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INSIDE

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"Science affects the way we think together."
Lewis Thomas

Make Way for Seedlings: Regenerating White Spruce in Alaska

Elizabeth Cole

Eleven years after planting, these Alaska white spruce are nearly 9 to 10 feet tall. Site preparation and choice of nursery stock were elemental to their success.

"The best time to plant a tree was 20 years ago. The next best time is now."
—Chinese Proverb

Changing fire regimes, insect epidemics, and increased timber harvests: since the 1960s, Alaska's boreal forests have experienced unparalleled levels of disturbance. Alaska white spruce (*Picea glauca*), a dominant boreal species, has been particularly affected. The tree is known for irregular cone and seed production, and seedlings are easily out-competed by faster growing vegetation, leaving people to wonder if white spruce would adequately regenerate on its own.

In the 1990s, insect outbreaks on Alaska's Kenai Peninsula and Copper River Delta reached epidemic proportions and spread north. Spruce bark beetles infested nearly 3 million acres of white spruce forest, killing more than 90 percent of the trees bigger than 4 inches in diameter. North of the Alaska Range, spruce budworm moved in and defoliated overstory trees and smaller spruce seedlings. Because green logs are worth more than beetle-killed logs, many landowners and Native Corporations increased harvest levels in an effort to stay two steps ahead of the bugs.

During this period, Japan and other Pacific Rim countries began buying more white spruce logs from Alaska as production of softwood timber from the Pacific Northwest declined over concerns for wildlife habitat.

IN SUMMARY

Alaska's boreal forests have experienced unprecedented levels of disturbance in recent decades. Fire is becoming more frequent and burning larger areas compared to the 1960s and 1970s. In the mid 1990s, insect outbreaks reached epidemic proportions. During the same period, timber harvesting increased to meet demand for logs no longer coming from Pacific Northwest forests. Alaska white spruce was particularly affected by these disturbances, bringing into question the ability of the species to regenerate naturally and reestablish the stands.

Andrew Youngblood, a research forester with the Pacific Northwest Research Station, and his colleagues at Oregon State University, have been studying Alaska white spruce for nearly two decades. For their latest study, they established five study sites across Alaska to learn what could be done to facilitate white spruce regeneration.

Eleven years later, they found that the method of site preparation and seedling stock type led to dramatic differences in white spruce seedling survival, height, and volume. Site preparation also influenced the composition and structure of competing vegetation. They found that areas not reforested immediately can be successfully restored to productive white spruce forests through a combination of vegetation control and use of quality planting stock.

"Natural regeneration of white spruce has been patchy," says Jeff Graham. "Where landowners have replanted, regeneration is much better." Graham, based in Palmer, Alaska, is the forest stewardship coordinator for Alaska's Department of Natural Resources, Division of Forestry. But what does it take to successfully regenerate white spruce? "In the boreal forest, reforestation without site preparation can be problematic," Graham explains, "Land managers want to know what will work and what is cost effective."

Fortunately, scientists were already investigating this question. A trio of researchers has been studying the growth habits and requirements of Alaska white spruce for nearly 20 years. Andrew Youngblood, a research forester with the Pacific Northwest Research Station, explains: "We started the work because there was a need to better understand how to manage white spruce as a viable forest product. The beetle outbreak—phenomenal in proportion—developed during this study."

In the early 1990s, Youngblood and his colleagues Michael Newton and Elizabeth Cole, researchers at Oregon State University, initiated a field study designed to answer three main questions:

(1) Does chemical or mechanical site preparation offer advantages over planting with no site preparation? And is one preparation technique more effective than the other?

(2) Is there a significant and persistent advantage to using larger planting stock?

(3) Does replanting need to happen immediately after disturbance for successful reforestation to occur, or is reforestation possible after waiting several years?

They established five study sites along a north-south transect that spans about 500 miles from Fairbanks to the Kenai Peninsula. To ensure that the seedlings would be adapted to local site conditions, the researchers obtained seeds from each site then sent them to nurseries in Alaska, British Columbia, and Washington for germination. This let the researchers see how different nursery practices affected seedling performance.

At planting time, some seedlings were 1 year old, grown in containers; some were 2-year-old bare-root transplants grown in containers for 1 year and then transplanted to a nursery field for 1 year; and some were 3-year-old bare-root transplants grown in containers for 1 year and then transplanted to a nursery field for 2 years. The researchers hand-planted some of each seedling type in each unit of the five study sites.

