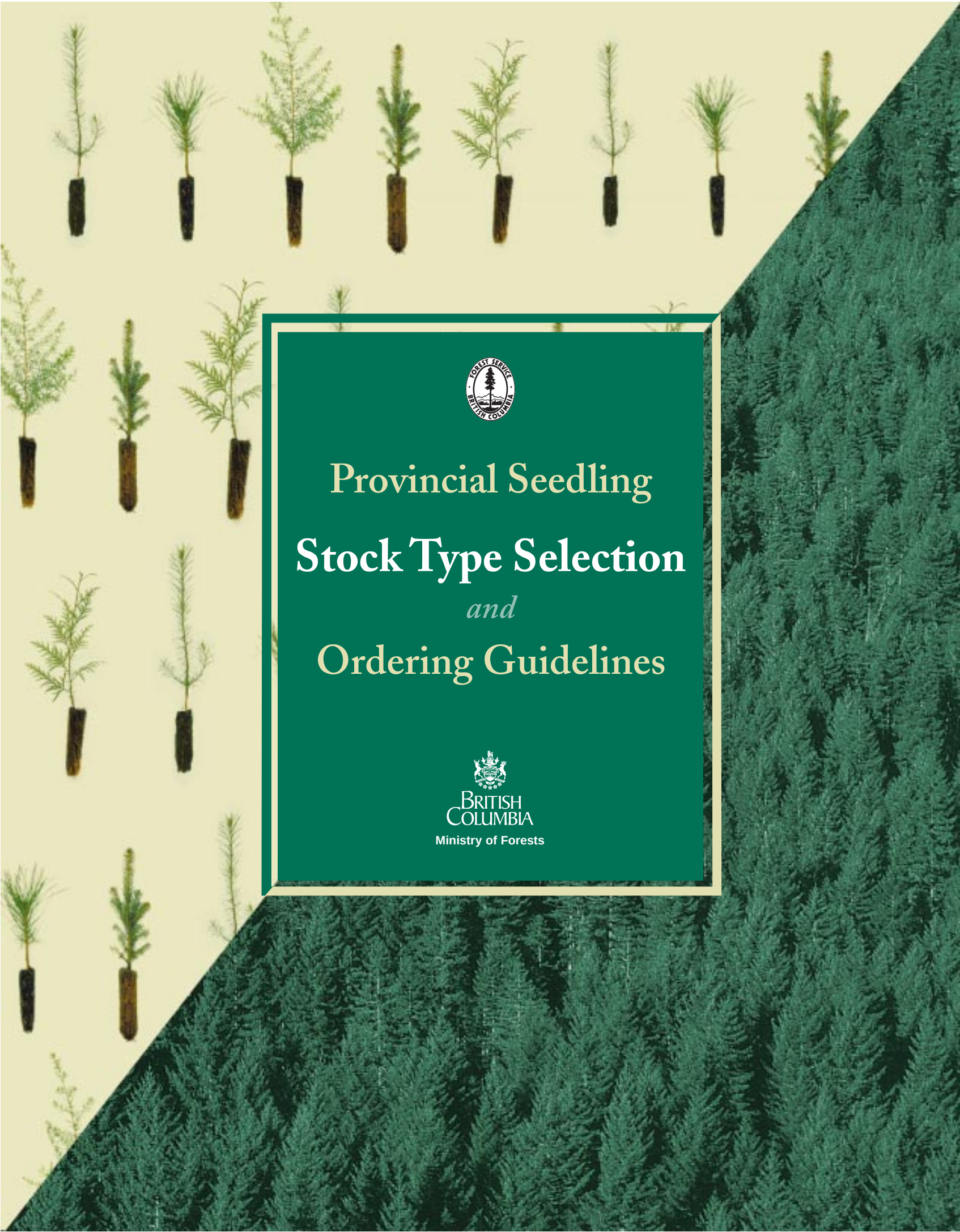

# Provincial Seedling Stock Type Selection *and* Ordering Guidelines

BRITISH COLUMBIA
Ministry of Forests

# Provincial Seedling

# Stock Type Selection

*and*

# Ordering Guidelines

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## Photo Credits

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# How to Use this Guide

This guide has been produced to assist silviculturists in making stock type selection decisions. The terminology and definitions used in describing stock types are explained for both field- and container-grown stock. Site and nursery factors that could influence your decision are presented for consideration in the selection process. Information on ordering seedlings and tracking your order is provided. A section on handling has been included to increase your ability to assess and manage seedlings upon receipt. Finally, common stock types are illustrated and described by species.

The information and recommendations contained in these guidelines are based on field and nursery experience, as well as that of district, regional and licensee specialists. The results of Ministry of Forests SX, EP, unpublished operational trials, and FRDA research trials have also been incorporated.

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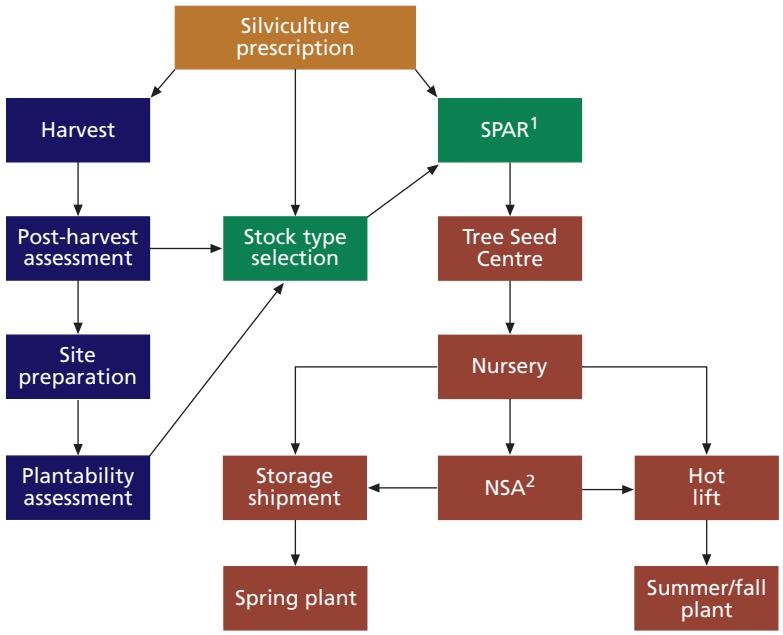
# Introduction

The objective of stock type selection is to decide, based on species, site conditions and experience, what seedling characteristics (e.g., height, root collar diameter) will best suit each site. The selection of stock types is an important element in the regeneration process (Figure 1) and is best considered during the development of the silviculture prescription (SP).

*Stock type selection directly influences the survival and performance of a plantation.*

Stock type selection has its greatest influence on the establishment and early growth phases of a plantation. With time, however, site conditions will usually assume a more important role in determining stand performance. Selection of an appropriate stock type can help to minimize the effects of site limiting factors on the establishment and early growth of seedlings. Choice of stock type can also significantly impact the length of time to achieve free growing obligations and to satisfy green-up requirements. In addition, choices made at this stage can affect future stand management decisions.




1 SPAR – Seed Planning and Registry System
2 NSA – Nursery and Shipping Admin System (for ministry-funded stock only)

FIGURE 1. The relationship of stock type selection to other components of the regeneration system.

Selection at the SP stage integrates harvesting, site preparation, nursery culture, future stand tending practices, and other resource uses, and encourages the prompt regeneration of sites. Stock type selection should also be kept in mind during post-harvest and plantability inspections. Any revisions to the selection should be made prior to the submission or confirmation of a sowing request.

Remember that you are not the only person who has had to select stock for a planting site. Check with others to find out what they have used, why they used it, how they used it, and what happened. For more information, contact your regional reforestation and site preparation forester or nursery services staff. In the northern interior region of B.C., members of the Northern Interior Vegetation Management Association (NIVMA) can query their database for trends in seedling performance by stock type and site characteristics.

The correct stock type decision should be based on site-specific considerations within a set budget. The selection process should consider site preparation, seedling and planting costs, and any commitments made in the SP or within a pest management plan for the site.

# Defining Stock Types

Container-grown seedlings are the most common stock types produced in B.C., however, field-grown stock types are still produced and planted to a limited degree. Most of the discussions in this guide refer to container-grown stock.

## Container-grown Stock Types

A stock type name is a shorthand method of specifying seedling morphology. For a given species, a stock type name is comprised of four elements—container type/container size/seedling age/season of planting. In selecting a stock type, first consider the desired seedling attributes in relation to site conditions, and then specify the shorthand notation as illustrated in Figure 2.

