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THAWING AND HANDLING GUIDELINES FOR CONIFER SEEDLINGS IN BRITISH COLUMBIA

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British Columbia • Forests, Lands and Natural Resource Operations •

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1. THAWING CONDITIONS

It is important that the environmental conditions experienced during thawing do not place stress on the seedlings. The main environmental variables to consider are temperature, sunlight, humidity, and air movement.

Temperature

If thawing is occurring in a storage facility, all doors and windows should remain closed as much as possible to provide a more constant temperature.

The internal carton temperature should be carefully monitored. Dial probe thermometers are very useful for measuring internal carton temperatures because they can be used without opening cartons. When measuring the internal carton temperature, insert the probe end of the thermometer through the side of the carton and bag into the foliage and root mass near the root collar. Dial probe thermometers should be periodically calibrated against a wall thermometer.

The internal carton temperature should not exceed 10°C. If temperatures get this warm, the seedlings should be cooled by reducing the temperature and/or opening the cartons and bags. The seedlings should be thoroughly examined for disease and heat damage and should be planted as soon as possible. As discussed earlier, respiration increases dramatically at temperatures above 10°C (Figure 1).

Rapid temperature fluctuations greater than 4°C should be minimized during and after the thawing process. Temperature fluctuations place stress on seedlings and reduce their vigor. If damage to the seedlings is suspected, the Root Growth Capacity (R.G.C.) of the seedlings should be tested before they are planted.

Remember: Internal carton temperatures must be carefully monitored and controlled.

If completely thawed stock is not shipped to the field immediately, it should be stored at 1 to 2°C. If poor air circulation has caused uneven warming, special attention must be given to ensure that all cartons are cooled to 2°C.

When cooling trees to the storage temperature (1 to 2°C) after thawing, do not allow the internal carton temperature to fall below 0°C. If a temperature drop to -5°C is experienced in the carton, the seedlings should be tested for R.G.C. and bud flushing before being shipped to the field. The roots are vulnerable to damage when temperatures get this low, particularly after being thawed. Bud tissue can also be damaged if it has dehardened in the thawing environment.

The vertical or horizontal orientation of seedlings in the cartons affects the thaw rate. Horizontally packaged seedlings tend to thaw quicker than vertically packaged seedlings.

Sunlight

If seedlings are thawed outside, they **must** be thawed in the shade. Shade can be provided by placing seedling cartons on the north side of a building, under a heavy reflective tarp, and/or under evergreen trees in as cool a spot as possible (eg. next to a stream). Reflective tarps should be elevated above the cartons or else heat absorbed by the tarp will be transferred directly to the cartons.

Never thaw cartons directly in the sun, as cartons will absorb heat very quickly if placed in the sunlight. The heat will cause rapid physiological activation and an increased respiration rate (Figure 1), and will compromise the health of the seedlings.

Seedlings may flush if they become physiologically active and remain in closed cartons. The new growth will appear very pale yellow or white. After planting, this tissue will be damaged by sunlight and growth will be compromised.

Remember: Seedlings should never be stored in direct sunlight.

Humidity

The plastic or plastic-paper bag inside the cartons acts as a vapour barrier that retains moisture. Condensed moisture on the inside of the bag is acceptable as it indicates that the seedlings are being kept in an environment with high humidity and are not experiencing moisture stress.

Cartons and bags should be opened to conduct regular inspections and then reclosed. It is important to keep the bag closed to prevent excessive moisture loss. The exception to this is if significant amounts of storage mold are detected. See Section 6 for details on the management of storage molds.

Remember: Seedlings should never be allowed to dry out.

Air Movement

It is critical that there is continuous air movement throughout the area used to thaw the seedlings. Air circulation provides a more constant temperature to the seedlings. Large portable floor fans and ceiling fans are very useful for air circulation. The speed and uniformity of thawing will be affected by the amount of air flow.