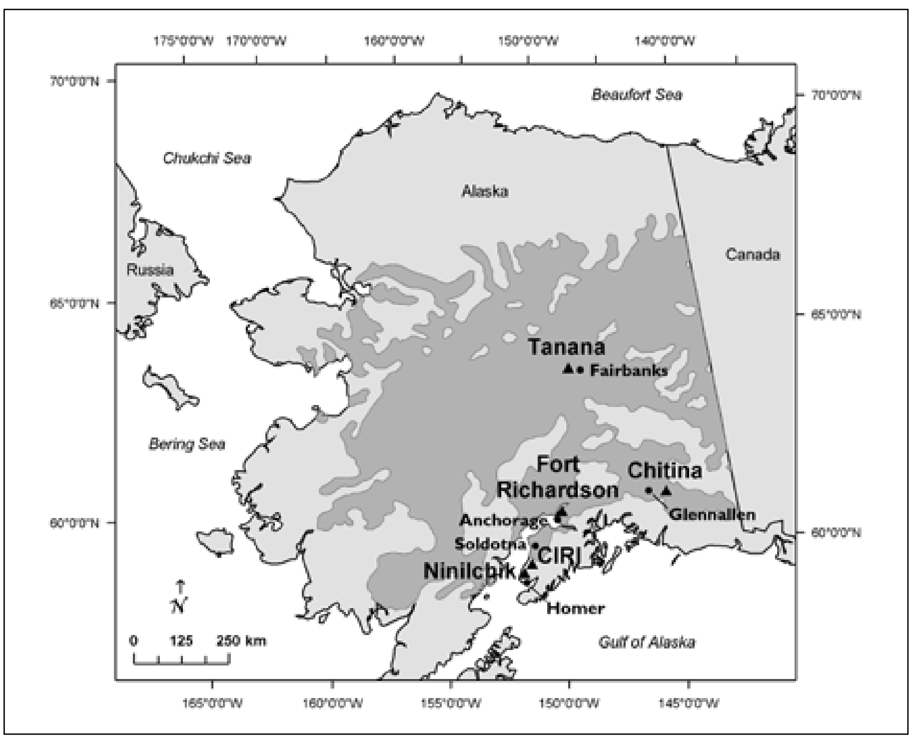
KEY FINDINGS

- More planted white spruce seedlings survived in experimental units where a bulldozer blade (mechanical scarification) was used to remove vegetation before planting, compared to units where herbicides were applied before planting or to sites with no site preparation.

- The bare soil exposed by mechanical scarification provided opportunities for wind-disseminated seeds to colonize. At some sites, this led to more forbs and woody shrubs, which compete with white spruce seedlings for light and soil nutrients.

- White spruce seedlings were taller and larger at sites where herbicides were applied in the fall before planting, compared to mechanically scarified sites or sites with no site preparation. Spraying reduced abundance of competing vegetation without providing the microsites for seed germination found after the blade scarification treatment.

- When comparing "old" sites cleared 3 years prior to planting, where a full component of competing species had become established, to "new" sites cleared immediately prior to planting, no difference was found in white spruce seedling survival or height growth that could be attributed to site preparation techniques.



The field installations for this study were established in five regions of Alaska within the range of Alaska white spruce (shaded area).

Purpose of PNW Science Findings

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SPRAY OR BLADE—WHAT'S THE DIFFERENCE?

Without a helping hand, white spruce seedlings are easily overtopped by faster growing grasses and shrubs. The white spruce seedlings lose out on soil nutrients and sun during the short growing season, and in the winter the taller surrounding plants, weighted down by snow, can crush the seedlings. Herbicides or mechanical treatments are two methods for controlling vegetation. Youngblood and his colleagues wanted to know if one method provided significant advantages over the other for spruce seedling survival and growth.

"We wanted to compare the herbicide application with mechanical scarification because it's a tool that is used infrequently, and rarely in the format that we applied it," Youngblood explains. In Canada, for example, it's not uncommon to apply herbicides 5 to 10 years after planting to release the white spruce seedlings from competing vegetation. "Our premise was that a release treatment forces you to give up initial accelerated growth because you're allowing competition to affect initial seedling growth. By using herbicides as a site-preparation technique, we're providing the best opportunity for that seedling to reach its most rapid height growth initially," he says.

So in the fall prior to planting, some plots received a single application of two herbicides for short-term removal of woody and herbaceous competitors. The herbicide treatment did not disturb the forest floor and left a decaying litter layer. In other plots, a bulldozer with a blade attachment was used to scrape away existing vegetation, exposing bare soil across most of the unit. For the sake of comparison, each study site had control plots that received no preparation.

The researchers replicated this design at each of the five sites across Alaska on "new" units that had been logged within the last year and "old" units where the timber harvest had occurred three years earlier.

Eleven years after nearly 12,500 seedlings had been planted, more white spruce seedlings had survived on mechanically scarified sites compared to those where herbicides were applied or to sites with no preparation. The herbicide treatment resulted in greater seedling height and volume compared to mechanical scarification across all sites. The herbicide treatment also resulted in greater seedling survival, greater seedling height, and greater seedling volume across all sites compared with no site preparation.