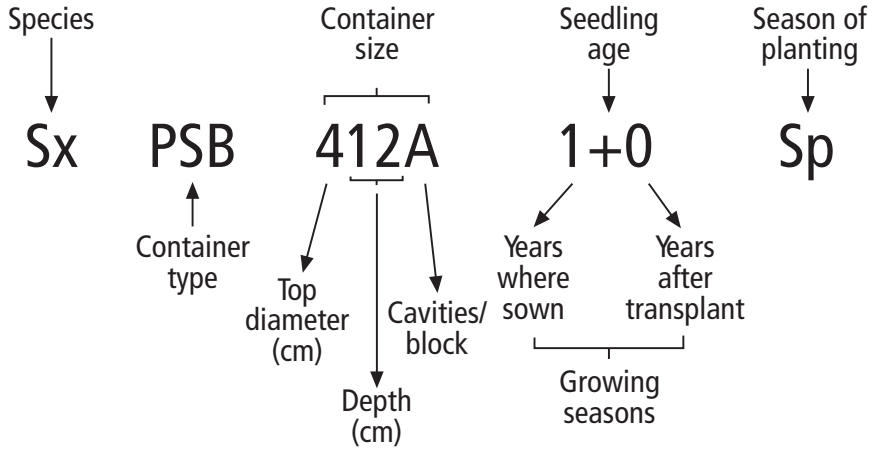



FIGURE 2. Example of stock type nomenclature. Species is interior spruce, container type is a plug styroblock, container size is approximately 4 cm wide by 12 cm deep cavity with 77 cavities per block, age is one year, and the season of planting is spring.

Table 1 provides the definitions for the various components of the stock type notation commonly in use. Table 2 lists the dimensions of the principal containers used.

TABLE 1. Abbreviations and their definitions as used in container stock types

| | |
|---|---|
| **Container type** | PSB – plug styroblock<br>PCT – plug copper treated<br>CRC – container rooted cutting<br>PAP – plug air-pruned (plastic block)<br>PAB – plug air block (styroblock)<br>PPT – plug-plug transplant |
| **Container size** | Approximate dimensions of cavity (see Table 2) |
| **Seedling age** | Two-part code with the two parts separated by a plus sign; total equals seedling age. For example:<br>• 1+0 = one year old, seeded and grown in same place<br>• .5+.5 = one year old, grown half the year where seeded, transplanted once, and grown half the year in another location<br>• 2+0 = two years old, seeded and grown in same place |
| **Season of planting** | Sp – spring<br>Su – summer<br>Fa – fall<br>Wi – winter |

TABLE 2. Container stock type density, container dimensions, and soil volume

| Container size | Cavity width (cm) | Cavity depth (cm) | Cavities/ block | Cavity volume (ml) | Seedling density (cavities/$m^2$) |
|---|---|---|---|---|---|
| 211A | 2.7 | 11.4 | 240 | 39 | 1130 |
| 313B | 3.0 | 12.7 | 160 | 65 | 764 |
| 410 | 3.6 | 10.5 | 112 | 80 | 527 |
| 415B | 3.5 | 14.9 | 112 | 93 | 527 |
| 412A | 4.2 | 11.7 | 77 | 126 | 366 |
| 415D | 4.3 | 15.2 | 77 | 172 | 366 |
| 512A | 5.2 | 11.9 | 60 | 220 | 280 |
| 515A | 5.1 | 15.2 | 60 | 250 | 280 |
| 615A | 6.0 | 15.2 | 45 | 336 | 215 |

# Field-grown Stock Types

Bareroot seedlings are designated either BBR for seedlings seeded directly into nursery beds (Plate 1), or PBR for seedlings sown in a container in the greenhouse and later transplanted to the nursery bed (Plate 2). Stock age is also included in the stock type notation.

PLATE 1. Examples of seedlings grown as bareroot stock types.

Plate 1a.
Fdc BBR 2+0

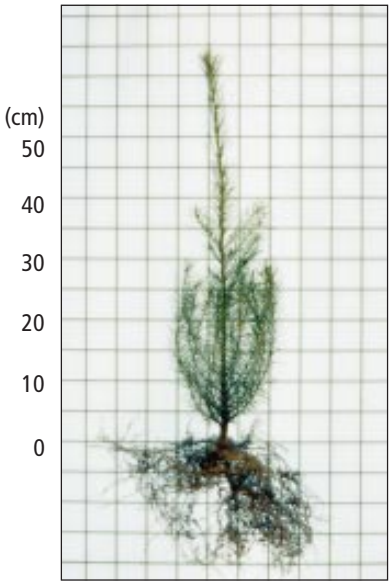



Plate 1b.
Pli BBR 1+0
(left) and
Pli BBR 2+0
(right)

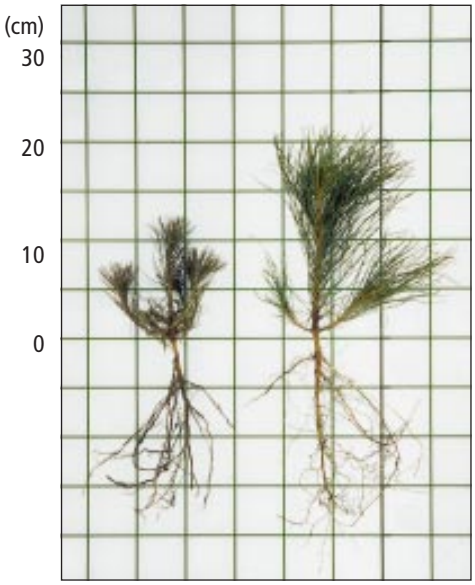



PLATE 2. Examples of seedlings grown as plugs and transplanted to nursery beds.

Plate 2a. Ss PBR 1+1

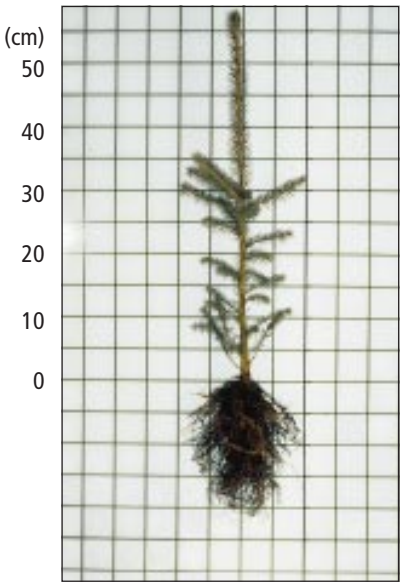



Plate 2b. Sx PBR .5+1.5

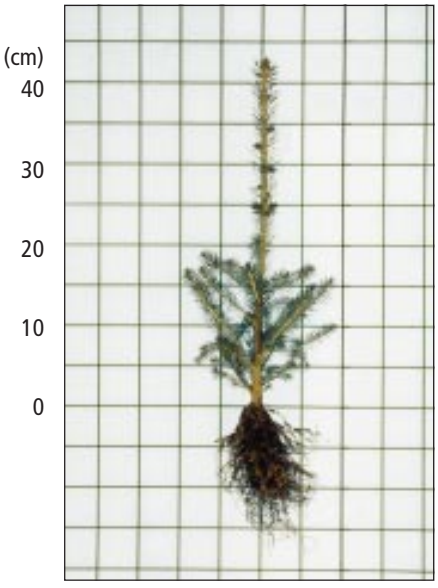
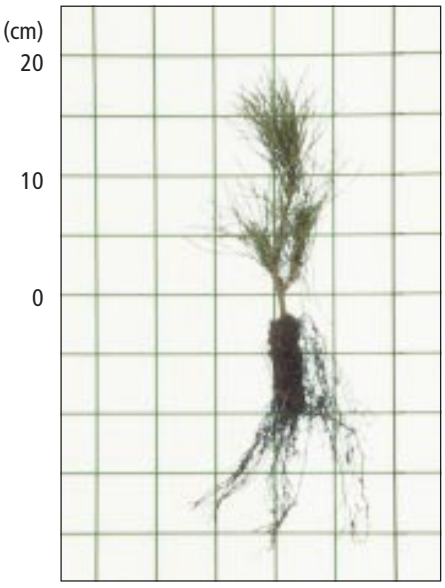



Plate 2c. Pli PBR .5+.5



# Choosing a Stock Type

Selection of a stock type is a biologically and economically crucial phase in the regeneration process. Silviculturists can exert control over the morphology of seedlings through stock type selection. The diversity of available stock types provides silviculturists with a set of tools for dealing with a wide range of reforestation situations (Plate 3).

Many factors must be understood and considered in order to select the most effective stock type for a given situation. This section provides detailed information on seedling biology, site factors, field logistics, and nursery culture that will influence your final stock type selection.

## Species

It is important to remember that correct species selection is necessary before a stock type selection can be made. In many cases, stock type selection may be directly influenced by species choices.

Species selection should be based on a variety of factors:

- Ecological acceptability for the site.
- Resource management objectives and future stand characteristics.
- Silvicultural system.
- Site limiting factors (e.g., frost, drought).
- Forest health (e.g., avoid planting Fdi where Armillaria is a problem).
- Resource plans.
- Local experience.
- Research trials.

