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# Some Management Implications from an Eastern White Pine Regeneration Experiment

D. Burgess, F. Pinto and S. Wetzel

## *Strategic Importance*

Eastern white pine (*Pinus strobus* L.) is a valuable species for wildlife, recreation, spiritual fulfillment and timber production. The high value of white pine timber provides the opportunity to invest in its management. Eastern white pine is typically managed using a shelterwood system which in Ontario involves two or three partial harvests followed by a final removal where most but not all of the overstory is removed.

***Abundant three-year-old natural regeneration of eastern white pine following scarification.***

Eastern white pine is well suited to partial cutting because of its mid-tolerance to shade. It can establish and grow in relatively small openings on nearly all soil types within its range. On higher productivity sites hardwood competition can make it difficult to naturally regenerate eastern white pine. The number and size of residual pine will also affect seedling establishment and early growth. Silvicultural studies are needed to improve our understanding of white pine response and assess the impacts of forestry practices.

Our approach to assess partial cutting and the impacts of site preparation on natural and planted pine regeneration involved use of a statistically sound experimental design (a randomized complete block, split-plot design with four replicates). The study investigated the effects of thinning and site preparation on white pine regeneration.

The Ontario Ministry of Natural Resources, Science and Technology Unit, and the Algonquin Forest Authority were consulted early in the development of this field study so that the results would be applicable for them.

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## *Eastern white pine shelterwood systems*

Successful white pine regeneration is favored if the following conditions occur simultaneously:

- A good seed year (Eastern white pine does not store its seed in the soil or in its cone like some other tree species.);
- A receptive seedbed (Eastern white pine requires live parent trees in close proximity to sites suitable for germination and early growth of seedlings. Higher numbers of parent trees usually mean more seed available for germination.);
- Proper environmental conditions for the seed to germinate and the seedling to establish and grow. (Eastern white pine seedlings are susceptible to competition from faster growing hardwoods. Non-site-prepared stands with high-density overstories will lessen the undergrowth's access to light, nutrients and moisture.)

The primary objectives of a shelterwood system are to ensure a sufficient amount of parent trees to produce seed and provide overstory protection for the developing regeneration. The shelterwood system in Ontario involves four types of stand entries:

1. A preparatory cut, or thinning from below, is used to improve the vigor of prospective seed-bearing trees. Low vigor trees are harvested while larger, healthy trees are retained.
2. A regeneration cut retains the largest, healthiest trees in the stand to be the source of seed and to create conditions that may limit white pine weevil and blister rust damage. Additional trees are kept for wildlife habitat such as live cavity, mast and supercanopy trees.
3. A first removal cut is applied to stands that have sufficient regeneration (at least 30 cm in height) in the understory to form a new white pine stand in the future. Some of the residual trees are harvested mimicking the eventual death of some trees after a natural disturbance such as a fire. Stands may be opened so that about 30% to 50% crown closure remains after this cut. This creates conditions that reduce white pine weevil and blister rust damage in white pine seedlings.
4. A final removal cut occurs when the white pine regeneration is about three meters in height. Some (usually 10-20 per ha) parent trees are retained for ecological (e.g. veterans) and habitat (e.g., mast, supercanopy and cavity trees) value.

Assuming that a regeneration cut is properly timed to coincide with a good seed year, sites should be prepared using mechanical scarification for either natural regeneration or for planting. Major competition can be expected on good sites from trembling and largetooth aspen, red maple and balsam fir. Mechanical scarification is frequently followed by a herbicide treatment to further delay vegetative competition. (Additional underplanting with white pine seedlings may be necessary in poor seed years and may be desirable to enhance productivity.)

## *The Study Area*

Three 110-year-old natural pine stands within the Petawawa Research Forest (45° 57′ N, 77° 34′ W), Chalk River, Ontario were selected for a study of the effects of thinning, site preparation and underplanting on eastern white pine seedling survival and early growth. The area was classified as an ecosite type ES 11.2 within the central Ontario Forest Classification (FEC) System. The canopy was predominately white pine with associated species (Table 1). The soils were acidic (pH 3.8) podzols and brunisols with textures ranging from coarse to fine sand.

