Stock Handling, Storage, and Transportation

Prior to the contract commencement, a number of operations are required to get the stock to the planting site or to the interim storage facilities. These operations are critical to the success of the project and must be carried out carefully not only to ensure that the planting stock arrives in excellent condition but also to ensure that the contract itself runs as smoothly as possible. The following sections outline the procedures for thawing, storage, handling, and transportation of stock.

The goal of handling, storage, and transportation is to ensure that the growth potential, present when a seedling is lifted at the nursery, is maintained until it is planted in the field.

6.1 Introduction

Proper stock handling, storage, and transportation procedures play a vital role in achieving high survival and the full growth potential of planted seedlings. Damage to seedlings is cumulative, often occurring at all stages from nursery to final planting. Seedlings are subjected to fluctuating levels of temperature, light, and moisture on their journey from nursery bed to planting hole. These stresses, together with physical damage, force the seedlings to shift resources to temperature adjustment and repair, resulting in lower growth potential. This leaves the seedling with less vigour for establishment after planting. Severe damage or stress will inevitably lead to seedling mortality. Stock handling, storage, and transportation guidelines are designed to minimize events that put seedlings under stress. These events include:

- temperature extremes,
- rapid temperature fluctuations - cell membrane ruptures,
- excessive moisture - reduced gas exchange,
- lack of moisture - seedling cell desiccation,
- excessive radiation - seedling stem and needle desiccation,
- physical abuse and damage, and
- moulds and fungi.

6.2 Stock Handling

Minimizing stress through careful handling, controlling temperatures, and keeping the seedlings moist is the key to maintenance of seedling vigour. Remember, everyone involved is responsible for the well-being of the seedling. All staff and contractors involved in the reforestation process should view the stock handling video *Seedling Care - Everyone's Concern* prepared by the

Silviculture Branch, Victoria (1989). A stock handling brochure (*Nursery to planting site: A team effort*) is also available.

6.3 Seedling Storage

Maintaining Vigour

Seedlings have a limited supply of carbohydrates when they are placed into storage. This carbohydrate supply can only decrease until the seedlings are planted and start growing again. Nurseries build up the seedlings carbohydrates for use in the field - a reserve that should not be wasted in storage. The status of this reserve is translated into the vigour of the seedlings. Losses of carbohydrates result in a reduction of the vigour of the seedling and the ability of the seedling to withstand stress.

Respiration occurs even at the low temperatures experienced during frozen storage. One of the products of respiration is heat. The rate of respiration is controlled primarily by temperature; the higher the temperature, the higher the rate of respiration and the faster the carbohydrate reserves are used up by the seedlings. It is therefore very important to dissipate the heat that is being generated inside the carton. See "Monitoring Temperatures" below for more information.

Respiration of cold- or freeze-stored, dormant stock uses small amounts of the carbohydrate reserves of the seedlings. Frozen storage at -1 to -2°C minimizes carbohydrate depletion (see "Types of Seedling Storage" below for more information).

After 6 months, *frozen*-stored stock has used the same amount of carbohydrates as *cold*-stored stock (at 1°C) uses in 2 months.

Controlling Disease

Frozen storage minimizes foliage diseases. Frozen storage arrests, but does not eliminate the risk of storage moulds. The mould will flourish when temperatures rise during thawing, so close monitoring for the disease is imperative. *Botrytis* ssp. and other storage moulds can proliferate at temperatures of 1-4°C, under high humidity and in the absence of light. These same storage conditions are the ones created for the protection of the seedling (namely cool temperatures, high humidity, and closure in a carton). (See "6.9, Stock Problems" for more information.)

Types of Seedling Storage

In British Columbia, seedlings are stored or handled in five acceptable ways:

1. Frozen stored at -2°C prior to shipment.
2. Cold stored at 1°C prior to shipment.
3. Cold stored at 2°C in portable refrigerated trailers near the planting site.
4. Cool stored at below 10°C awaiting planting in a short term (<1 week) cache at or near the planting site.
5. Hot lifted with shipment directly to the planting site.

Frozen storage - Stock scheduled for planting after March 15 is generally frozen stored. The storage period for this stock can extend up to 7 months. Frozen storage generally applies to interior species that have been lifted in fall or early winter and are scheduled for spring planting. Take care when thawing out frozen stock (see "6.4, Thawing Frozen Stock").

Cold storage (prior to shipping) - Stock scheduled for planting prior to March 15 (mostly coastal stock) is usually stored at temperatures above freezing. The storage period for this stock is generally less than two months. Arrange short term storage in permanent buildings or in mobile refrigerated trailer vans.