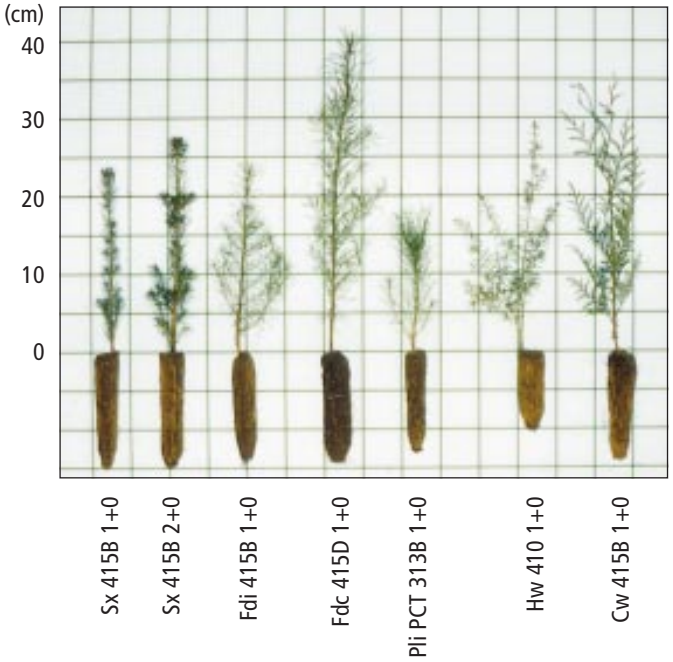
## Seedlot

Seedlot selection should be based on the following four factors:

- Availability of seed orchard seed.
- Consideration of seed transfer guidelines and the level of genetic improvement for a specific trait(s).
- Seedlot quality (germination and vigour).
- Local seedlot performance.

An appropriate stock type selection can optimize the match of a species/seedlot selection to specific site conditions.

PLATE 3. Selection of common regeneration species and stock types based on 1997 sowing requests. Notice the difference in root collar diameter between the Sx 1+0 and Sx 2+0 stock types.




# Seedling Characteristics

The physiological condition and carbohydrate reserves of the seedling determines its resistance to stress and its ability to establish quickly. An acceptable stock type selection represents a blueprint that, when grown and handled properly, will reliably produce seedlings of optimum size and satisfactory physiological quality.

## Size

Seedling size is the most important morphological characteristic of a stock type. Select the size of seedling that overcomes the site limiting factors—then select the stock type that matches those requirements. Stock type morphological specifications are the basis for selecting stock by field staff and grading stock in the nursery. Table 3 gives an example of the 1997–98 morphological specifications for some Sx stock types.

Three basic principles are used in choosing a container size and seedling age:

- More or longer growing seasons produce taller seedlings with larger stem diameters.
- Larger container sizes hold more growing media and produce seedlings with more roots, larger root collar diameter, and generally greater height (depending on container depth). These seedlings are more expensive to grow and plant.
- The wider the seedling spacing in the nursery, the more branching will occur and the woodier (i.e., greater root collar diameter) the seedling will be. High densities produce small, poorly branched seedlings.

As nursery culture has developed, size expectations have increased. Whereas in the past large stock could only be provided in 2+0 seedlings or transplants, now tall, robust seedlings can be grown as 1+0 stock. These seedlings also achieve large root masses quickly. However, if growth cycles are not matched to appropriate planting windows (refer to "Nursery Production Time," Figure 6), seedlings can become root-bound and prone to root diseases. This change in culture, morphology, and root health is the reason for preferring any 1+0 over a 2+0 Sp culture. As a seedling becomes larger and older, there are fewer cultural techniques that a nursery can use to control growth and prevent disease without reducing the vigour of the seedling. Seedlings cannot be left in the nursery forever!

In addition to root disease, 2+0 seedlings at the nursery are subject to risk of over-winter damage. The 2+0 crops are typically over-wintered in open

TABLE 3. Acceptable Sx stock type morphological specifications determined by the Ministry of Forests for 1997–98 ministry-funded crops. Morphological specifications vary by species. Specifications for other species are available from Ministry of Forests Nursery and Seed Operations Branch. These specifications are reviewed and revised annually. These specifications are guidelines for licensees.

| Sx Interior Spruce | Height (cm) | | | Root collar diameter (mm) | |
|---|---|---|---|---|---|
| Stock type | Minimum | Target | Maximum | Minimum | Target |
| PSB 313B 1+0 | 11 | 17 | 25 | 2.2/2.4* | 2.8/3.0* |
| PSB 410 1+0 | 12 | 18 | 27 | 2.4/2.6* | 3.0/3.2* |
| PSB 415B 1+0 | 13 | 22 | 28 | 2.6/2.8* | 3.3/3.5* |
| PSB 412A 1+0 | 14 | 24 | 35 | 2.8/3.0* | 3.6/3.8* |
| PSB 415D 1+0 | 14 | 25 | 40 | 3.0/3.2* | 3.8/4.0* |
| PSB 512A 1+0 | 15 | 27 | 40 | 3.3 | 4.0/4.2 |
| PSB 615A 1+0 | 20 | 40 | 50 | 4.0 | 5.0 |
| PSB 415B 2+0 | 14 | 27 | 40 | 3.6/4.0* | 4.8/5.0* |
| PSB 415D 2+0 | 16 | 30 | 44 | 4.0/4.4* | 5.3/5.7* |
| PSB 615A 2+0 | 20 | 35 | 50 | 4.5/5.0* | 6.0/6.5* |
| PBR .5+1.5 | 17 | 27 | 37 | 4.0 | 5.0 |

* The smaller number represents the specifications on stock lifted prior to September 15. The larger number applies after this date.

compounds, hence risk being damaged or killed by low temperatures.

The size of seedlings can be expressed in terms other than height and root collar diameter. Shoot/root ratio is a comparison of shoot dry weight to root dry weight. It is manipulated primarily by seedling spacing in the nursery. Higher nursery densities tend to produce trees with higher shoot/root ratios and increased incidence of foliage disease. Seedlings with high shoot/root ratios are more prone to water loss after out-planting from transpiration because a higher proportion of foliage is shade adapted, lacking sufficient cuticular waxes. They are also less sturdy hence more prone to being damaged by vegetation or snowpress. These issues have been integral in the continued shift in preference for larger stock types.

Sturdiness ratio is another means for expressing the shoot to root relationship. It is the ratio of seedling height to the root collar diameter. In the nursery, seedling height and stem diameter are measured as illustrated in Figure 3. The lower the value, the more sturdy the seedling and the less likely it will suffer physical damage from vegetation or snow.

Both shoot/root and sturdiness ratios change with the age of the seedling in the nursery. More importantly, these ratios change after out-planting. Do not look for a stock type in the nursery with exactly the same ratios as a seedling after a few years in the field. Instead, select seedling stock types that grow into the target ratios established as field performance measures.

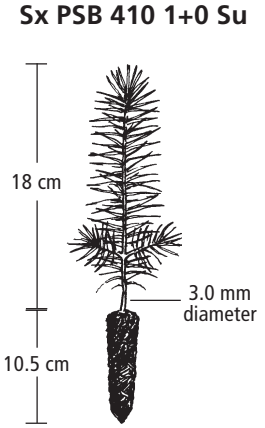



FIGURE 3. Spruce seedling with a height of 18 cm and root collar diameter of 3.0 mm showing where measurements are taken in the nursery. This seedling would have a sturdiness ration of 18:3 = 6.

# Site Limiting Factors

Once species and seedlot selection have been made, the selection of a stock type is, in most cases, reasonably simple. There are few stock type selection decisions where only one stock type is acceptable—there is usually a choice. The stock type selection must be made partially on a cost basis—the less expensive tree, in most years on most sites, may be the most cost-effective choice. In other years and on other sites, however, less expensive stock types may show lower survival and performance. Increasing planting densities under some circumstances is not recommended as stem distribution may become clumped. If survival is low, replanting may be required to compensate for losses. While the use of the less expensive and less reliable stock may save on initial costs, it may incur the risks and expenses associated with more variable performance.

It is at the edaphic, climatic, and logistic extremes that stock type selection becomes the most critical. Linking the stock type prescription with the species prescription at the SP stage helps to identify these thresholds. To deal with stock type selection under the environmental extremes, it is crucial to first identify the limiting factor(s) for the prescribed species on the intended site. A stock type choice can then be made with the goal of ameliorating specific limiting conditions for that species.

Although only a single factor may be considered limiting, a seedling weakened by one factor may become more prone to injury and poor growth from other factors. There are potentially many limiting factors but stock type selection is not capable of addressing the specifics of every limiting factor.

## Frost and winter desiccation

*No stock types can be used to avoid frost damage.*

If frost damage, frost heaving, or winter desiccation are expected, the initial damage/mortality is typically encountered in the first growing season. The principal ways of minimizing frost and winter desiccation damage and frost heaving are:

- Species selection (e.g., Pl>Bl>Sx).
- Site preparation.
- Site avoidance.
- Planting season.
- Well-hardened seedlings.
- Microsite selection.
- Minimize exposure of mineral soil when screefing.
- Select short, sturdy stock types.