The main plot treatments were thinning to:

1. A one-crown width opening between trees resulting in 37% canopy cover and 62% of the total volume being harvested;
2. A two-crown width opening between trees resulting in 16% canopy cover and 82% of the total volume being harvested; and,
3. A control (uncut) spacing which had an 80% cover.

The trees were marked prior to harvest so that large, well-distributed and healthy residual trees suitable for future products, health and other values would be left.

Scarification was completed in the fall of 1994 and coincided with an excellent seed year for white pine. The four site preparation treatments were:

1. blade scarification (using a John Deere 350 bulldozer with a six-way movable blade);
2. brush control using herbicide (a ground application of 1.5 kg/ha, Vision® [n-phosphonomethyl] applied with backpack sprayers);
3. blade scarification and brush control; and
4. untreated (control).

*Table 1a. Basal area ($m^2$ / ha) on control, non-thinned (Th 0) plots*

| Class (cm) | White pine | Red pine | White spruce | Balsam fir | Red maple | White birch | Aspen | Other species |
|---|---|---|---|---|---|---|---|---|
| 0-25 | 1.60 | 0.43 | 0.60 | 1.07 | 0.53 | 0.12 | 0.19 | 0.09 |
| 25.1-37 | 3.38 | 2.41 | 0.51 | 0.01 | 0.05 | 0.28 | 1.24 | 0.05 |
| 37.1-49 | 6.07 | 10.01 | 0.21 | 0 | 0 | 0 | 1.29 | 0.03 |
| 49.1+ | 5.56 | 6.23 | 0.05 | 0 | 0 | 0 | 0.20 | 0.00 |
| Total | 16.62 | 19.08 | 1.37 | 1.09 | 0.58 | 0.40 | 2.92 | 0.17 |

*Table 1b. Basal area ($m^2$ / ha) after thinning to one-crown spacing (Th 1) plots*

| Class (cm) | White pine | Red pine | White spruce | Aspen |
|---|---|---|---|---|
| 0-25 | 0.10 | 0.05 | 0.05 | 0.02 |
| 25.1-37 | 1.14 | 0.72 | 0.03 | 0.04 |
| 37.1-49 | 2.32 | 3.24 | 0 | 0.19 |
| 49.1+ | 4.05 | 1.93 | 0 | 0.12 |
| Total | 7.61 | 5.94 | 0.08 | 0.37 |

*Table 1c. Basal area ($m^2$ / ha) after thinning to two-crown spacing (Th 2) plots*

| Class (cm) | White pine | Red pine | White spruce | Aspen |
|---|---|---|---|---|
| 0-25 | 0.03 | 0 | 0 | 0 |
| 25.1-37 | 0.34 | 0.12 | 0 | 0.04 |
| 37.1-49 | 0.93 | 1.29 | 0.03 | 0 |
| 49.1+ | 2.40 | 1.55 | 0 | 0 |
| Total | 3.70 | 2.96 | 0.03 | 0.04 |

## Residual tree damage from harvesting

The damage to residual trees (assessed by FERIC [Forest Engineering Research Institute of Canada]) was very low with only 2% of the designated residuals wounded. Half of the damaged trees had wounds smaller than 100 $cm^2$ and the other half had wounds averaging 625 $cm^2$ in size. This low level of damage was attributable to:

a) Experienced, well-trained loggers and equipment operators given enough financial incentives to encourage careful harvesting;

b) Close supervision during the harvesting operations; and,

c) Harvesting was done during winter when trees are more resistant to stem damage.

## Windthrow losses

Windthrow was relatively low with the highest number occurring in the heaviest thinning treatment. Two years after treatment, losses to windthrow were 1.75, 1.50 and 2.50 trees/ha, respectively, in the control, one-crown and two-crown thinned areas. Windthrow becomes a significant management consideration as residual tree densities decrease.

## Seedling establishment

Scarification (mechanical site preparation) reduced competing understory vegetation and prepared more seedbed areas. The treatment reorganized the duff and coarse wood material into small piles scattered over the treatment area. This effectively exposed enough mineral soil to improve germination and yet retained nutrients on the site. Consequently, greater numbers of natural white pine became established on scarified sites that had not been thinned (Table 2). Initially, the numbers of seedlings reflected the good seed year and were relative to the number of seed trees left after thinning.