To promote an even thaw, cartons should be placed at least 5 to 10 cm apart on pallets, and the pallets should be at least 15 cm apart. Loaded pallets can be stacked on each other. An empty pallet should be placed between the stacked pallets. If a curling rink is used as the thaw facility, three pallets should be placed below the cartons to keep them off of the refrigeration units in the floor. Do not place cartons directly on any floor.

If cartons are thawing unevenly on a pallet, they may have to be rotated from bottom to top to achieve uniform thaw.

2. RAPID THAW METHOD

The rapid thaw method is the **preferred** method for thawing seedlings. When thawed rapidly, seedlings lose less of their carbohydrate reserves before outplanting (Figure 2).

There are several potential risks associated with the rapid thaw process. First, the rapid thaw process quickly alters a seedling's physiology in preparation for new growth. Seedlings **must** be planted as soon as possible after thawing. Second, there is greater risk that seedlings will experience significant temperature and moisture stresses if kept at these higher temperatures after they are thawed. These stresses usually cause seedlings to devote their energy to survival and repair rather than to growth and will reduce field survival and performance.

Remember: Plant seedlings as soon as possible after rapid thawing.

The optimal ambient temperature for a rapid thaw is 10 to 15°C. The optimal internal carton temperature is 5 to 10°C (Figure 4). If additional storage is required after seedlings are thawed, the temperature should be lowered to 2°C.

Monitoring

Seedling health and condition should be monitored from when thawing begins until the seedlings are shipped to the field. The recommended monitoring frequencies for the rapid thaw method are:

a) Temperature (room and carton)	3 times per day
b) Degree of thaw	2 times per day
c) Root and shoot activity (flushing, new growth)	1 time per day
d) Mold development	1 time per day
e) Root moisture content (bareroot especially)	1 time per day
f) Foliage colour / discolouration	1 time per day

Monitoring **must** be done frequently because problems may arise quickly. Frequent monitoring also ensures that the thaw process is carefully controlled. It is recommended that these inspections be recorded so that the thaw process can be charted to ensure that seedlings are provided with the best possible thaw conditions.

Remember: Problems may develop quickly during the rapid thaw process. Frequent monitoring is required.

If the temperature and / or desired degree of thaw are incorrect, appropriate actions must be taken to correct the problem immediately.

If problems are noted with respect to root and shoot activity, mold development, root moisture content, and / or foliage colour, the planting agency should be immediately notified that the seedlings should be shipped to the field for planting.

Contact your Nursery Services Office and / or your Regional Planting Coordinator if unsure of:

- the nature of a problem encountered when inspecting the stock,
- how to deal with affected seedlings, or
- whether the seedling condition will reduce the viability of the seedlings for reforestation.

Estimated Thaw Times

Estimated thaw times depend on the factors outlined in Section 6. If thawed at 10°C, estimated thaw times for the different stocktypes are:

Container seedlings packaged horizontally	5 to 8 days
Container seedlings packaged vertically	6 to 10 days
Bareroot seedlings	1 to 3 days

Seedlings should not be held for more than one or two weeks after thawing. It should be noted that the rapid thaw method has considerable flexibility since the thawing period is much shorter than for the slow thaw method.

3. GENERAL CONSIDERATIONS

Handling

Cartons must be handled with care at all times. Throwing, dropping or crushing cartons places stress on the seedlings. Root cells can be damaged by dropping seedlings. When dormant seedlings are dropped, their root growth and height increment may be reduced. When actively growing seedlings are dropped, their survival may be reduced (McKay *et al*. 1993).

Remember: Seedlings are living organisms that can be damaged by inappropriate handling.

Dealing With Storage Mold

Notify your local Nursery Services Office and / or Regional Planting Coordinator if moderate to extensive amounts of storage mold are discovered on the seedling foliage.