Once an appropriate species has been chosen, planting should be timed to avoid early frost or late frost (see Table 4 for species relative frost tolerance). Avoid planting valley bottoms prone to cold air drainage and radiative frost until later in the season. Although these sites may be snow free early in the spring, depending upon the species, they should not be planted until after the risk of frost has passed. Some sites (e.g., high-elevation biogeoclimatic zones—ESSF, MH, northern biogeoclimatic zones—SBS, BWBS, and northern subzones of the ICH), may be prone to frost at any time of the year. The most conservative planting strategy is to plant these sites with summer-shipped stock that will not be as easily damaged by frost and to plant protected microsites.

TABLE 4. Relative tolerance to growing-season frost for provincial tree species

| Relative tolerance to growing-season frost | Tree species |
|---|---|
| Very low | Cw, Dr, Fd, Hw, Mb |
| Low | Bg, Bn, Lw, Ss |
| Moderate | Ba, Bl, Pw, Py, Sx, Yc |
| High | At, Acb, Act, Ep, Hm, Lt, Pl, Pj, Pa, Sb |

Source: Province of British Columbia. 1995. Establishment to Free Growing guidebooks. B.C. Min. For., Victoria, B.C.

Frost heaving is a frequent occurrence on many sites with fine-textured soils, especially in northern British Columbia if the stock is planted late in the season. Small, shallow containers, such as the PCT 211A and PCT/PSB 410, are not appropriate for these conditions as they are more prone to frost heaving than larger or deep-planted stock types such as PSB/PCT 313B/415B. For some species, PCT stock types may be more suitable than PSB stock types because of their better root egress in the upper soil layer.

## Drought

Soil moisture can limit the length of the planting season and strongly influence seedling establishment. It is determined by five factors:

- Season.
- Soil characteristics (i.e., organic matter, texture, coarse fragments, density, depth).
- Vegetation (particularly grasses).
- Slope position, elevation, and aspect.
- Evapotranspiration.

Droughty soil conditions are often accompanied by high temperatures and low relative humidity. Herbaceous and grass competition may further aggravate these droughty conditions by competing with seedlings for available soil moisture. Droughty site conditions are frequently associated with shallow, stony soil, and with south aspects, and low elevations in the southern interior.

The following is a list of the principal ways of dealing with drought conditions:

- Select drought-tolerant species (e.g., Pl>Bl>Se).
- Site prepare spots to minimize drought effects (e.g., disc trench).
- Time planting to avoid drought period.
- Select sheltered and/or shaded planting microsites.
- Use only well-hardened seedlings.
- Favour depressions as planting microsites.
- Avoid planting in dense grass cover or other competing vegetation.

*Stock types cannot be used as a substitute for correct planting time.*

Time planting to coincide with periods of acceptable soil moisture and low moisture demand during and following planting to assure adequate root growth prior to the onset of drought. Be aware of situations where soil moisture conditions are adequate for planting but the weather conditions are warm and dry; a high transpirational demand may be placed on seedlings.

Well-branched, woodier stem morphology, and hardened tissues are important seedling traits for minimizing transpirational water loss during establishment. For example, PSB 313B 1+0 seedlings may be more at risk to drought because they are not as woody or branched as the larger PSB 415B 1+0. Under shallow, stony soil conditions, the shallow-rooted stock types, such as PSB 410 1+0 or PSB 412A, may be better suited. Similarly, a late-planted PSB 313B 1+0 Sp may be more sensitive to drought than a PSB 313B 1+0 Su because of the additional transpiration demands placed on the seedling by a succulent flush. Avoid stock with large shoots coupled with poorly developed or small root systems. A well balanced tree is critical for droughty sites.

## Flooding

Flooding and saturated soil conditions with poor aeration are typically Sx, Ss, and Cw fluvial and alluvial sites as well as Plc bogs and Sb/Lt wetlands. Saturated soil conditions are accompanied by low soil temperatures and low oxygen. Correct species selection, raised microsite selection, drainage ditches, and mounding by mechanical site preparation (MSP) are ways to deal with high and fluctuating water tables.

*Stock type selection cannot be used to alleviate saturated soil conditions.*

## Physical damage

Physical damage may be due to a variety of factors depending on the site:

- Snowpack effects (press, creep, abrasion, and glide).
- Vegetation press (herbs, grasses).
- Animals (browsing, trampling).
- Falling debris (ravelling).

To a limited degree, physical damage can be moderated by stock type and species selection. A large, robust seedling will be the most resistant to these damaging factors. A large stem diameter will help prevent the seedling from being bent and trampled. A seedling with a well-branched stem is more likely to recover from physical damage by re-expression of apical dominance from a branch or subterminal buds. A well-branched stem also helps shed vegetation. For these reasons, seedlings that are sturdier or larger, such as the PSB 412A or PSB 415D are preferred to a PSB 313B 1+0 for dealing with anticipated physical damage.

Seedlings can be protected from ungulate browsing by netting, sleeves, or plastic tubes but in some cases, particularly Cw, these devices may cause seedling deformities if not regularly maintained. Obstacle planting, locating the seedling near an obstacle such as a log or stump, is another way to protect them from ungulate browsing and trampling. For some species, such as Cw, the browsing may be so severe that it is better to select a species that is not as palatable.

*There are no stock types that can be used to avoid rodent browsing.*

Large diameter woody stems are less palatable and better able to endure small mammal browsing than small diameter stems. Planting when rodents are not foraging, and at low periods in their population cycles, can be a successful avoidance strategy. Reduction of vegetation cover by the use of some site preparation techniques can reduce rodent habitat and improve seedling survival. Fertilization at time of planting may compound browsing problems.

### Vegetation competition

Vegetation differs from most other site factors in that it can have both physical and physiological impacts on seedlings. Vegetation may affect seedlings physiologically by limiting moisture, nutrients, soil temperate, and light. Large, robust seedlings are better able to deal with both the physical and physiological effects of vegetation than smaller stock types. Sites with extreme competition from grasses, shrubs, or herbs, will require site preparation before any stock type will be successful.

### Duff/Forest floor materials

On sites with a high level of debris, thick moss mats, or deep loose duff layers, site preparation, not stock type selection, may be the key to achieving reforestation objectives. If forest floor planting is prescribed under these conditions, larger stock types are recommended (e.g., 415B, 412A) as these can be planted more securely into the loose materials and there is less risk of burying the larger tops. BBR and PBR are not recommended for these conditions due to the difficulty in securing a proper planting microsite for these stock types.

### Plantability

The three most common plantability problems are shallow soils, excessive rotten wood and debris, and high spring water table. Where shallow, stony soils or high water table prevail, select a shorter stock type, such as a PSB/PCT 313B/410/412A 1+0. For shallow, stony soils be sure to time the planting to take advantage of soil moisture. BBR and PBR stock types have special plantability considerations and should be restricted to sites where a planting depth of at least 30 cm can be assured.

## Site Preparation Selection

*Stock type selection alone, without site preparation, may not be capable of alleviating a site limiting factor.*

For some limiting factors, site preparation and/or microsite selection in combination with a specific stock type will be more effective than stock type selection alone. The type of site preparation and associated stock type may influence how you manage your project in a number of ways:

- Predetermining planting density and distribution.
- Customizing microsites.
- Altering plantability.
- Reducing planting administration costs.
- Decreasing basic silviculture costs.

*Correct site preparation can significantly reduce planting costs.*

The benefits of the site preparation method and stock type options available for alleviating a specific site limiting factor must be examined from a cost-benefit point of view. A balance must be maintained that best suits the site conditions while being cost effective. For example, all or part of the MSP costs may be recovered by decreased planting costs.

The following is a list of the common site limitations that site preparation can help to alleviate:

- Frost and winter desiccation.
- Cold soil temperatures.
- Soil moisture.
- Flooding.
- Vegetation competition.
- Animal damage.
- Compacted soil and low aeration porosity.

# Field Operational Considerations

Appropriate selection of a stock type and co-ordination with the nursery provide the best assurance that the right seedlings will be ready when the site is to be planted. Implementation of the planting program, however, requires that seedlings be transported and planted when site and stock characteristics coincide. Planting and handling logistics, therefore, must be considered during the stock type selection process.

Stock types should be selected to allow for maximum flexibility of the planting program. Rather than selecting stock types with a limited flexibility, such as BBR 2+0, select those with greater flexibility such as PSB 1+0, and concentrate on better planning, planting, site preparation, timing of planting, and communication with the nursery. Do not expect custom stock type design and selection to make up for a lack of attention to these and other factors.

Each planting program (e.g., regular plant; replant or fill plant; backlog; underplanting) has its own special planning requirements. Although it is not possible to anticipate all of the logistical problems that can influence stock type selection, proper planning can minimize the risks. The following is a list of major planning concerns that could affect stock type selection:

- SP obligations.
- Stock availability.
- Planting cost.
- Planting site location.
- Planting site conditions.
- Planting site accessibility.
- Interim storage facilities and handling.
- Availability of suitable transportation.
- Planter availability.

