Hot-planting Opens New Outplanting Windows at High Elevations and Latitudes
by Thomas D. Landis and Douglass F. Jacobs

In North America, forest and native plant nurseries grow most of their stock for the traditional outplanting windows during the winter and spring. Outplanting success has been best at these times because frequent precipitation keeps soil moisture high, and low solar input reduces transpirational water losses low (Figure 1).

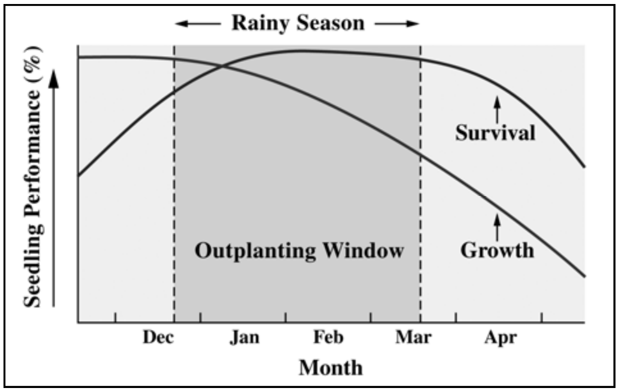

Figure 1 - Most North American nursery stock is outplanted during the tradtional windows of winter and early spring.

To meet customer's demands, nurseries grow their stock the year before, harvest them in the early winter and store them until the outplanting sites are ready. In locations where late winter or early spring outplanting is possible, this means a few weeks to several months of storage. Nurseries do a good job of hardening plants to endure the stresses of harvesting, storage, shipping, and outplanting. If refrigerated storage is possible, the stock is packaged in specially-designed bags or boxes to protect the plants and minimize water loss. Other nurseries store their plants in open or sheltered storage until they can be shipped to customers. These practices and scheduling have become so routine that nurseries and their customers don't think much about them at all.

Is Overwinter Storage Necessary?

I like to stress that long-term storage is primarily an operational necessity rather than a physiological requirement for several reasons:

Facilitating harvesting and shipping - The large numbers of plants being produced at today's nurseries means that it is physically impossible to lift, grade, process, and ship all stock at the same time. Therefore, one of the primary benefits of storage facilities is that they help to "spread-out" scheduling and processing during the busy harvesting and shipping seasons.

Distance between nursery and outplanting site - Many nurseries are located at great distances, often hundreds or even thousands of miles, from their customers. The further the distance from nursery to outplanting site, the greater the need for storage.

Differences between the lifting window at the nursery and outplanting windows. Nurseries are often located in different climates than their customers to take advantage of milder climates and longer growing seasons. This is especially true in the mountainous west where nurseries must be located in valleys at lower elevations that have drastically different climates than higher elevation outplanting sites.

Therefore, eliminating the need for long-term storage would save considerable hassle and expense as well as avoid the numerous risks of holding plants overwinter.

What is "hot-planting"?

As the name suggests, "hot-planting" is when nursery stock is harvested, shipped, and outplanted without long-term refrigerated storage. For the reasons listed above, hot-planting is not very common nowadays. Looking back, however, long-term storage wasn't needed when all nurseries were established close to their outplanting sites. Plants were dug up in the nursery one day and shipped and outplanted within a few more. Back then, transportation was slow and plant handling and packaging was rather simple. Knowing what we now do about plant physiology and stock quality, it's amazing how well those early plantations performed.

Although hot-planting has been used in both bareroot and container nurseries, it is currently making a comeback with container stock. Here are a couple of examples:

1. Fall outplanting at high elevations in western North America - On most reforestation and restoration sites, soil moisture is the overriding limiting factor to plant survival and growth. On high elevation outplanting sites, however, cold soil temperatures may be as important or perhaps even more important a limiting factor as soil moisture. Access to high elevation planting sites may be restricted by snow that may not melt until late June (Figure 2A), or even July (Jacobs 2004). That melting snow keeps soil temperatures cool and, because root growth of a wide variety of native species is restricted below 10 ^{o}C (50 ^{o}F) (Figures 2B and 2C), these cold temperature can be limiting to outplanting success.