The researchers found the bare soil exposed by the mechanical scarification provided opportunities for wind-disseminated seeds to take root. This led to more competition from

Elizabeth Cole

Sprayed site preparation: Alaska white spruce growing at a Tanana site 11 years after planting.

Elizabeth Cole

Scarified site preparation: Alaska white spruce growing at a Tanana site 11 years after planting.

Elizabeth Cole

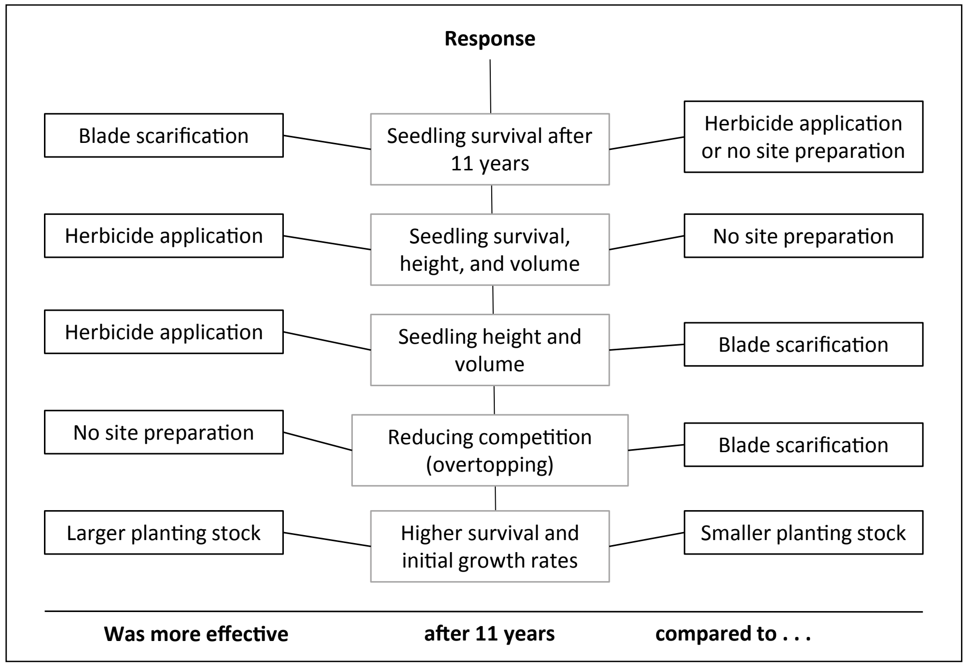
No site preparation (control): Alaska white spruce growing at a Tanana site 11 years after planting.

other vegetation compared to sites where herbicide was initially applied or the control sites.

Taking a step back to consider the forest for the trees, Youngblood points out the benefits of allowing other vegetation to become established, even while managing for white spruce. “This is providing an important hardwood component in the stand, which is very beneficial for the sustainability of moose populations,” he says. “Even though you may lose some height growth for white spruce, you’re increasing the diversity of the overall plant community by encouraging natural establishment of willow and paper birch.”

Moose have a critical role in many Alaska ecosystems and are valued culturally and as a food source by many Alaskans. An earlier study by the research team found that moose could help white spruce seedlings become established by browsing back the willow and paper birch.

Plants help moderate soil temperatures, shading the soil in the summer and insulating it in the winter. The researchers monitored monthly soil temperatures to determine what effect the treatments would have on seedling survival and growth. They found that soil temperatures increased 3 to 5 ^{o}F during the growing season in the first 3 to 4 years after blade scarification. This warming was not evident after vegetation became reestablished.



This chart summarizes the effects of different site preparation techniques on the survival and growth response of planted white spruce seedlings in Alaska.

They found some winter damage to smaller planting stock in blade-scarified plots on the old units in two regions. In some locations, the ground may freeze and thaw multiple times during the winter. As ice forms in the soil, the soil is pushed upward; a small seedling with a poorly developed root system can be pushed out of the soil. With its roots exposed to the elements, the seedling usually dies early in the next growing season. “Frost heaving isn’t uncommon after mechanical scarification,” Youngblood explains. “It’s driven by soil texture, moisture availability in the soil, and freezing temperatures.”

INVESTING IN NURSERY STOCK

Replanting an area is an investment. For it to pay off, most of the newly planted seedlings need to survive and thrive. Youngblood and his colleagues designed their study to see if there was an advantage to planting larger white spruce seedlings rather than smaller seedlings. Smaller seedlings are easier to plant and are less expensive than larger ones because they spend less time in a nursery. However, smaller seedlings may be more easily overtopped by competing vegetation. Small seedlings with poorly developed root systems are also more susceptible to frost heaving than are large seedlings with deeper roots.