Table 5 reviews some logistical concerns associated with several commonly used stock types.

## Site accessibility

Transporting seedlings to and storing seedlings at remote planting sites can be costly. This is a particular concern for any hot-lift planting program. Consider alternative transportation methods that minimize transportation time, such as helicopters. Where larger stock types are being used for backlog planting, their large size may require specialized transport at the planting site (e.g., helicopter lifting small stashes of seedlings into the middle of the block).

*Smaller stock types are more cost-effective to transport and to maintain in interim storage than larger stock types.*

Smaller stock types are more cost-effective to transport and to maintain in interim storage than larger stock types. For example, nearly twice as many PSB 313B 1+0 Sx seedlings will fit in a box as PSB 415D 1+0. Due to their relative sensitivity to adverse storage conditions and specialized handling requirements, BBR and PBR stock types should not be considered for use in remote areas unless site conditions exclude all other stock types. Handling problems and prolonged field storage of stock used in remote planting sites should be anticipated. In order to maintain stock condition at remote planting sites, it may be necessary and desireable to arrange for stock handling, storage, and care of seedlings with the planting contractor or to designate a stock maintenance manager.

Many spring planting operations at high elevations (ESSF) are delayed because of late snowmelt on the planting site. Often the delay may be too long and the planting cancelled. Consider summer rather than spring planting for sites prone to these conditions.

TABLE 5. Suitability of acceptable stock types for various operational factors. The table indicates the relative suitability for remote locations (good, fair, or poor stock type choice for remote locations); handling requirements (few, moderate, or many requirements in order to preserve stock quality); and plantability (easy, moderate, or difficult stock type to plant).

| Plantability | Handling requirements | Remote locations | Season | Stock type |
|---|---|---|---|---|
| Easy | Moderate | Good | Su | PCT 211A 1+0, PSB/PCT 313B 1+0, PSB 313B 2+0, PSB 410 1+0, PSB/PCT 412A 1+0 |
| Easy | Few | Good | Sp | PSB/PCT 412A 1+0, PSB/PCT 313B 1+0, PSB 410 1+0, PSB/PCT 415B 1+0 |
| Moderate | Moderate | Good | Su | PSB/PCT 415B 1+0 |
| Moderate | Moderate | Fair | Su | PSB 415B 2+0, PSB 415D 1+0 |
| Moderate | Few | Fair | Sp | PSB 415D 1+0 |
| Moderate | Moderate | Fair | Su | PSB 415D 2+0 |
| Moderate | Moderate | Poor | Sp | PSB/PCT 512A, PSB 615A 1+0, PBR .5+.5 |
| More difficult | Many | Poor | Su | PSB/PCT 512A |
| More difficult | Many | Poor | Su | PSB/PCT 515A, PSB 615A 1+0 , PSB 615A 2+0 , PBR .5+.5, PBR .5+1.5 |
| More difficult | Many | Poor | Sp | PSB/PCT 515A, BBR 2+0 |

In other situations, the planting site may be snow free but inaccessible. Clearing snow from roads or using helicopter transport should be considered to gain access to the planting site but this will require additional lead time to get the necessary equipment to the site. The cost of clearing snow should be compared to the risk of increased mortality due to delayed planting and planter availability. Stock type selection should also be based on a comparison of the cost of snow removal to the cost of summer planting and specialized summer storage.

Helicopter-logged sites, although generally requiring small numbers of seedlings, are almost always restricted to the PSB 313B/410/415B stock types because of access and transport constraints.

## Delivery Dates

The required seedling delivery date can be one of the most important variables in stock type selection (see Figure 4 for graphs of stock age and stock type by season sown for the 1997 planting season). All other decisions, such as ordering and growing, flow backwards from the anticipated delivery date.

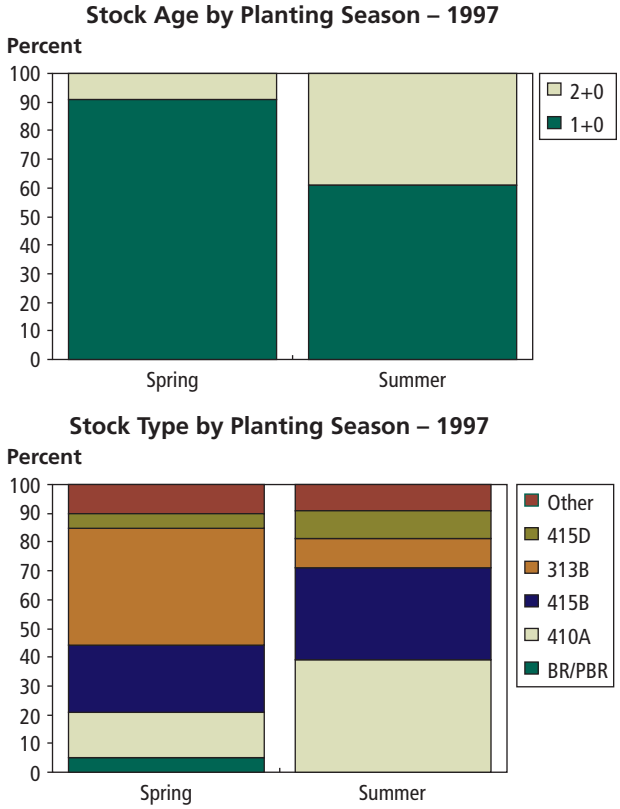



FIGURE 4. Trends in stock age and stock type by planting season, 1997.

Planting should be planned for a particular date and adjusted for site and weather conditions. The seedlings used in different planting seasons are expected to respond differently—spring-planted stock will flush; summer and fall-planted stock maintains budset. For spring planting, the actual planting date depends upon soil temperature, likelihood of frost, slope position and aspect, and block access. For summer and fall planting, the planting window depends upon soil moisture, likelihood of frost, and slope position and aspect. The timing of summer and fall planting is further complicated by the condition of the stock. Stock should not be planted unless it is sufficiently hardened-off.

There are five delivery dates:

- Spring delivery of cold- or frozen-stored stock.
- Spring delivery of hot-lifted stock.
- Summer delivery of hot-lifted stock.
- Fall delivery of hot-lifted stock.
- Winter delivery of stored or hot-lifted stock (south coast only).

The specific dates used in the different forest regions are indicated in Table 6.

*The earlier the sowing request can be submitted, the greater the likelihood of meeting the specified delivery date.*

For nurseries to have hot-lift stock ready for shipping by a specific date, each sowing request must be accompanied by a delivery date. Nurseries attempt to have the seedlings adequately hardened-off so that seedlings can be shipped by the chosen date.

## Spring delivery

The spring plant is when the majority of seedlings are planted (see Figure 5 for graph of stock sown by season for 1997). Because most stock for spring planting is frozen or cold-stored it can be thawed for delivery as desired. The start date of planting varies depending on the biogeoclimatic zone (Table 6) and block access. Prolonged storage depletes carbohydrate reserves and reduces the vigour of seedlings. No planting of spring-delivered stock is recommended after June 21.

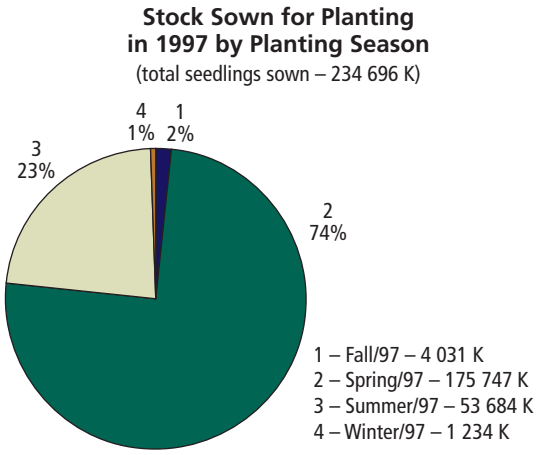



FIGURE 5. Allocation of requested stock by planting season, 1997.

Planting operations must take the thawing schedules of different stock types into account. Before delivery, the tops and roots must be evenly thawed, which takes about 5 to 10 days for container stock and about 3 days for bareroot. Once thawed, stock should be planted immediately. Spring-delivered stock rapidly loses both dormancy and hardiness; it will flush shortly after planting. In this condition, the seedlings are very sensitive to any stress (drought, frost, high temperatures) and very vulnerable to storage moulds. Planting delays, common for high-elevation sites due to late snowmelt, may make planting prior to June 21 infeasible. Under these conditions, consider the feasibility of a summer delivery.

## Hot-lift spring delivery (coastal only)

Hot-lift spring deliveries of Fdc, Ss, Sx, Cw has been preferred for some coastal planting projects. This stock type is available as soon as site conditions permit and the stock can be lifted from the nursery. Never hold this stock in storage for prolonged periods once it has been lifted; plan on planting within one week of lifting (see Table 6).

