Thawing, Handling, and Outplanting Frozen Stock
by Thomas D. Landis

The 2 different types of refrigerated storage used in forest, conservation, and native plant nurseries are cooler storage and freezer storage, and they are differentiated by the ambient temperatures (Figure 1) and the recommended duration of storage. Cooler storage is best for storage periods of 2 months or less whereas, freezer storage is recommended if plants must be held longer. In particular, freezer storage has proven ideal for plants that are harvested in early winter but can't be outplanted until later in the spring. While frozen storage has real advantages, many customers have had questions about what happens when the stock is ready to be shippped:

1) Can frozen stock be shipped without damage?
2) What is the best way to thaw the stock?
3) Is it possible to outplant frozen stock?

Handling and shipping frozen nursery stock - Although this question has not been addressed in any formal research, operational experience has shown that nursery plants can be handled and shipped while frozen without any significant injury. Frozen stock is still alive, however, and so storage containers should not be handled roughly or tossed around like packages of frozen food.

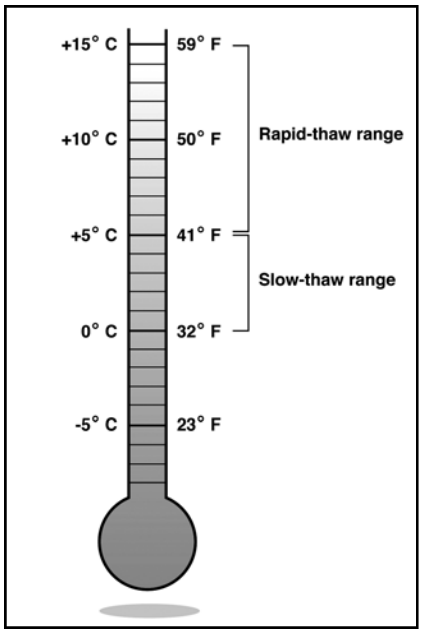

Figure 1 - Frozen nursery stock has traditionally been thawed by a "slow" regimen of cooler temperature for a longer time, or a "rapid" regimen of warmer temperatures for a shorter time (modified from Paterson and others 2001).

Table 1 - Common thawing regimes for frozen container nursery stock

Speed of Thawing	Temperatures	Duration	Reference
"Slow" Thaw	5 °C (41 °F)	7 days	Camm and others (1995)
	0 to 3 °C * (32 to 37 °F)	42 days	Rose and Haase (1997)
	0 to 3 °C * (32 to 37 °F)	21 to 35 days	Kooistra and Bakker (2002)
"Rapid" Thaw	5 to 15 °C (41 to 59 °F)	9 days	Camm and others (1995)
	7 °C (45 °F)	5 days	Rose and Haase (1997)
	5 to 10 °C (41 to 50 °F)	5 to 10 days	Kooistra and Bakker (2002)
	12 °C (54 °F)	4 to 8 days	Helenius and others (2004)

* Operational cooler storage conditions

Thawing frozen plants - The root plugs of container stock freeze together and so must be thawed before they can be separated and outplanted. Some customers want their stock thawed before shipping by either "rapid" or "slow" thawing **(**Figure 1). However, the thawing temperatures and time intervals recommended in the literature vary considerably (Table 1). Originally, slow thawing was considered best (for example, Mitchell and others 1990) and was typically done at the nursery. Research trials found no differences, however, between rapid or slow thawing after two growing seasons (Rose and Haase 1997). When the quality of seedlings thawed with both techniques was tested**,** rapidly thawed stock was more cold hardy and also resumed shoot growth earlier than slowly thawed seedlings (Camm and others 1995). Three months after outplanting, shoot and root growth were similar for plants from both thawing regimens. In one of the most well-designed and long-term studies (Helenius and others 2004), freezer-stored Norway spruce *(Picea abies*) container stock was thawed in cardboard boxes at 39 or 54 ^{o}F (4 or 12 ^{o}C) for up to 16 days before outplanting. When checked 3 years later, the best thawing temperature was 12 ^{o}C (54 ^{o}F) for about a week.