*Table 2. Natural tree regeneration (thousands of seedlings per ha) two growing seasons after treatment.*

| Species | Brush control | Control (uncut) Non-scarified | Control (uncut) Scarified | One-crown thinning Non-scarified | One-crown thinning Scarified | Two-crown thinning Non-scarified | Two-crown thinning Scarified |
|---|---|---|---|---|---|---|---|
| White pine[1] | no herbicide | 15.6 b | 248.3 a | 5.7 b | 64.7 ab | 3.8 b | 11.8 b |
| | herbicide | 20.8 b | 168.6 ab | 4.5 b | 57.3 ab | 1.9 b | 16.0 b |
| Red pine | no herbicide | 0.0 b | 0.0 b | 0.2 b | 1.5 a | 0.0 b | 0.0 b |
| | herbicide | 0.0 b | 0.0 b | 0.0 b | 0.2 b | 0.0 b | 0.0 b |
| Other | no herbicide | 27.7 b | 259.8 a | 20.8 b | 35.8 b | 13.2 b | 26.1 b |
| species[2] | herbicide | 29.4 b | 83.1 b | 25.0 b | 35.9 b | 8.9 b | 18.8 b |
| Total | no herbicide | 43.3 b | 508.1 a | 26.8 b | 102.0 b | 17.0 b | 37.9 b |
| | herbicide | 50.2 b | 251.8 ab | 29.4 b | 93.4 b | 10.8 b | 34.8 b |

[1] Number of seedlings within a species group followed by the same letter do not differ significantly (p = 0.05) using the Tukey HSD significance test.

[2] Consisting mainly of balsam fir, red maple, trembling aspen and white birch.

## *White pine seedling growth response*

Three years after planting, thinning and site preparation interacted to improve seedling height growth (Figure 1). Mean root collar diameter also increased from 1.1 mm (control) to 3.2 mm (two-crown, scarified with brush control treatments). The treatment combination greatly improved seedling shoot mass, mean height and root collar diameter, especially of the planted white pine seedlings.

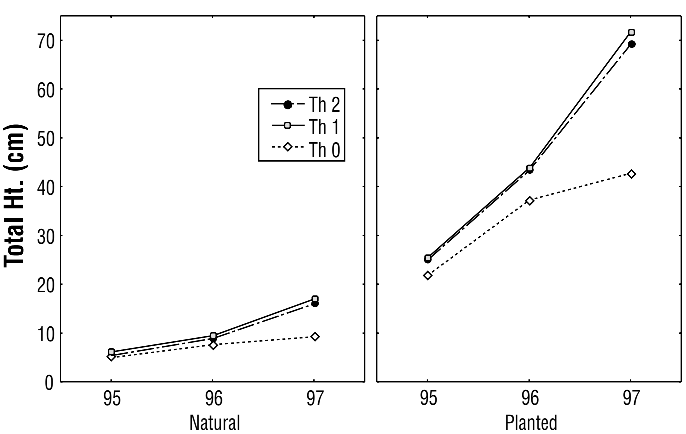


***Figure 1. Total height growth of white pine seedlings during the first three growing seasons. (Planted seedlings are older than natural seedlings, averaging 14 cm in height when planted at the start of the growing season in 1995; natural seedlings were only germinating at that time).***

## *Environmental factors affecting eastern white pine regeneration*

Various shelterwood or multi-aged silvicultural systems can be used to adjust the available resources for the residual trees and understory seedlings (nutrients, light, water, and temperature regimes). The role of management is to design treatment combinations to improve white pine establishment, growth and stem quality.

### *a) Nutrient differences*

Nitrogen is typically most limiting to tree growth. Nutrient availability can be a significant factor in white pine development, but only when competing vegetation is controlled. A deficiency can significantly reduce seedling biomass and height growth. So far, the seedlings have not shown a growth response to nitrogen, and nutrient differences among the treatment areas are diminishing three years after thinning and scarification. The nutrient status of natural and planted white pine and early growth was improved, though, by applying a combination of thinning, scarification and brush control treatments.

Blade scarification did not remove the forest floor but redistributed it into small piles. This approach was effective in initially decreasing competition and increasing root growth of the pine seedlings. The distribution of the scarified piles may have compensated for any reduction in nutrients and this may become more important through time, especially if the nutrients become accessible as the scattered slash piles decay.