Cold storage (prior to planting) - Stock (unless hot lifted) may be cold stored at 2°C in portable refrigerated trailers (or other facilities such as ice-cooled insulated sheds) near the planting site.

Cool storage (Field Cache Storage) - Cool storage immediately prior to planting at or near the planting site is required to protect seedlings while ensuring a continuous supply to the planters.

Hot lifting - There is no cold storage with hot lifting. Hot lifting is used mostly in summer and fall planting (see "Summer Planting" under "2.3, Season of Planting" in the section "Project Planning and Prescription Development"). For summer planting, seedlings are irrigated immediately before lifting. Once lifted, seedlings may be cool stored (<10°C) overnight. The volumes of seedlings that can be produced for such lifting are limited by the nursery space available, and by the volume of seedlings that can be lifted during the short lifting season. The various lift capacities by nursery are available from regional reforestation staff.

Exert taken from BC Ministry of Forests, Forests Practices Branch - Silviculture Manual 1999

To be successful, hot-lifted stock must be planted immediately. It is recommended that transportation of seedlings to the field occur overnight and delivery be as close to the planting site as possible.

Hot lifting is also used for spring planting, mostly on the coast. However, holding stock over winter in the nursery, fields, or the greenhouse and lifting in the spring generally puts the seedlings at risk to hazards such as frost, cold temperatures that may damage trees, and wet ground in nursery beds (bare root). The volumes of seedlings that can be lifted and shipped in a hot-lift situation are often limited by the lifting window at the nursery and the proximity of the planting site.

Monitoring Temperatures

Constant and proper monitoring of seedling cartons is an essential part of seedling storage and handling. Carton temperature is usually monitored using the probe-type thermometer pushed into the centre of a carton. This may not be effective for cartons stacked on pallets. Thermocouples with long traces are available and can be placed into the centre of pallets or be used in other circumstances where probe-type thermometers are ineffective. Refrigeration units should all be equipped with thermometers to monitor air temperatures and to regulate cycling of refrigeration units.

Local Storage Facilities

Primary storage facilities that are centrally located are not always convenient for planting programs. A variety of other local and interim storage facilities may be required. When using alternate storage facilities, give care and attention to maintaining constant temperatures.

Interim storage facilities may include:

- cold storage buildings - potato coolers, fruit storage, dairy storage,
- curling rinks/arenas,
- reefer trailers,
- ice bunkers,
- root cellars,
- snow caches,
- mylar-vinyl (Silva-cool™) tents, and
- trucks fitted with an insulated (F.I.S.T.™) type canopy and insulated floor.

Temporary Field Storage

The on-site temporary field storage must be maintained as closely as possible at the proper temperature (<10°C) to ensure seedling survival and vigour. This can be accomplished, where appropriate, by using portable refrigerator vans or reefer units to serve as on-site cold storage. These units provide a controlled environment but require constant monitoring and maintenance. Satisfactory field storage can often be prepared by using the natural environment, reflective tarps, and a little ingenuity. Refer to the following list for the do's and don'ts to be considered when developing a temporary field storage.

1. Don't leave boxes of trees in an unrefrigerated truck in (≥10°C) warm weather.

2. Don't stack boxes more than three high without spacers or racks to allow for proper air circulation.

3. Do provide shelter by stringing a clean, good quality reflective tarp over the cache to protect it from the sun, rain and frost and to ensure full shade; allow indirect light for active (hot lifted) seedlings (boxes open).

4. Do ensure that there is sufficient space between and below boxes for adequate air circulation and to dissipate heat. Palletize the storage area.

5. Do check to ensure temperatures do not exceed 10°C: clean, good quality reflective tarps should be used to cover the boxes for short periods (1-2 hours) until proper storage is prepared.

6. Do use clean, good quality reflective tarps to avoid heat buildup, white side out and silver side in. The white surface is reflective, absorbing little radiation when clean, as well as being highly emissive, allowing for quick release of heat buildup (see FERIC Field Note No.: Silviculture-32, Reflective tarpaulins for silvicultural use: Comparing ability to resist heat transfer, 1991.)

7. Do provide special care for hot-lifted/summer stock that are shipped in a partially dormant condition. Top growth has ceased, terminal buds have set, but the roots are still actively growing and are highly vulnerable to desiccation or damage. Ensure that growing roots are not exposed to drying conditions or subjected to physical abuse.