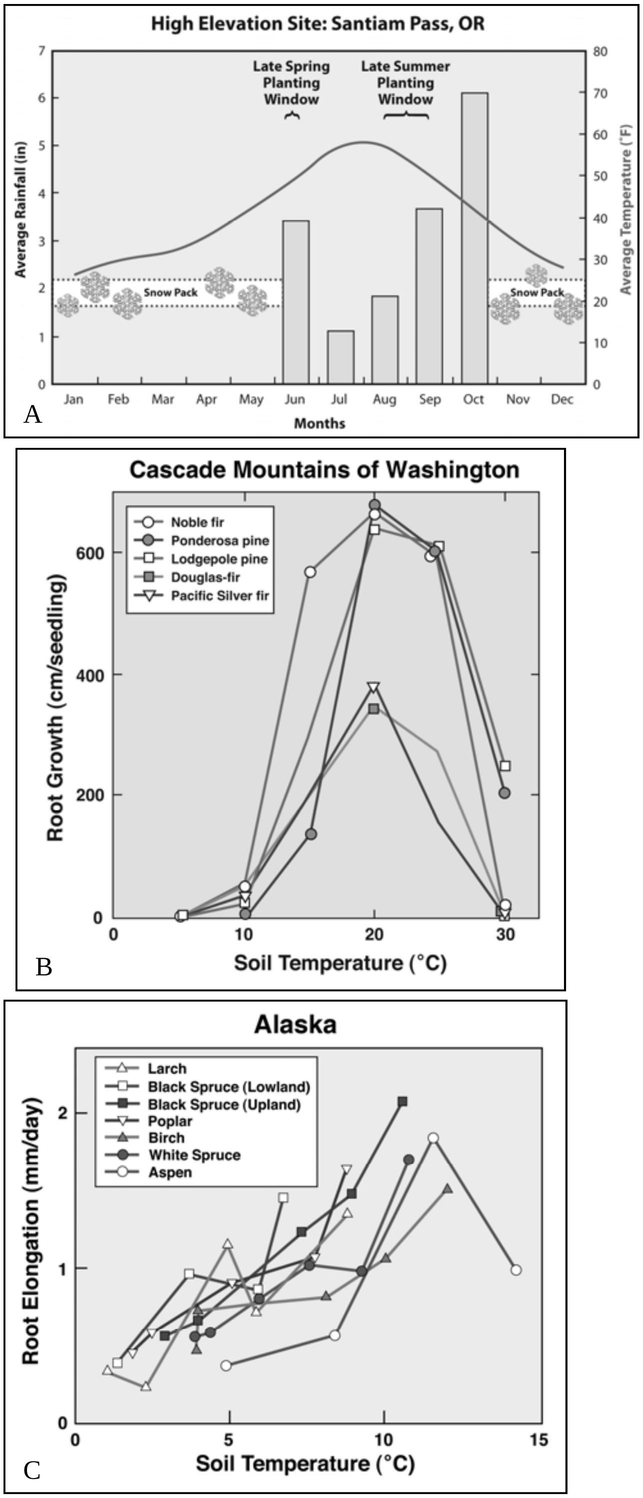

Figure 2 - Access to high elevation outplanting sites can be delayed until late spring or even early summer due to persistent snows (A). Research with tree seedlings from both high elevations (B) and high latitudes (C), has shown that roots do not grow or take up water in cold soils. B modified from Lopushinsky and Max (1990); C modified from Tryon and Chapin (1983).

So, container plants are being outplanted in the fall to take advantage of warmer soils so that they can produce enough new roots to become established before winter. This allows plants to become conditioned to the local environment and break bud and grow rapidly the following spring (Faliszewski 1998). The success of these outplantings is very site dependent, however, and hot-planted stock needs to be properly conditioned.

