# The Impact of Stunting of White Spruce at Eveleth Nursery

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*Stunting and purple discoloration of 1-0 white spruce in the Lake States have been shown to be associated with low foliar phosphorus. A $9,800 loss was sustained by the Eveleth Nursery in Minnesota because stunted stock did not meet seedling specifications at lifting.*

Stunting and purple discoloration of 1-0 red pine and white spruce seedlings (stunting syndrome) have been recognized as significant problems in Wisconsin State nurseries and two Forest Service (Region 9) nurseries -the Eveleth Nursery at Eveleth, Minn., and the J. W. Tourney Nursery at Watersmeet, Mich. In 1977, Wisconsin Department of Natural Resources nurseries at Hayward, Wisconsin Rapids, and Boscobel recorded 13,18, and 23 percent, respectively, of their 1-0 red pine seedlings were affected (*2*). That same year, a similar problem was noted on both species at the Eveleth Nursery and on red pine at the Tourney Nursery. Stunting has continued to appear since 1977 at all five nurseries.

The stunting syndrome becomes noticeable at the end of the first growing season. Affected seedlings have purple foliage and are about 1/2 the height of the green nonaffected stock. The portions of the beds that have seedlings showing these symptoms are generally poorly stocked with groups of healthy and stunted trees along the bed rows. Although the cause of the symptoms is unknown, the purple coloration of the foliage suggests a phosphorus deficiency (*1*).

Because of the frequent occurrence of stunting, State and Private Forestry personnel conducted a survey to determine the impact of stunting on survival and growth of white spruce at the Eveleth Nursery. White spruce was selected for evaluation because it was generally more severely stunted than red pine. Another objective of the survey was to determine whether soil nutrient deficiencies were associated with stunting of seedlings.

## Methods

Fifty percent of the beds with 1-0 white spruce were sampled in August 1978. Disease distribution was determined by systematically selecting six sample points along each of the 26 beds in block 9. At each sampling point, a standard seedling inventory frame, 6 inches by 4 feet (15 cm by 1.2 m), was used to delineate the seedlings to be examined. The total numbers of stunted seedlings and nonstunted seedlings were noted for each row. The distribution of stunted seedlings was then plotted.

Stunted and nonstunted seedlings were tagged for future evaluation. Ten plots of 24 seedlings (12 stunted and 12 nonstunted) were established in September 1978. Seedling height was measured at this time and recorded as first-year growth. Height and root collar caliper measurements were recorded 1 and 2 years later. Upon lifting, the seedlings were graded by nursery personnel to determine the percentage of culls associated with stunted and nonstunted stock. .

To determine the dollar losses associated with white spruce stunting, the number of stunted seedlings was multiplied by the cull percentage (stunted cull percentage minus nonstunted cull percentage). This product was then multiplied by the 1981 cost per 1,000 trees.

After the distribution of stunting was determined, stunted and nonstunted seedlings were collected and taken to the University of Minnesota's Research Analytical Laboratory for foliar analysis. Simultaneously, because the symptoms were those of a phosphorus deficiency, soil samples taken from beneath the stunted seedlings were taken to the University's Soils Department for analysis of pH, total nitrogen (N), phosphorus ($P_2O_5$), and potassium (K).

## Results

Distribution of stunting by unit, sample point, and row is given in figure 1. Stunting was least severe in the northwest portion of the block. Based on stunting-distribution observations for units 2 through 8, 28 percent of the 2.5 million 1-0 white spruce seedlings were affected.

The difference in first-year growth of stunted and nonstunted seedlings was dramatic. Stunted 1-0 seedlings