8. Keep the seedlings cool to minimize respiration and use of water. Ensure roots are kept moist. If the seedlings will be in field storage for

more than a few days, a local source of water will be needed to irrigate the stock as required.

Field Caches

Seedling caches are best set up on the edge of the planting block in the shade of standing timber, preferably on snow or near streams. Shaded areas under bridges may form perfect caches, but sudden runoff from rain or heat may cause a river to rise, with potentially disastrous results.

Clean, good quality reflective-type tarpaulins are the best covers for seedling caches (see FERIC Field Note No.: Silviculture-32 *Reflective tarpaulins for silvicultural use: Comparing ability to resist heat transfer*, 1991 and FERIC Report, *Effectiveness of reflective tarpaulins in protecting tree seedlings against heat stress*, 1993).

Keep field cache temperatures below 10°C. Follow procedures outlined in "Temporary Field Storage" above. For spring planting, stock should not be field cached for longer than a week, while summer planting stock should be used within 3 days.

When summer or hot lifted stock is delivered to the field cache, the cartons must be opened and bundles placed upright in locations where indirect light is available. Do not leave them in closed reefers. Shade seedlings from the sun.

Air Circulation

Whether storing or transporting stock, it is critical that cartons be spaced so that air is allowed to circulate freely around them. Heat buildup is a critical concern and can cause stress and seedling damage quickly. The heat from respiration must be allowed to dissipate.

Use refrigeration facilities that have been designed to accommodate pallets of cartons. With reefers or other forms of temporary storage, use spacers (2.5 × 10 cm) between layers of cartons. Also provide space between cartons (3-5 cm). This allows air to circulate around the pallets and cartons.

If curling rinks or other similar storage facilities are used, large portable fans will have to be used to circulate air. Air circulation is critical to maintaining proper box temperatures.

6.4 Thawing Frozen Stock

General

Thawing guidelines are currently under revision. For more information, contact the Nursery Services Section, Victoria.

Handling Active Seedlings (Summer Stock)

Once seedlings have become physiologically active, their vigour is reduced if left in cold dark storage. Active seedlings must be shipped to the field and planted immediately. If this is not possible, the following must occur:

1. Immediately upon arrival at the field storage or cache, open and fold back the cartons and liners and place the cartons in continuous shade. This is essential to reduce the temperature stress on the seedlings.

2. Place container seedlings packaged horizontally in a vertical position (foliage up) in the cartons. Bareroot seedlings must be removed from the cartons and heeled in if the stock is not going to be used immediately (within 1-2 days). Follow the procedures outlined in "6.10, Heeling In." Bareroot stock being used immediately can be treated the same as container stock.

3. All seedlings must be thoroughly watered immediately and not be permitted to dry out before being planted. Excess water should be drained from the cartons.

6.5 Handling Cartons

Seedlings are very susceptible to shock resulting from physical abuse and stress. Seedling cartons must be handled carefully, like boxes of eggs rather than bales of hay. Key actions that will minimize damage to the seedlings when handling cartons include transferring stock from damaged to undamaged boxes as damaged boxes or punctured liners can lead to moisture stress. Also, never stack boxes more than three high, unless they are separated by spacers. This will prevent the seedlings from being crushed and will allow air movement between boxes.

6.6 Transporting Seedling Cartons

The transportation of seedlings from the nursery or storage facility to the planting site is a critical phase in the reforestation process. During this transportation phase, the responsibility for the seedlings passes from the nursery to ministry or licensee personnel and finally to the planting contractor. In order to minimize damage when transporting both spring and summer planting stock the following concerns must be taken into account.

- Handle boxes carefully; bouncing them around in the back of a pickup or on an ATV causes physical damage, shock, and stress. Ensure they are firmly packed and use proper racks. Have them covered properly and drive slowly!
- Do not drop, throw, or crush the boxes together; the boxes may not break but the trauma affects the seedling.
- Maintenance of correct temperature is critical (<10°C).
- Use the right type of vehicle; refrigerated trucks for long distances, a covered van with good ventilation for shorter hauls, or a truck equipped with a F.I.S.T.™ type canopy (refer to FERIC Field Note No.: Silviculture-23 *Evaluation of an insulated canopy for seedling transportation: Summary Field Note*, 1990).
- Ensure the truck bed is insulated from the exhaust system heat.
- Monitor box temperatures to ensure seedlings are not heating up.

  heat increases respiration = reduced field performance
  respiration increases heat

- Ensure adequate air flow around the boxes on longer trips as heat trapped inside results in higher respiration. For short hauls, cover the seedlings securely with clean, good quality reflective tarps with the white side up.
- Avoid transporting in the heat of midday and park in the shade.
- Water summer stock as necessary to keep roots moist and reduce temperature.
- Mist with backpack/pump sprayer.