These results suggest that a good operational procedure would be to remove bundles of frozen stock from shipping containers and lay them on the ground overnight, or open shipping boxes or bags in a well-ventilated shady location. Never attempt to thaw frozen nursery plants by placing them in direct sunlight (Figure 2A) as this can cause serious moisture and temperature stress. Do not physically pry frozen root plugs apart because this can cause serious damage (Mitchell and others 1990). Defrost only enough stock that can be planted in a couple of days. The ideal situation is to set-up a thawing operation where frozen stock is removed from refrigerated storage and then thawed in a shade structure (Figure 2B).

Outplanting frozen stock - Outplanting nursery stock with frozen root plugs would save the time and effort needed to thaw plants. The initial obstacle was that root plugs were frozen together, but technology for packing singulated plants is now available. However, field trials of outplanting frozen stock have had mixed results. In British Columbia, the performance of western larch (*Larix occidentalis*), lodgepole pine (*Pinus contorta*), and interior spruce (*Picea glauca* x *Picea engelmannii)* planted while frozen was not significantly different from thawed plants 2 years after outplanting (Kooistra and Bakker 2005). This was on a cool, cloudy site, however, and subsequent studies found that site conditions have an overriding effect. In an outplanting study of Norway spruce seedlings in Finland, thawed seedlings outperformed frozen stock in survival and shoot and root growth in both warm and cold soils (Helenius 2005). In a more recent trial, the physiological processes of thawed and frozen Douglas-fir container seedlings that were exposed to either "cool and moist" or "warm and dry" conditions were monitored. Thawed plants had higher photosynthesis rates and more active buds and roots than plants that were planted frozen, which could affect subsequent outplanting performance (Islam and others 2008). Obviously, more research trials under a wide variety of outplanting site conditions are needed before outplanting frozen stock can be recommended.

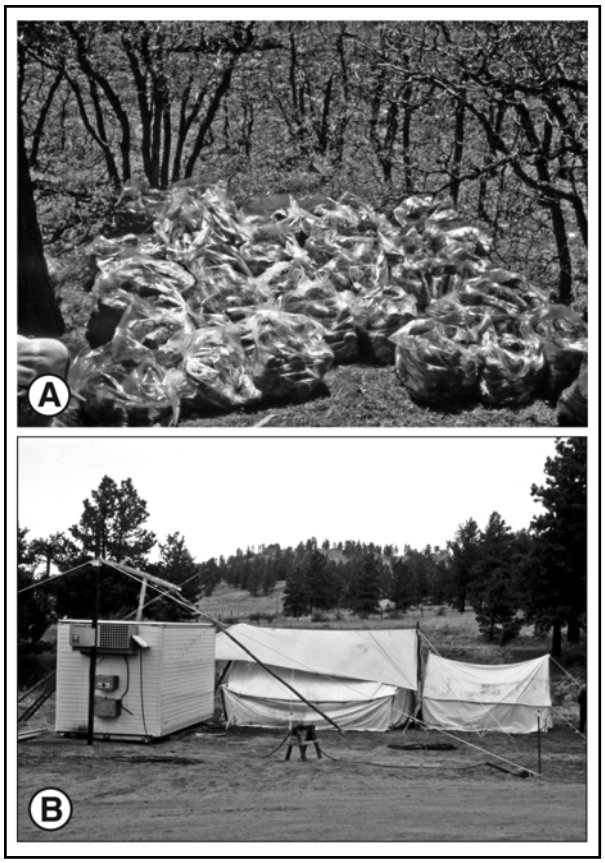

Figure 2 - Never expose frozen plants to direct sunlight (B), but open boxes or bags and leave them in a protected, shady location (B)

Summary

Freezer storage has become an accepted practice in forest, conservation and native plant nurseries, but concerns have been raised about how best to thaw and handle frozen nursery stock. Boxes or bags of frozen seedlings should be handled with care but can be shipped to the outplanting site without special consideration. While both slow and rapid thawing regimens have been used, research and operational experience has found that

opening the boxes or bags in a sheltered and shady location will be effective in a few days to a week. Seedling can be outplanted while still frozen on low moisture stress sites but it's probably best to thaw all stock first.

References

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