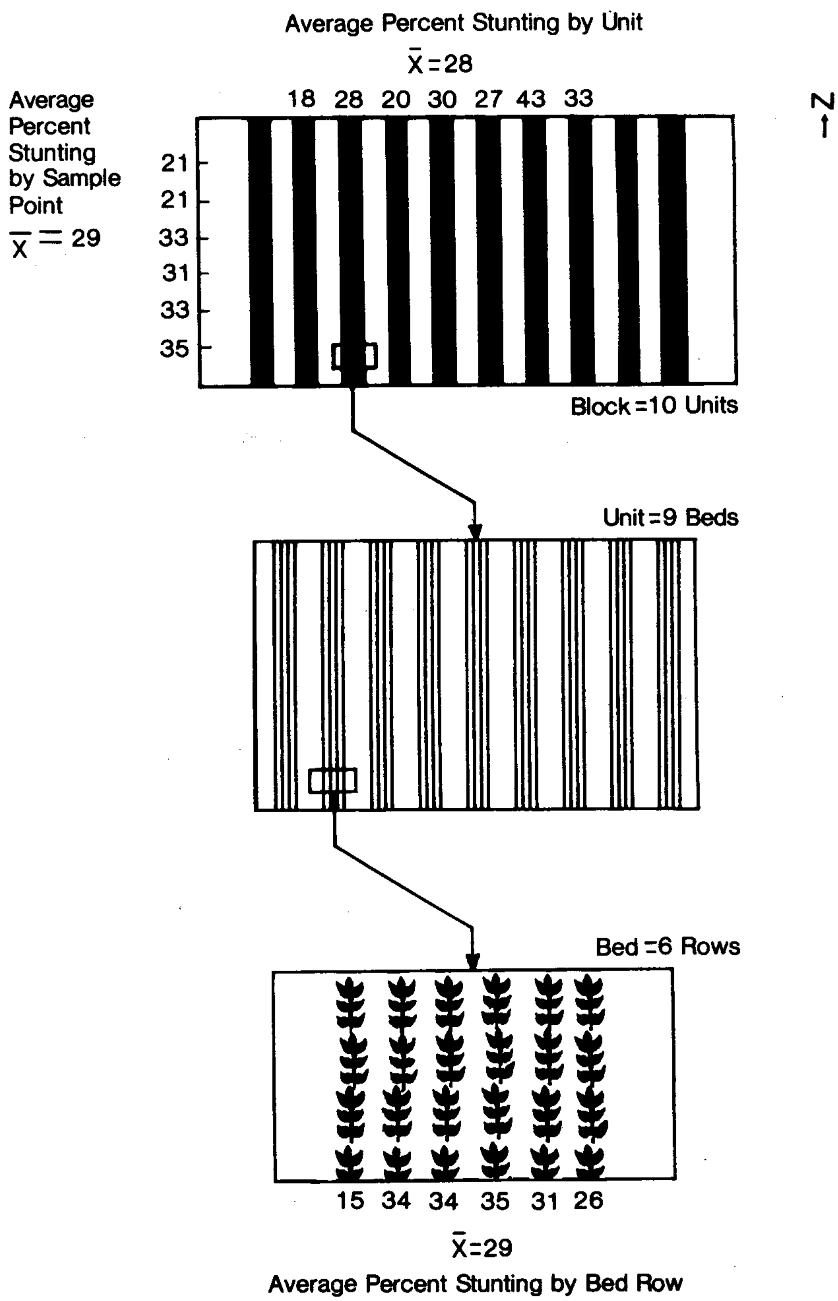


**Figure 1.**—*Distribution of 1-0 white spruce stunting in block 9 at Eveleth Nursery, September 1978.*

were about 1 /2 the size of non stunted seedlings (table 1). After two seasons, they were 42 percent taller than nonstunted seedlings and 54 percent larger in caliper. At lifting, the average top height of stunted seedlings had increased to 78 percent of that for nonstunted seedlings. A similar recovery was not observed for caliper. The average caliper of stunted seedlings was 61 percent of that observed for nonstunted seedlings after 2 years. No tree mortality was noted during the evaluation period.

Cull percentage for stunted seedlings was five times greater than for nonstunted seedlings (27.6% versus 5.4%). Based on the Eveleth Nursery cost per 1,000 seedlings ($63.00), these added cull seedlings cost the nursery $9,800 in 1981.

Foliar analyses showed a marked difference in total N and P levels in affected and nonaffected seedlings (table 2). Stunted seedlings had 25 percent less N and 72 percent less P than nonstunted seedlings. The foliar analysis for other elements indicated no notable differences between stunted and nonstunted trees.

Soil samples from stunted and nonstunted plots showed no significant differences in levels of pH, N (total), $P_2O_5$, and K (table 3). All samples were found to contain adequate levels of phosphorus at 200 pounds per acre (224 kg/ha).