The recommended method of managing storage mold is to:

1. Minimize thaw time by rapid thawing seedlings.

2. Ship cartons to the field as soon as possible, even if they are still partially frozen.

3. Open the boxes underneath a tarp at the planting site. Air movement through the open boxes will retard mold growth.

4. Plant seedlings that are still alive as soon as possible.

Thawing Times

Although estimated thawing times have been provided for the rapid and slow thaw methods, the exact rate of thaw depends on a number of factors, including:

- type of thaw facility
- thawing method
- stock type
- species
- seedling age
- packaging arrangement - cartons will thaw more rapidly if the seedlings are packaged horizontally than if they are packaged vertically.
- seedling density - cartons that are tightly packed with seedlings will thaw slower than cartons with fewer seedlings.
- moisture content of the root plug - plugs that were very moist when placed in frozen storage will have more ice to thaw and therefore will thaw at a slower rate.

Keep these factors in mind in the process of thawing to a specific date. Remember that seedlings that arrive in frozen bundles on the planting site cause operational headaches. On the other hand, thawed seedlings left in storage too long may have reduced vigor and, ultimately, reduced survival and field performance.

Handling Thawed Seedlings That Are Physiologically Active in Storage

Note: The procedures in this section are meant for those exceptional cases where seedlings have already broken bud and flushed while in storage.

If physiologically active seedlings are left in cool, dark storage for extended periods, their vigour will be reduced. If active seedlings that are still viable are encountered in storage, the planting agency should be immediately notified that the seedlings should be shipped to the field for planting. Your local Seedling Services Office and/or Regional Planting Coordinator should also be notified.

Seedling stress should be minimized until planting is possible. The following recommendations should be implemented at the field or at any other location to which seedlings have been shipped:

1. Immediately upon arrival, the cartons must be placed in continuous shade and the bags must be opened and folded back. This is essential to reduce temperature stress on the seedlings.

2. Seedlings packaged horizontally must be placed vertically in the cartons.

3. Seedling moisture levels should be inspected. If the root plugs are dry, the seedlings must be thoroughly watered. Seedlings should not be permitted to dry out before being planted. Excess water should be drained from the cartons. Please note that the root systems of bareroot seedlings will dry out more rapidly than those of container seedlings. Bareroot seedlings will therefore require more frequent watering.

4. A sample of 25 seedlings should be randomly selected from the seedlot and sent immediately to your local Nursery Services Office for R.G.C. testing.

4. TRANSPORTING SEEDLINGS TO THE PLANTING SITE

Seedlings should be handled carefully during transportation. Throwing, dropping, or crushing the cartons can damage the seedlings.

A refrigerated vehicle is the preferred method of transporting seedlings as it keeps them cool and protects them from high temperatures. An insulated truck box that keeps the seedlings cool is the next best alternative. If these methods of transportation are unavailable, seedlings may be transported under a Silvacool tarp.

Seedling transportation time should be minimized. Upon arrival at the planting site, seedlings should be removed from the truck. Do not leave seedlings in the truck overnight.

5. STORAGE OF SEEDLINGS AT THE PLANTING SITE

Seedlings must continue to be cared for at the planting site. Stock that has been carefully grown, lifted, stored, thawed, and transported to the site can easily be destroyed by poor management practices at the site.

Cartons should be stored in the shade. A Silvacool tarp should be secured above the cartons with the reflective liner facing the seedlings and the white surface of the tarp facing the sky. The tarp should extend well beyond the cartons to protect them from the sun throughout the day. The tarp should be elevated above the cartons to prevent direct heat transfer from the tarp to the cartons.

Cartons should be stored off the ground so they don't become water-logged. Local materials such as poles and other debris may be placed beneath the cartons to elevate them.

6. CONTACT INFORMATION

Seedling Services is responsible for managing and monitoring the production of seedlings used to reforest crown land. Seedling Services is part of BC Timber Sales Ministry of Forests, Lands & Natural Resource Operations (MFLNRO)

For more information, contact:

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