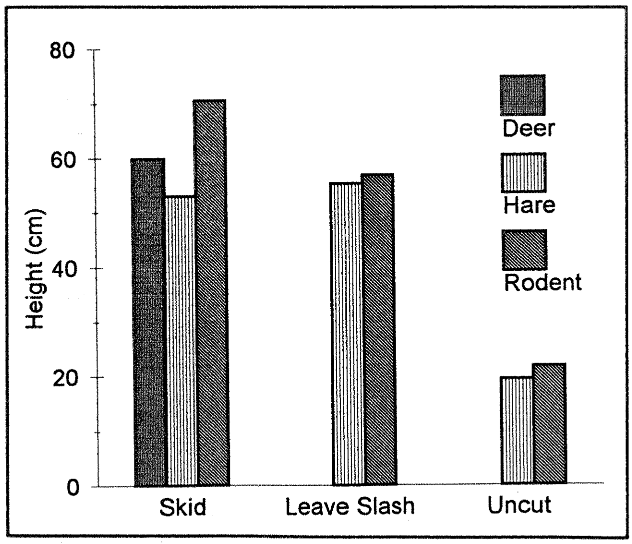

Figure 8.—*Average height of northern white-cedar seedlings in 1990.*

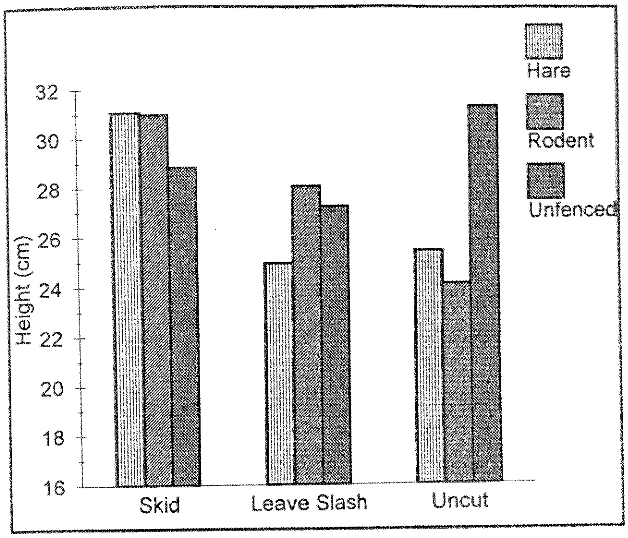

Figure 9.—*Average height of northern white-cedar seedlings in 1980.*

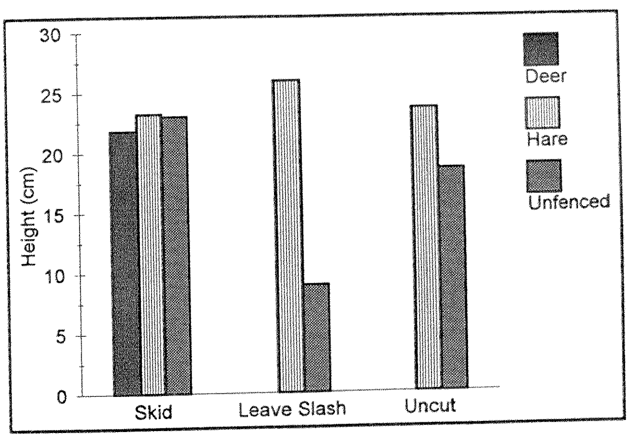

Figure 10.—*Average height of northern white-cedar seedlings in 1981.*

DISCUSSION

Seedbed Frequency and Quality

Effects of site preparation treatments on seedbed frequency were similar to the results from a study on the reproduction of tamarack. In both studies, burning increased the frequency of Burn-Type Bryophytes, while skidding increased the frequency of Sphagnum Moss seedbeds (Davis *et al.* 1996). Verme and Johnston (1986) also found that burning changed the growing conditions and shifted the vegetation from sphagnum-dominated moss communities to fire succession mosses (Burn-Type Bryophytes). They found a greater density of northern white-cedar seedlings established on the burned plots. Although we also saw this trend in seedbed frequencies (fig. 1), the conclusion by Verme and Johnston (1986) that Burn-Type Bryophytes provide a better seedbed than Sphagnum Moss was not supported (see the tabulation on page 4). Verme and Johnston (1986) hypothesize that climate factors can influence the success of germination as sphagnum mosses dry out during the summer season while Burn-Type Bryophytes remain more moist (Johnston 1971). This theory is supported by the observation that northern white-cedar becomes established on skid roads where the compacted moss stayed moist (Johnston 1990). The seedbed quality index, as calculated in this study, is influenced by a variety of correlated factors. For example, the Sphagnum and Leaf Litter seedbeds were dominant on the Leave and Uncut treatment areas, where the microclimate might be more suitable for northern white-cedar germination (Johnston 1977). Low germination rates of northern white-cedar seedlings on the Burned site could be related to low stocking before treatment and to possible moisture limitations on the mineral substratum found on the Burn site.