**Table 1.**—*Average height and caliper measurements and percentage of culls for stunted and nonstunted white spruce seedlings at Eveleth Nursery*

| | Height[1] | | | Caliper[1] | | Culls at 3-0[2] |
|---|---|---|---|---|---|---|
| | 1st yr. | 2d yr. | 3d yr. | 2d yr. | 3d yr. | |
| | *Cm* | *Cm* | *Cm* | *Mm* | *Mm* | *Percent* |
| Stunted | 1.3 | 7.9 | 19.3 | 1.4 | 2.6 | 27.6 |
| Nonstunted | 2.8 | 19.2 | 24.7 | 2.5 | 4.2 | 5.4 |

[1]Region 9 reforestation handbook stock specifications recommend a minimum height of 13 centimeters and caliper of 3 millimeters for white spruce seedlings to be planted.
[2]Seedlings were culled because they failed to meet minimum height and caliper specifications.

**Table 2.**—*Foliar mineral analysis of stunted and nonstunted 1--0 white spruce foliage at Eveleth Nursery*

| Seedling condition | Mineral content[1] N | P | K | Ca | Mg | Fe | Mn | Al | Zn | B | Cu |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | *%* | *%* | *%* | *%* | *%* | *P/m* | *P/m* | *P/m* | *P/m* | *P/m* | *P/m* |
| Nonstunted | 2.07 | 0.28 | 1.19 | 0.49 | 0.17 | 975 | 157 | 958 | 154 | 19 | 10 |
| Stunted | 1.51 | .08 | .87 | .52 | .19 | 1,183 | 260 | 1,340 | 120 | 30 | 5 |

[1]All results are expressed on a dry-matter basis.

**Table 3.**—*Total nitrogen, phosphorus pentoxide, potassium, and pH of soils associated with stunted and nonstunted white spruce seedlings at Eveleth Nursery*

| Origin of soil sample | pH | Total N | $P_2O_5$ | K |
|---|---|---|---|---|
| | | *Percent* | *Lb/acre* | *Lb/acre* |
| Under nonstunted seedlings | 5.20 | 1.37 | 200 | 197 |
| Under stunted seedlings | 5.76 | 1.00 | 200 | 219 |

**Discussion**

The $9,800 loss presented here represents the situation at a specific nursery for a single year. Within the Lake States, stunting appears frequently on both red pine and white spruce, but in no set pattern. Stunting may occur year after year or may disappear for several seasons and then reappear. The stunting episode outlined in this paper is not a rare occurrence. It is however, the first to be documented with dollar-loss figures. The authors feel that these losses are significant, especially when the general occurrence of this problem is considered.

This study did not follow trees in the field to evaluate the subsequent performance of the stunted seedlings. Although the average height of these seedlings had increased to 78 percent of that for the nonstunted trees by lifting time, it should be noted that the seedlings had been top pruned. Therefore, stunted trees attained *78* percent of the top pruned height, not actual height. It is possible that stunted trees may continue to grow at a slower rate than their nonstunted counterparts. If this is true, dollar losses associated with the stunting of white spruce would be greater than those cited for this nursery evaluation.

The low level of stunting in the northwest portion of block 9 did not correlate with specific nursery practices or seedlots.

The purple discoloration and low foliage P levels of the stunted seedlings suggest that the stunting problem is associated with a P deficiency. The mineral analysis of the soil from portions of the beds that had stunted stock did not show correspondingly low P levels. Therefore, it appears that factors other than soil nutrient content are contributing to this deficiency.

Phosphorus deficiencies may result from low soil pH values, which inhibit the assimilation of P in plants (*3*). At pH levels less than 6, P availability decreases with increaseing acidity. Soil pH values under nonstunted and stunted seedlings were 5.2 and 5.76 respectively (table 3). If pH was the limiting factor for P assimilation, the nonstunted trees would have had lower foliage P levels than the stunted trees. This, however, is the reverse of our findings.

The P deficiency noted here is not in agreement with the findings of Berbee and others (*2*). They analyzed the foilage both of red pine and white spruce and found no significant difference for P levels between stunted and nonstunted seedlings. No explanation can be given by the authors for this discrepancy in results.

No seedling mortality occurred during the period of this evaluation. However, it should be noted that there appears to be poor germination and/or survival during the first growing season in those portions of seedbeds that have stunted seedlings. Our plots were established at the end of the first growing season. If mortality is associated with the earliest phase of stunting, it would not have been recorded in this evaluation.

**Conclusions**

1. Stunting was associated with phosphorus deficiency of seedling foliage in spite of the phosphorus-rich soils in which they were grown.

2. Stunted 1-0 white spruce seedlings do not show increased rate of mortality when followed through the 3-0 stage.

3. Because of the failure of stunted 3-0 stock to meet grading specifications, significant dollar losses are associated with the occurrence of stunting.

## Literature Cited


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