*b) Light*

Eastern white pine is initially slow growing compared to competitive hardwoods. Favorable light conditions and controlled competition allow seedlings to take advantage of improved soil water availability, higher soil temperatures and the available nutrient supply.

Brush control is the single most effective site preparation treatment for reducing plant competition. In this study, it dramatically improved white pine seedling growth suggesting that light or below-ground resources, or both, were major limiting factors. Seedlings increased in biomass with light intensity as did leader diameter, root collar diameter and root weight.

*c) Soil temperatures*

Soils were consistently warmer (1 - 2 °C) in the scarified and brush-controlled plots. The warmer soil conditions persisted throughout most of the growing season and promoted vigorous root development.

*d) Interactions between environmental factors*

Eastern white pine showed a positive growth response to a combined increase in light, moisture and nitrogen supply. Difference in soil temperatures, water availability and use, and other environmental factors caused by the various silvicultural treatments need to be measured and understood to determine how trees adapt and compensate for unfavourable environments. To increase growth, factors that are limiting photosynthesis, and to what extent, must first be identified.

Windthrow after two years was greatest in the widest spacing. The risk of windthrow is affected by tree density and form, the characteristics of the landscape, the nature of the soils (including moisture), and depth of rooting.

## White pine weevil

In general, partial cover conditions (shade, reduction in the variation of daily and seasonal microclimatic factors such as temperature, and the retention of habitat conditions for weevil predators) limit leader attacks from the white pine weevil. The fact that white pine height growth was almost as good in the one-crown as the two-crown spacing is of particular interest when considering the advantage of shade in the control of the white pine weevil; this combination of protection from the weevil population with only marginal decreases in growth makes this species an ideal candidate for partial cutting.

## Implications for management

A shelterwood system will allow for the harvest of the poorer quality stems and species that would be more likely to be killed by natural disturbances such as a wild fire. A shelterwood system will also accelerate the development of larger residual trees with pine as a preferred species. These residual pines will achieve larger tree sizes at a much earlier age, thereby advancing the technical rotation age of the pine by some 20 to 30 years. Treatment did not reduce the available browse and diversity of herbaceous species.

In summary, our investigations of the effects of thinning and site preparation on regeneration of eastern white pine indicated the following:

- Partial cutting in mature pine stands can be done without causing significant damage to residual trees by using experienced crews and providing financial incentives and close supervision.
- The correct application of a shelterwood system results in retention of a higher proportion of pine trees than trees of other species and an increase in the average diameter of pine trees after thinning compared to the average diameter of pine before thinning.
- The number of pine seedlings is related directly to the number of large healthy parent trees retained, i.e. more pine seedlings are establish when more large healthy pine parent trees are retained.
- Wide openings after thinning, such as the two-crown spacing treatment, will increase the amount of windthrow and probably weevil damage.
- Scarification must coincide with good pine seed crops.
- Managers may postpone scarification until good seed years. However, managers should recognize that there could be growth and subsequent rotation losses incurred by solely relying on natural stock and initial delays in regeneration establishment.
- Planting is required in years with poor seed production.
- Scarification improves pine regeneration (both number and stocking) most in the non-thinned treatments; forest managers may be able to scarify within pine stands before thinning to encourage natural regeneration of eastern white pine.
- A relatively high number of seedlings must be established, as natural mortality rates are high and some will be damaged in future thinnings.
- A combination of site preparation and thinning produces the best regeneration establishment, survival, and early growth, particularly on high-productivity, high-competition sites.

## *Additional Reading*


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## *Contacts*


Darwin Burgess,
Pacific Forestry Centre, Canadian Forest Service
506 West Burnside Road, Victoria, BC, V8Z 1M5,
(250) 363-0724
dburgess@pfc.forestry.ca

Fred Pinto, Ontario Ministry of Natural Resources,
3301 Trout Lake Rd., North Bay ON P1B 6V2,
(705) 475-5563
fred.pinto@mnr.gov.on.ca

Suzanne Wetzel,
Great Lakes Forestry Centre, Canadian Forest Service,
1219 Queen Street East, P.O. Box 490, ON P6A 5M7,
(705) 759-5740
swetzel@NRCan.gc.ca


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