The differences in the amount of advanced regeneration between treatments suggest a potential for increasing the regenerative potential of a site. However, after any clearcutting of dense forest, the advanced regeneration is prone to damage from sudden exposure through sunscalding and/or desiccation (Thornton 1957). Burning, of course, eliminates most, if not all, advanced regeneration. Although this has the advantage of initially eliminating growth of competing vegetation, it may be a short-lived effect as shown by reappearing balsam fir seedlings 5 years after the burn. Full-tree skidding reduced the density of advanced regeneration of northern white-cedar to a lesser extent. The Leave treatment may be the least destructive because the slash left on site may protect the advanced regeneration. It becomes apparent that on sites where healthy advanced regeneration of northern white-cedar is present in sufficient numbers, harvesting technology that protects advanced regeneration could greatly improve regeneration stocking.

Northern White-Cedar and Balsam Fir Reproduction

Verme and Johnston (1986) recommend limiting harvesting disturbance to take advantage of advanced regeneration when significant amounts of northern white-cedar regeneration are present. But this study showed that within 5 years after harvesting, most advanced regeneration was eliminated or was not distinguishable from new seedlings on all site treatments (fig. 6). This discrepancy might be partially explained by the lack of deer browsing in the study area used by Verme and Johnston (1986), while deer were abundant in the Brule River Experimental Forest. Because deer prefer older seedlings, they might have browsed the advanced regeneration preferentially (Johnston 1990) when younger, smaller seedlings were covered with snow.

While the seedling density was the highest in the Uncut treatment, height growth of northern white-cedar seedlings in clearcut areas was twice or more than in uncut areas. The growth rates in clearcut areas were similar to rates found in other studies (Verme and Johnston 1986), supporting the hypothesis that light slash is not detrimental to northern white-cedar growth but heavy shade is (Johnston 1990).

In summary, all site preparation treatments provided adequate germination conditions for northern white-cedar. However, balsam fir also took advantage of the reduced hardwood competition and improved seedbed conditions, especially on the burned sites. After 5 years, balsam fir density was more than five times as high as northern white-cedar density on burned sites. This shift might have been enhanced by greater browsing pressure on growth and density of northern white-cedar.

Browse Treatment

Dramatic effects of browsing on height growth of northern white-cedar can be seen over the entire study period. All of the exclosure treatments were beneficial to the regeneration of northern white-cedar. The differences between deer, hare, and rodent browsing on average seedling heights were very small, suggesting that deer were the main herbivores in the study area. Verme and Johnston (1986) found that damage from snowshoe hare was minor, even in areas with low deer densities. In other areas, damage from snowshoe hare can be more detrimental than deer browsing (Johnston 1990).

The elimination of most northern white-cedar reproduction in the Unfenced control by the third year after harvest indicates the need for browsing control measures. Suggestions include controling deer during the regeneration phase or physically protecting seedlings from browsing. One suggested silvicultural treatment is to clearcut over a period of 5 to 10 years, small patches located adjacent or close to each other, so that eventually an area of 16 to 64 ha is completely cut (Verme and Johnston 1986). This method assumes that deer will avoid the center of the clearcuts due to the lack of cover in these open patches, thus thwarting browsing. Alternatively, excluding deer by fencing regeneration areas will reduce herbivory to levels that will allow satisfactory growth rates.

Conclusions

The results of this study support the need for harvesting techniques that integrate the requirement of northern white-cedar for open growing conditions and protection from browsing. Germination and initial establishment of northern white-cedar do not seem limiting on clearcut areas. To obtain the maximum amount of northern white-cedar regeneration most efficiently, full-tree skidding without treating residual slash can be recommended. However, concerns about fuel loading or creating different species mixtures might make other harvesting and site preparation methods more desirable. All site preparation treatments were effective in producing conditions that allowed high densities of northern white-cedar seedlings as well as balsam fir and black spruce to germinate. In any case, without any consideration for deer browsing, herbivory will reduce northern white-cedar density and growth, thus allowing other competing vegetation (e.g., balsam fir) to outgrow northern white-cedar and dominate the site. Even in areas with abundant advanced regeneration, seedling protection from browsing seems to be necessary. Elimination of balsam fir seed sources in areas adjacent to the harvest units would reduce the competition and should be considered in the sale layout.

Because of the slow growth rates of northern white-cedar, taking advantage of advanced regeneration would eliminate the need to create good seedbed conditions during harvesting operations and would decrease the time needed until a new stand becomes established and provides habitat for deer as overwintering areas. Although harvesting operations should be designed to eliminate or set back advanced regeneration of other competing species, especially balsam fir, care needs to be taken to avoid damage to advanced northern white-cedar regeneration. These treatments help ensure that northern white-cedar will be a significant component of future stands.

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Our job at the North Central Forest Experiment Station is discovering and creating new knowledge and technology in the field of natural resources and conveying this information to the people who can use it. As a new generation of forests emerges in our region, managers are confronted with two unique challenges: (1) Dealing with the great diversity in composition, quality, and ownership of the forests, and (2) Reconciling the conflicting demands of the people who use them. Helping the forest manager meet these challenges while protecting the environment is what research at North Central is all about.

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