If the planting contractor is responsible for transporting seedlings, these conditions must be clarified at the pre-work conference and monitored by the planting project administrator.

Disposal of Cartons

Conditions for the disposal or return of reuseable tree cartons are covered under Clause 1.7 of the Planting Contract Schedule A (FS 767). An example is included in Appendix 1, Forms Management. Charges for not returning reuseable cartons are outlined in Clause 4.9 of the FS 767. A basic charge of $25 each will be levied.

6.7 Carton Temperatures and Monitoring

To obtain the required inside-carton temperatures, the ambient temperature of a refrigerated facility must be lower. For example, an ambient temperature

of 0°C to -1°C may be needed to maintain carton temperatures of 1°C to 2°C. A dial probe thermometer, pushed through the side of the carton and liner into the foliage, is a simple method of determining carton temperatures. Monitor cartons in a number of places in the cooler unit to determine if the unit is cooling evenly.

For spring stock, keep all cartons closed, except for regular inspections or when dealing with a storage or stock problem. Never leave the cartons open: keep the polymer lined bag tightly rolled and closed to reduce the risk of damaging desiccation and stress.

Open boxes of summer (hot-lifted) stock and stand bundles of seedlings vertically.

Reefer Operation and Maintenance

The use of refrigerated reefer trailers is a common practice for temporary storage of cartons of seedlings. When properly maintained and operated, they are an excellent storage option. To ensure that reefers function properly check them regularly. Contract only quality reefers that are known to be in good working order. Include a maintenance schedule in the contract as well as how to contact the owner/operator in an emergency. Ensure reefer operator understands fully the maintenance requirements of the reefer. Check to see if reefer temperatures are in Fahrenheit or Celcius (°F or °C). Confusing the scales can result in frozen stock and root damage to seedlings.

If the contractor fails to follow the maintenance schedule, or a preventable malfunction occurs and seedlings are damaged or die as a result, ensure the reefer contract states that the operator will be held responsible for the loss.

6.8 Seedling Care During Planting

Planters - the last link in the reforestation chain. Everyone down the chain must do their job correctly to ensure healthy, vigorous seedlings. But it is the planters who have the largest role to play in the survival of the seedling and the success of future plantation performance.

The following specifications should be included in the contract and reviewed at the
pre-work conference.

The planting contract administrator should ensure that:

- Planting bags are in good condition; torn bags allow air that will dry out the roots.
- Moist humid conditions are maintained around roots by placing several centimetres of moist absorbent material in the bottom of the bags.
- Bareroot trees may be root dipped before loading. If required, ensure that peat slurry is used, that roots are dipped for no more than one minute, then allowed to drain briefly before bagging; do not shake them.
- Bundles are unwrapped or untied carefully; do not allow them to be wrenched free as the thin bark or roots may be damaged.
- Bundles are handled carefully; do not allow trees to be jammed into the bags or planters to overload their planting bags.
- The rooting medium on container stock is not broken up.
- Bareroot trees are separated by shaking the roots loose in the bag, not torn free.
- Only one tree is taken out at a time; all others must remain in the bag. Do not carry trees in your hand.
- A reflective bag liner must be used to protect the trees from exposure during carrying.
- The number of trees carried during hot dry weather is reduced to reduce the exposure time in the planting bag. Planting stock is rotated frequently; a planter should not have seedlings in the planting bag for more than 2 hours.
- For spring trees, the planter closes the box after loading and uses a clean, good quality reflective tarp to protect the trees that remain in the box.
- Never more than one half day's supply of seedlings is stored outside the main storage area.
- During lunch or other breaks, planting bags are emptied or placed in the shade.
- Only one bundle of each species or stock type being planted is to be opened at one time.

6.9 Stock Problems

The following is a list of common stock problems and the action to be taken. When you are in doubt about the quality of the planting stock, contact the ministry officer in charge of the contract or regional silviculture staff before planting.