The researchers found that larger seedlings had a greater chance of survival compared to smaller seedlings. Nursery practices that resulted in large stock gave the seedlings a growth advantage that was still apparent after 11 years. Transplanting 1-year-old container-grown seedlings to a nursery field for another year or two so the seedling could develop a more extensive root system generally led to larger seedlings, but not always. Some 1-year-old container-grown seedlings survived as well or better than older seedlings grown in the same nurseries. In general, seedling size at planting time was a better predictor of success than seedling age.

“The handling costs are much higher when you have larger stock,” Youngblood says, “But the larger stock provided advantages that translate to long-term gains.”

The researchers found that the seedlings could be successfully grown in nurseries outside Alaska. In fact, seedlings produced in nurseries outside of Alaska, in which day length was directly manipulated to mimic the light conditions of the northern latitude, had greater survival, height, and volume after 11 years than did seedlings grown in Alaska. This means that nursery processes used elsewhere can accommodate seedlings intended for Alaska.

A WIDER WINDOW OF OPPORTUNITY

Following disturbance, it doesn’t take long for early colonizers like bluejoint grass, fireweed, and alder to move in. Any attempts to reforest without site preparation becomes a race to get the tree seedlings in the ground so they’ll have a fighting chance against faster growing vegetation. Financially, however, it may not be possible for a landowner to reforest areas right way. Or sufficient nursery stock may not be readily available. These were the management dilemmas the researchers hoped to address as the third component of their study.

Youngblood and his colleagues looked for differences in reforestation success on newly harvested sites and sites where vegetation had already begun to recolonize the disturbed area. They found that time since disturbance didn’t appear to matter, if vegetation was controlled and quality planting stock used. And, no difference in seedling survival or height growth could be attributed to site preparation treatments.

“This was the most surprising result for me,” Youngblood says. “I thought we would find more difference in time since disturbance. From an operational standpoint, this gives land managers a larger window in which to operate. It's a common assumption that there's a 2-year period for reforesting an area; this study goes a long way in refuting that for this species in Alaska."

"We appreciate that this work was done in Alaska," says Graham, the forest stewardship coordinator. "So much of forestry research tends to happen outside the state. It's really helpful to have information specific to our situation."

For now, the researchers have mothballed the study but emphasize that much could still be learned in the future. At the study site near Fairbanks, for example, spruce budworm came into the surrounding stands after the researchers planted their research plots. "There was significant defoliation of the seedlings and a lot of height growth was lost," explains Youngblood. "Because we made a major investment in that site, we decided to continue monitoring seedling growth. I'm glad we did because it generated some very useful information about seedling growth in the face of a budworm outbreak. Initially, it was one of our best sites in terms of growth, but the numbers don't reflect that because the trees were so severely defoliated. In another 20 or 30 years it will be interesting to see if they've not only caught up but also surpassed the height growth of other sites. Even though Fairbanks is further north than our other sites and the growing season is short, the air temperature and amount of sunlight it receives during the growing season is greater than in south-central Alaska." Theoretically, this should lead to better growth.

Andrew Youngblood

Sites that lack active management, such as this old clearcut in the Matanuska-Susitna Valley, present challenges for white spruce establishment because competing vegetation already dominates.

Watching trees grow takes time and commitment. "Long-term studies are important for many species, including Alaska white spruce," says Youngblood. "If you're working with a target species that you're managing for 100 or 200 years, you can't begin to answer the questions by confining your observation to the first 5 years."

"The true meaning of life is to plant trees, under whose shade you do not expect to sit."

—Nelson Henderson

LAND MANAGEMENT IMPLICATIONS

- Initially, blade scarification appeared to increase growing season soil temperatures, but differences lasted only 3 to 4 years as vegetation developed onsite. Frost-heaving during the first or second year after planting was especially prevalent with small planting stock in blade-scarified plots on the old units in two regions.
- Seedling age was not a strong predictor of seedling performance. Nursery practices that resulted in large stock types provided the greatest future gains in growth and productivity. Seedlings grown to larger sizes before outplanting are less likely to be overtopped by competing vegetation and may be more likely to withstand herbivory by small mammals, compared to smaller seedlings.
- Seedlings produced in nurseries outside Alaska, requiring direct manipulation of day length, had greater survival, height, and volume after 11 years than did seedlings produced by a nursery in Alaska without light-environment modification. Rearing, lifting and handling, storage, and distribution processes used elsewhere can accommodate seedlings intended for Alaska.
- Productive white spruce forests may be successfully restored through vegetation control and use of quality planting stock. No disadvantage was found, in terms of seedling survival and subsequent growth, by waiting to reforest an area if, for example, funds or nursery stock are not available.

FOR FURTHER READING

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