TABLE 6. Planting seasons for biogeoclimatic zones by forest region. The dates used for spring planting are the most common for the biogeoclimatic zone in the region. Start dates will vary from year-to-year and depend upon climatic condition and site access. Finish dates for summer and fall planting are dependent on climatic conditions. Planting dates listed as possible are only being used under special conditions. If stock is generally not available for a planting season, it is listed as not available. Winter planting is often feasible in the Vancouver Forest Region in the southern most areas at low elevations.

| | Planting season | | | |
|---|---|---|---|---|
| | Cold-stored stock | Hot-lift stock | | |
| | Spring only | Spring | Summer | Fall |
| Biogeoclimatic zone/region | Start–Finish | Start–Finish | Start–Finish | Start–Finish |
| BWBS: Prince George | May 10–Jun 20 | Not available | Jun 21–Aug 15 | Do not plant |
| CDF: Vancouver | Feb 1–Apr 30 | Feb 1–Apr 15 | Do not plant | Sep 15–Oct 15 |
| CWH: Vancouver | Feb 1–May 24 | Feb 1–Apr 15 | Do not plant | Sep 15–Oct 15 |
| CWH: Prince Rupert | Apr 20–Jun 20 | Not available | Jun 21–Aug 20 | Aug 20–Sep 20 |
| ESSF: Kamloops/ Cariboo | May 24–Jun 20 | Not available | Jun 21–Aug 20 | Not advised |
| ESSF: Nelson | Apr 30–Jun 20 | Not available | Jun 21–Aug 20 | Not advised |
| ESSF: Prince Rupert/ Prince George | May 24–Jun 20 | Not available | Jun 21–Aug 20 | Do not plant |
| ESSF: Vancouver | May 24–Jun 20 | Not available | Aug 15–Aug 31 | Sep 1–Sep 15 |
| ICH : Prince Rupert/ Cariboo | Apr 20–Jun 20 | Not available | Jun 21–Aug 20 | Aug 21–Sep 20 |
| ICH: Kamloops | Apr 20–Jun 20 | Not available | Jun 21–Aug 30 | Not advised |
| ICH: Nelson | Apr 20–Jun 20 | Not available | Jun 21–Aug 30 | Not advised |
| ICH: Prince George | May 8–Jun 20 | Not available | Jun 21–Aug 20 | Not advised |
| IDF: Cariboo | Apr 15–May 30 | Not available | Do not plant | Do not plant |
| IDF: Kamloops | Apr 1–May 15 | Not available | Do not plant | Not advised |
| IDF: Nelson | Apr 15–May 15 | Not available | Do not plant | Not advised |
| IDF: Vancouver | Mar 1–May 24 | Not available | Do not plant | Sep 15–Oct 15 |
| MH: Prince Rupert | May 24–Jun 20 | Not available | Jun 21–Aug 20 | Do not plant |
| MH: Vancouver | May 24–Jun 20 | Not available | Aug 15–Aug 31 | Sep 1–Sep 15 |
| MS: Kamloops/Cariboo | Apr 30–Jun 20 | Not available | Possible | Not advised |
| MS: Nelson | Apr 30–Jun 20 | Not available | Do not plant | Not advised |
| PP: Kamloops, Nelson | Apr 1–May 15 | Do not plant | Do not plant | Do not plant |
| SBS: Prince George, Cariboo, Kamloops, Prince Rupert | Apr 15–June 20 | Not available | Jun 21–Aug 15 | Do not plant |
| SBPS: Cariboo, Prince George, Prince Rupert | Apr 15–May 30 | Not available | Jun 21–Aug 15 | Do not plant |

## Hot-lift summer delivery

All stock planted in the summer season will be hot-lifted. Summer-delivered hot-lifted stock has acquired a terminal bud and has some degree of hardiness—it will not flush after planting, has lower requirements for water, and is better able to control moisture loss. However, summer planting stock is still very physiologically active. Roots are particularly active and vulnerable to damage. The essence of "hot-planting" is speed: lifting, packaging, shipping, and planting must be completed within a few days. Special care is essential so that active roots are not exposed to drying conditions or subjected to physical damage between the nursery and the site. Late June and early July delivery dates are typically more difficult for nurseries to meet than mid-July dates.

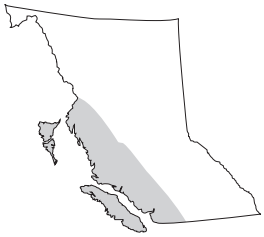
Choice of nurseries is important; choose a nursery that can reliably deliver this stock on time. Smaller stock types such as the PSB 410/412A are generally available during late June and early July. Specify your delivery date when ordering seedlings to assist nurseries in having your stock ready when needed (see "Ordering and Tracking Stock Types," page 24). This will assist the nurseries in having your stock ready when you need it.

Summer stock should be checked for succulence (see "Receiving and Handling Stock," page 27). If the stock has not fully hardened-off, the seedling will still have a high requirement for moisture, will handle poorly, and will not be able to control moisture loss—it may perish quickly. Consider planting this stock later in the summer.

In the case of 2+0 outdoor compound-grown stock, hardening-off is weather dependent. An unusually cool wet spring will delay stock development. Although some stock can be held over for spring planting the following year, this is not recommended for the 2+0 outdoor compound-grown stock due to its size and potential for becoming root-bound and prone to disease.

## Fall delivery

Although this is the least used delivery date, it may be appropriate for coastal and coast-interior transition sites. It is generally not advisable for the interior, due to the high probability of frost heaving associated with early frosts. The stock is usually hardened-off well enough that it can wait at the nursery until suitable field conditions exist. This stock should be planted when soils are still warm and some root growth can occur provided that there is adequate soil moisture. This stock will have acquired more dormancy and will typically be hardier than early summer stock. If early snow or frost occur, this stock may have to be held over for spring planting—but it can not be held over for summer planting! If site climatic conditions are still hot and dry, consider delaying the planting or plant north aspects and wetter sites before moving onto south aspects and drier sites.



# Nursery Production Time

Each nursery facility has specific planning requirements, cropping duration, capabilities and limitations for each stock type, which should be taken into consideration.

The time it takes to grow a seedling (Figure 6) varies with stock type. The time factor must be considered during the stock type selection process in order to match the desired delivery date.

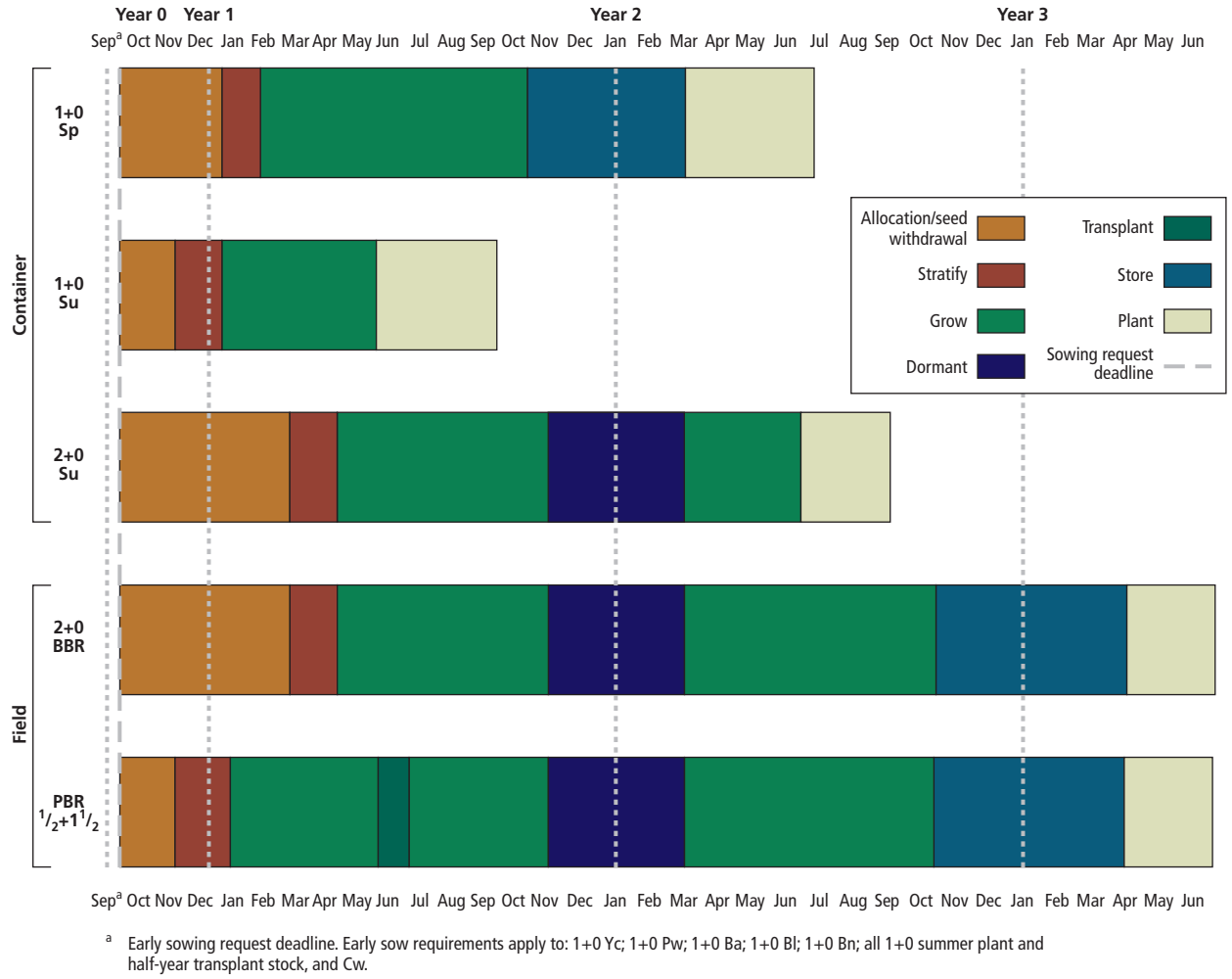
# Cost

Nursery production costs are reflected in seedling prices. In general:

- Larger seedlings cost more to produce due to the amount of nursery space consumed (see Figure 7).
- As seedling age increases, production costs increase.
- Over-wintering or holding over 1+0 for 2+0, increases the risk of crop damage. Damaged, unacceptable seedlings increase the cost of acceptable seedlings.

There is a horticultural truism that says:

**"Don't plant a 25¢ tree in a 10¢ hole."**




[a] Early sowing request deadline. Early sow requirements apply to: 1+0 Yc; 1+0 Pw; 1+0 Ba; 1+0 Bl; 1+0 Bn; all 1+0 summer plant and half-year transplant stock, and Cw.

FIGURE 6. Sowing request in relation to administration and age of major stock types. Actual sow dates and cultural cycles may vary by species, nursery, and specific stock type. *(Note that 1+0 summer stock can be sown and available for planting in seven to eight months.)*

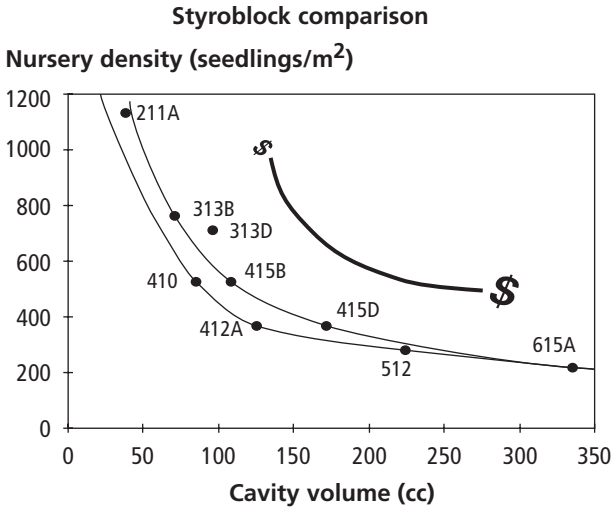



FIGURE 7. Relative seedling cost in relation to stock type density.

The same applies for forestry: match the site preparation and microsite to the species and stock type selection. Consideration must be made of the entire cost of the regeneration system and the potential impact and value of increased survival and productivity. The cost to purchase and plant a seedling must be considered, but:

*The most important cost is the cost of the surviving seedling at free growing.*

In considering these cost issues, remember that the cost to purchase the stock alone may be less than half of the cost to package, store, transport, and plant

the seedling. In turn, the entire cost to plant may range from less than one-third to double the cost to prepare the site. But the cost of failure and replanting can be even greater.

Direct costs of storage, handling, and transportation should be included in any stock type selection consideration. Forest Service stock type morphological specifications, seedling costs, and storage and transport costs are available from regional reforestation and site preparation foresters, and nursery services officers. Table 7 gives an example of the different stock type costs for Sx delivered to Kamloops Forest Region that could be used in a cost-benefit analysis. Although seedling cost is a major component of the cost of regeneration, the cost of storage and transportation can be substantial, particularly for larger stock types destined for remote locations. Depending on stock type, conventional storage and transportation costs can add 2 to 6¢ per seedling.

*If there's no performance difference between stock types, don't pay the premium.*

An often neglected, but not insignificant cost, is the administrative overhead associated with coordinating and communicating with the nursery and planting crew. Larger or more specialized stock types require more attention than smaller stock types. Summer-plant stock types require more coordination between the nursery and the planting site than do spring-planted stock types. Shipment to remote areas, specialized transport, and interim storage can add even more to the cost of seedlings. Larger stock types always incur additional costs.

Although risk management considerations may dictate spreading the sowing request among several nurseries, this may add considerably to

TABLE 7. Acceptable Sx stock type costs for Kamloops Forest Region. Cost will vary by species and region. There are no storage costs for summer planting. Costs are determined from the 1997–98 Ministry of Forests *Commercially Equivalent Rates and Storage and Transportation Costs*. These costs are reviewed and revised annually.

| Sx Kamloops Forest Region | | | Costs (¢/seedling) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Transport | | |
| Stock type/ Age class | Season | No./box | "B" class seed | Seedling | Storage | Spring | Summer | Total |
| PBR .5+1.5 | Sp | 180 | 0.4 | 23.80 | 2.44 | 0.72 | | 27.36 |
| PBR .5+1.5 | Su | 180 | 0.4 | 23.80 | | | 1.81 | 26.01 |
| PSB 313B 1+0 | Sp | 340 | 0.4 | 14.80 | 1.29 | 0.38 | | 16.87 |
| PSB 313B 1+0 | Su, Fa | 340 | 0.4 | 14.80 | | | 0.96 | 16.16 |
| PSB 313B 2+0 | Su, Fa | 320 | 0.4 | 16.30 | | | 1.02 | 17.72 |
| PSB 410 1+0 | Sp | 225 | 0.4 | 20.72 | 1.95 | 0.58 | | 23.65 |
| PSB 410 1+0 | Su, Fa | 225 | 0.4 | 20.72 | | | 1.44 | 22.56 |
| PSB 415B 1+0 | Sp | 225 | 0.4 | 20.42 | 1.95 | 0.58 | | 23.35 |
| PSB 415B 1+0 | Su, Fa | 225 | 0.4 | 20.42 | | | 1.44 | 22.26 |
| PSB 415B 2+0 | Su | 225 | 0.4 | 24.80 | | | 1.44 | 26.64 |
| PSB 415D 1+0 | Sp | 150 | 0.4 | 29.47 | 2.93 | 0.87 | | 33.67 |
| PSB 415D 1+0 | Su, Fa | 150 | 0.4 | 29.47 | | | 2.17 | 32.04 |
| PSB 415D 2+0 | Su | 150 | 0.4 | 32.59 | | | 2.17 | 35.16 |
| PSB 615A 1+0 | Sp | 125 | 0.4 | 52.00 | 3.51 | 1.04 | | 56.95 |
| PSB 615A 1+0 | Su, Fa | 125 | 0.4 | 52.00 | | | 2.60 | 55.00 |

administration time. For hot-lifted stock, it may be preferable to have all stock for a request or specific planting project grown at one nursery.

The cost to purchase the same stock type varies depending on the species. For example, PSB 313B 1+0 *Abies* cost 20¢/seedling compared to 14.8¢/seedling for Sx. This reflects nursery cultural practices and seed expenses. As well, natural stand Ba seed costs 4.3¢/seedling compared to 0.7¢/seedling for Hw, and 10.9¢/seedling for Yc.

# Nursery Treatments

Some knowledge of nursery practices is necessary to take best advantage of desirable characteristics of stock types.

## Copper-treated containers

This concept was pioneered with Pli. Untreated container walls allow lateral roots to turn down, resulting in the accumulation of most of the active growing tips at the base of the plug. Copper-treated container walls prevent lateral roots from turning down, effectively "pruning" them at the wall. These roots resume lateral growth upon release from the container, affecting lateral root egress higher up the plug. Lateral root egress from the upper portions of the plug increases seedling stability and access to nutrients and warmth nearer the soil surface. Studies have shown this to be beneficial, increasing initial root egress, survival and performance in general, particularly on fine-textured soils. This has led to a general increase in the recommendation and request for copper-treated Pli stock types. In addition, copper treatment may help reduce the incidence of root and foliage diseases. Copper treatment has been applied experimentally to most other species, and to 2+0 stock types in general as a means of reducing the degree of rootbinding. However, assuming that the concept will generally benefit other species in the same manner may not be correct. Although detriment has not been observed, species such as Sx and Ss, which naturally produce a lot of roots adventitiously just below the root collar, may not require it unless the crop is in danger of becoming root bound. Fdc may be a candidate for copper-treated culture if, along with altering root morphology, the incidence of root dieback is also lessened.