Problem	Action
1. Dry roots: bareroot	Dip in warm water, peat moss slurry, no longer than 1 minute (see also "Root Dipping" in the "Project

	Planning and Prescription Development" section of this chapter).
container	Water to saturation point, keep foliage dry as possible, drain surplus water. Leave in water only long enough to wet the centre of the bundle.
2. Tops flushing, roots active	Indicates that seedlings have broken dormancy and are starting to grow. Open boxes to prevent heat buildup, plant first, if possible and water if necessary.
3. Cold weather	Protect from freezing with tarps, pack boxes closely and shelter under trees.
4. Torn/damaged boxes	Check for excessive dryness and water as needed; if necessary, plant first; replace or repair boxes or repack if still in storage.
5. Partly frozen	Separate and sort bundles, repack frozen ones to finish thawing slowly in the shade. Do not expose to the sun or heat source or expose seedlings to drying conditions.
6. Grey moulds	**Botrytis** - open boxes, allow air circulation, water foliage lightly if drying occurs; plant first. Check for bark or stem damage from the mould; should have lime-green inner bark. Generally, if mould has not affected the stem, the trees are okay to plant but should be planted as quickly as possible.
7. Excess moisture	Remove trees, drain bags, and repack trees upright, or open boxes and punch small drain holes in liner. Leave boxes open until excess moisture has gone. Plant as soon as possible.
8. White mould	Mycorrhizal fungi on the roots that aid seedlings in nutrient and water uptake. Characterized by the smell of mushrooms. Beneficial.

6.10 Heeling In

The process of heeling in of bareroot planting stock is not commonly practiced today in British Columbia. Heeling in, which involves temporarily planting bareroot seedlings that are still in bundles**,** into trenches, puts an additional stress onto the seedlings. It is strongly advised that this process only be used as an absolute *last resort*. If, in your opinion, it must be done, contact the planting project administrator or silviculture staff before proceeding.

6.11 Pesticide Notification

All district offices have a collection of Material Safety Data Sheets (MSDS) for each pesticide used in conifer seedling nurseries.

The Silviculture Practices Regulation (Part 3, Division 2) requires that:

On or after July 1, 1996, a person who is required to establish a free growing stand under a silviculture prescription must use only seedlings and vegetative propagules that indicate on their shipping containers whether or not the seedlings or vegetative propagules have been treated with pesticides.

Information on the use of pesticides on seedlings is recorded in two ways:

1. At different times during the year, normally after final lift for stock to be frozen stored and at other times for summer stock, a detailed history of pesticide application is sent out to the regions on all ministry planting stock. The regions then distribute this information to the appropriate districts depending on seedlots requested. This information will be provided where applicable to the contractor at the pre-work conference. Once the contractor receives the pesticide information, it is to be posted and readily available to the planters.

2. If pesticides have been used on the seedlings, each carton will carry a stamped notification that pesticides have been used and precautions are to be taken.

NOTICE

These trees may have been treated with pesticides. Residues may be present. The following precautions are recommended:

1. Wash your hands before eating or smoking,
2. Do not use bags for storage of food or clothing,
3. Change and wash your gloves frequently.

Hand washing facilities must be provided by the contractor to the workers at the work site.

When any pesticide has been applied within one month (30 days) of stock being packaged for storage or shipment, the date of the application is handwritten on the box as (year, month, day) of last application.

A ministry publication entitled *Putting people first; Minimizing tree planter's exposure to seedling pesticides* (FS 449) is also available.

6.12 Suspension of Planting-Climatic Factors

Planting under certain weather conditions is a waste of time, funds, and trees. In deciding whether to continue or to suspend planting, several factors must be considered.

Soil Moisture

If soil moisture at the seedling root level is 40% or less, planting should be suspended. As a rough guide, soil that has reached this critically low level has lost its dark colour, is powdery or crumbly, and will not hold together when squeezed in the hand. The decision to suspend planting should also be based on current weather patterns and forecasts for the area. Hot and dry conditions being forecast should be factored into a decision to suspend.

Relative Humidity

Proper handling of seedlings and special care of the roots is critical when the relative humidity drops to 50%. At a relative humidity of 30%, or at 25^{o}C air temperature, planting should be suspended, especially when soils are dry. If soils are still moist, planting on early shift is a practical means of avoiding such adverse conditions. If the planting program has to be extended to the point where the weather is unfavorably hot and dry and soil moisture levels are low, late starting projects on severe sites should be cancelled. The excess of trees thus available may then be used, if of suitable provenance, to plant alternate areas.

Frost and Snow

Planting should be suspended if the ground cannot be scalped free of frost crystals or snow, if acceptable naturals cannot be seen, or if the selection of appropriate microsites is impeded. Planters must be instructed not to use snow or frozen soil to back fill planted trees. The adverse consequences of planting in frozen ground can be reduced by planting south facing slopes first until the ground has warmed up on other aspects.

Exert taken from BC Ministry of Forests, Forests Practices Branch - Silviculture Manual 1999