2. Summer outplanting in boreal Canada and Scandinavia - Instead of the typical late spring outplanting, experience has shown that the outplanting window can be extended into summer months. Summer outplanting projects are also being driven by a shortage of skilled planters and the growing use of planting machines. Recent research has shown that summer outplanting can be effective. In Finland, for example, Norway spruce (*Picea abies*) and silver birch (*Betula pendula)* seedlings have been successfully hot-planted from mid-June through early-August. The importance of warmer soil temperatures has been proven by better root egress during these summer outplantings than during the traditional outplanting window of late May (Louranen and others 2004, 2006). Summer outplanting has also been widely used at northern latitudes in western Canada (Revel and others 1990) and occasionally in the mountains of the Pacific Northwest and Rocky Mountains. For example, in 2005 more than half of approximately 40 million planted white spruce (*Picea glauca*) seedlings in Alberta, Canada were outplanted during the summer (Tan and others 2008).

Blackout as a Hardening Tool

One of the main reasons for the recent resurgence of hot-planting is the use of short-day ("blackout") treatments to harden nursery stock before summer or fall outplanting. Although primarily used at high latitude nurseries (>45°) in Canada and Scandinavia, blackout has recently proven effective in northern California (Jacobs and others 2008).

Originally used to control flowering in greenhouse flower crops, blackout has recently been adapted to forest nurseries. A successful blackout system must do 3 things (Jopson 2007):

1. Light must be reduced to low enough levels to trigger budset and induce hardening—

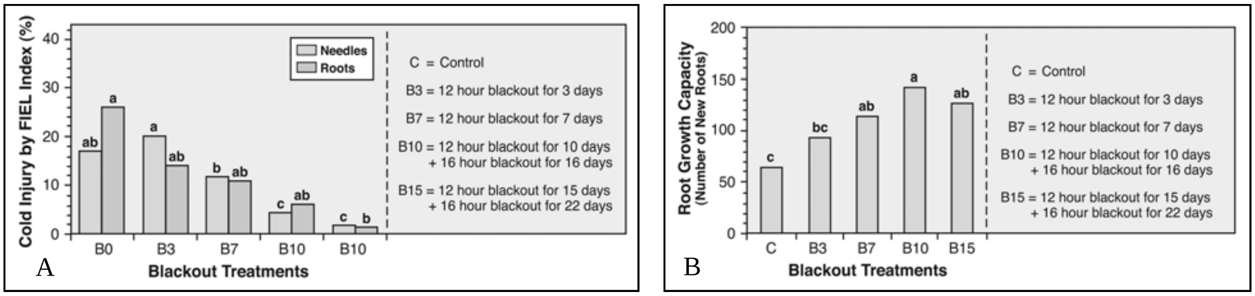

Figure 3 - Short-day treatments ("blackout") helped condition white spruce seedlings for summer outplanting by increasing cold hardiness (A) and new root egress (B). Modified from Tan and others (2008).

approximately 3 foot-candles (30 lux) for northern California species. Research has shown that blackout treatments as short as one week can be effective although 3 to 6 weeks may be needed for less responsive species and seed sources (Jopson 2007). In Norway, the proper blackout treatment varies with seed source and nursery location (Kohmann and Johnsen 2007).

2. Coverings must be porous to prevent the buildup of high temperatures and humidity which can stress plants and negate the effectiveness of the blackout treatment.

3. Blackout curtains must be easily applied to completely cover the crop. Although hand installation is effective, it is time-consuming and labor-intensive for large-scale operations. Automated blackout curtains are commercially available and can be retrofitted to most propagation structures.

Although moisture, mineral nutrients, temperature, and daylength are all used to induce dormancy and hardiness, blackout is the only treatment that can be successfully employed during summer or early fall without the risk of damaging stress. Recent research with white spruce in northern Canada (Tan 2007) found that blackout treatments induced cold hardiness of both needles and roots (Figure 3A) and stimulated root egress after outplanting (Figure 3B). This is important because frost injury to foliage and frost heaving have both been cited as serious drawbacks to summer or fall outplanting.

Interestingly enough, almost no research has been done on whether blackout could be used to harden bareroot stock for hot-planting. The few tests that have been done show that it could be effective inducing dormancy and hardiness during summer (Kohmann 2008; Rikala 2008). Blackout curtains have been installed on metal hoops over container stock being grown outdoors so this same technology could work in bareroot beds. It would be interesting to see some operational research on this promising cultural treatment.

The Importance of Rapid Root Egress

For hot-planting to succeed, nursery stock must "hit the ground running". Plants must be conditioned to immediately initiate new roots that will grow out into the surrounding soil. Not only is this important to avoid serious moisture stress but rapid root egress is critical to avoid frost heaving later in the fall. In soon-to-be-published research with white spruce container stock in northern Alberta, new root egress was found to be highly correlated with survival, shoot growth, and stem diameter growth (Figure 4).

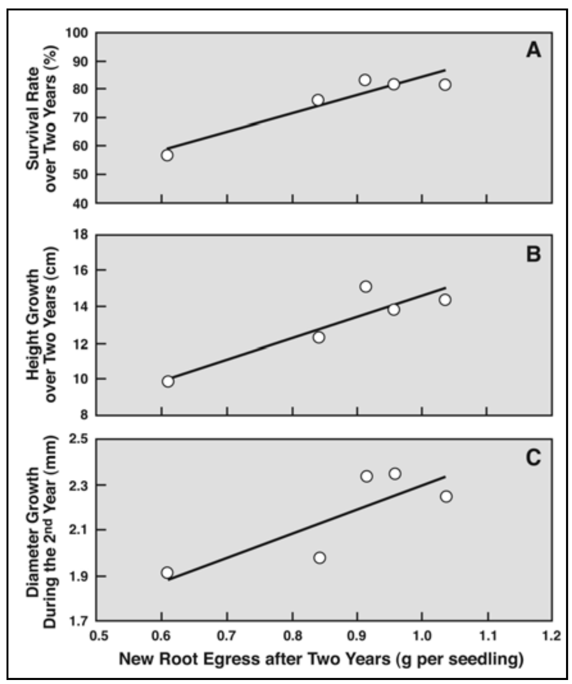

Figure 4 - New root egress was critical to the outplanting success of white spruce container seedlings in northern Alberta: survival (A), shoot growth (B), and stem growth (C). Modified from Tan and others, in press.

Operational aspects of hot-planting. The key to a successful hot-planting operation is careful coordination between the nursery and the planter.

Stock should be packed upright in cardboard boxes without plastic bag liners which can reduce air exchange and increase respirational heat build-up. Using white boxes will help to reflect sunlight and keep in-box temperatures cooler (Kiiskila 1999).

Hot-planted stock is more sensitive to shipping and handling stresses than fully-dormant and hardy plants. Increasing shipping distances from 6 to 75 miles did not cause a noticeable effect but, interestingly enough, plant height was reduced 3 years after outplanting— the longer the shipping distance, the greater the effect (Luoranen and others 2004).

On the outplanting site, nursery stock should be stored upright and kept in the shade. Irrigating seedling plugs immediately before outplanting was found to significantly increase the survival of hot-planted birch and spruce seedlings (Luoranen and others 2004).

Summary

Hot-planting will never replace traditional winter or spring outplantings, but does deserve a second look when site conditions warrant. Eliminating overwinter storage has many benefits from both biological and operational standpoints. The key to successful hot-planting is good planning and close coordination between nursery and customer.

Although it can be used for both bareroot and container stock, container nurseries have more cultural options to induce dormancy and hardiness before shipping. Shortening daylength with blackout curtains has proved very effective for inducing budset and increasing cold hardiness. Species and seed sources have shown considerable variability in their response to blackout, however, and so trials are needed to establish the best treatment.

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