Also still under investigation are the anti-fungal effects of copper that may be of value when growing species that are sensitive to root diseases such as Fdc and Hw.

*At the nursery, copper-treated container culture may require adjustment of nutritional schedules to offset the influence of copper on the availability of other mineral nutrients.*

## Air pruning containers

The concept is similar to copper treatment in that it prunes lateral roots prior to them being able to turn down at the container wall. It also encourages lateral root egress from upper plug regions after outplanting (Plate 4). The difference is that the pruning agent is air instead of copper. At this point in time it appears that air pruning provides a root morphology at least intermediate between a copper-treated and untreated container. Perhaps the question to ask is how many roots egressing from the top of the plug does a seedling need to overcome stresses requiring this ability.

## Blackout

In order to meet specified delivery dates on summer- and fall-shipped crops, and stated morphological specifications in general (e.g., seedling height), stock may be induced to set bud prior to natural induction. This can be achieved by traditional means such as drought stressing, or by shortening photoperiod or "blacking out" (Plate 5). Photoperiod control is thought to be a less stressful budset induction tool. Exact duration and photoperiod employed varies with species, stock type, provenance, and nursery preference. For summer delivery crops, blackout treatments are usually imposed three to four weeks prior to shipment to ensure adequate bud set and sufficient hardening-off. If the time between budset induction and planting is extended beyond five weeks, stock may start to reflush, perhaps requiring a repeat of the process and delay in planting. Budset induction affects the onset of dormancy and hardiness cycles. Depending on chilling and storage

PLATE 4. Post-planting root egress from Pli seedling grown in a PAB 410. Note that new root growth egress is from all regions of the plug. Photo credit: Anne Johnson-Flanagan.

PLATE 5. Conifer seedlings in greenhouse with blackout curtains almost closed. Photo credit: Eric van Steenis.

schedules, earlier induction may, in this way, be able to affect the timing of budflush the next growing season. An effect of up to several days has been reported in the literature.

*Stock scheduled for summer planting has to be taken on schedule or it may reflush in the nursery and remain too succulent for planting.*

## Growth regulators

A recent alternative to blackout is the use of a plant growth regulator (PGR) to induce budset for summer-shipped and spring-plant crops. In addition, it may be used to control height growth in the first year of a 2+0 crop. The only PGR currently registered for reforestation seedling stock is paclobutrazol. The chemical's mode of action is to inhibit gibberellin production resulting in a reduction in the rate of cell division and elongation. Trials have shown that paclobutrazol will reduce seedling height growth while increasing stem diameter and root weight. Also, some trials have reported increased seedling survival and enhanced drought resistance. The chemical is applied approximately two weeks prior to the time when conventional growth inhibiting practices (blackout, drought and nutrient stress, temperature) would be used. The effects on seedling morphology, physiology and long-term outplant performance are unknown and further assessment is needed to effectively evaluate the potential benefits or detriments to seedling growth.

## Rooted cuttings

Rooted cuttings have traditionally been used to bulk up material for which seed was in short supply or of very poor quality. An example is Yc. More recently, the process has been employed to bulk up material of superior genetic quality. Examples are

black cottonwood (Act), Sx, and Ss. Because the technique starts with a sizable portion of plant material, it usually yields a robust product that easily meets minimum root collar diameter specifications. A proportion of rooted cuttings may exhibit plagiotropic growth—these are culled before shipping. Plantation trials have shown growth and form of rooted cuttings to be equivalent to seedlings.

### Somatic seedlings (emblings)

These are produced by removing embryos from individual seeds and vegetatively multiplying them by a process termed somatic embryogenesis. In this way each chosen seed becomes the parent of a line or clone of "emblings" or "somatic seedlings." The process is used to bulk up seed from genetically superior crosses that might otherwise be in too short a supply to generate a substantial seedling crop. At present, the cost of production is very high due to the labour requirements to transplant the embryos. In the future, encapsulating embryos into artificial seeds will greatly reduce the individual propagule cost. At this time, the cost may only warrant bulking up material with very high genetic worth (e.g., seeds generated from putatively weevil-resistant spruce parents).

### Top-pruning

Overheight stock often incurs additional grading, lifting, storage, and planting costs and may at times be completely inappropriate for the site to which it is destined. Some broadleaf deciduous species, as well as Cw, may grow too rapidly, easily exceeding contract height specifications. If anticipated early enough, stock can be top-pruned to stay within height specifications. Early top-pruning (before mid-July) also encourages more lateral branching without causing multiple tops, and prevents lower foliage from senescing. Later top-pruning may delay hardening-off, result in unsatisfactory growth form, and lead to increased incidence of storage moulds due to dense canopies and damaged stems. Top pruning is not recommended for birch or red alder, as tops die back from the cut.

### Root-pruning

The BBR and PBR (field grown) stock types are routinely root-pruned at the nursery to encourage branching of individual roots and the development of a more fibrous root system. This type of root system is essential to assure plantability and proper establishment of the stock. Root-pruning is a nursery practice and should not be required once the stock arrives in the field.

### Plug transplants

Plug transplant stock is initially grown as mini-plugs in high density blocks. Approximately 10 weeks after germination, the mini-plugs are transplanted into larger containers, (typically 512/515/615) to complete their growth. This practice generates several efficiencies for the nursery which translates into savings in the production costs of the larger container stock types.

## What Have Other People Used?

In addition to conducting your own site assessment, it is also appropriate to draw on the experience of others. The history of local successful and unsuccessful plantations is relevant. The common stock types used on similar sites in a biogeoclimatic zone will often be acceptable for the planting site being prescribed. Remember when making comparisons, that nursery cultural methods and stock morphological specifications may have changed over the years and that certain stock types used in the past may no longer be comparable to those being grown today.

*There are many stock types being requested that are inappropriate, usually because they do not take advantage of more suitable cultural techniques or they are simply the wrong stock type choice.*

## Stock type trends

It is also useful to consider what silviculturists are using in other areas. There was a bewildering array of 44 different stock types requested in 1997—there will be more! Considering the number of species and delivery dates used, there are over a thousand different stock types that could be created. Obviously many of these combinations are inappropriate or obsolete.

Enormous changes in stock type selection have occurred during the past several years. In 1987, bareroot, 211A, and 313A styroplugs accounted for more than 70% of the stock sown in British Columbia (see Figure 8). These same stock types accounted for less than 12% in 1993. During the same period, the larger B-sized container types grew in popularity (see Figure 9), approaching close to 70% of total orders in 1993, up from 55% in 1990.

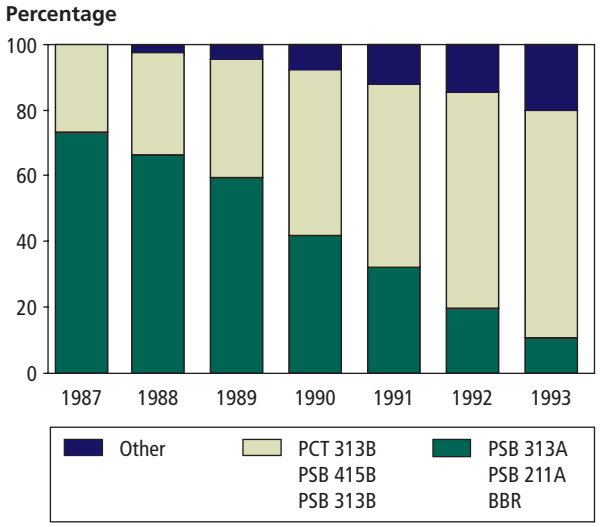



FIGURE 8. Percentage of stock group sown in B.C. by year, 1987 to 1993.

From 1993 to 1997 the predominant shift in the sowing profile has been an increase in the PSB 410 to 20% of the total sowing, with a proportionate decline in the sowing of PSB 313B (see Figure 10). The combination of 211A/313B stock types comprised 47% of the sowing in 1993, compared to 32% in 1997. The combination of 410/415B/415D/412A was only 34% of the sowing in 1993, but had increased to 61% by 1997. It should be noted however, that these provincial trends are dominated

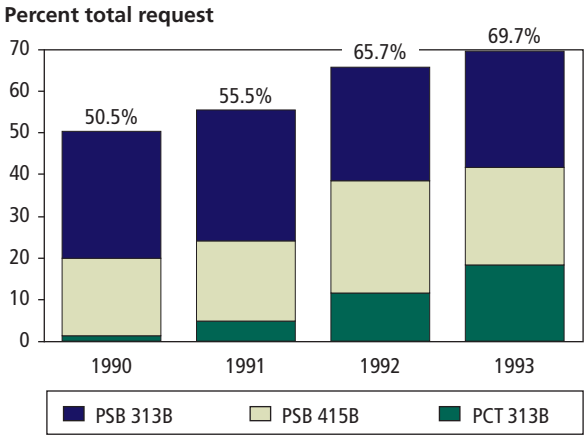



FIGURE 9. Percentage of stock group requested by year, 1990 to 1993.

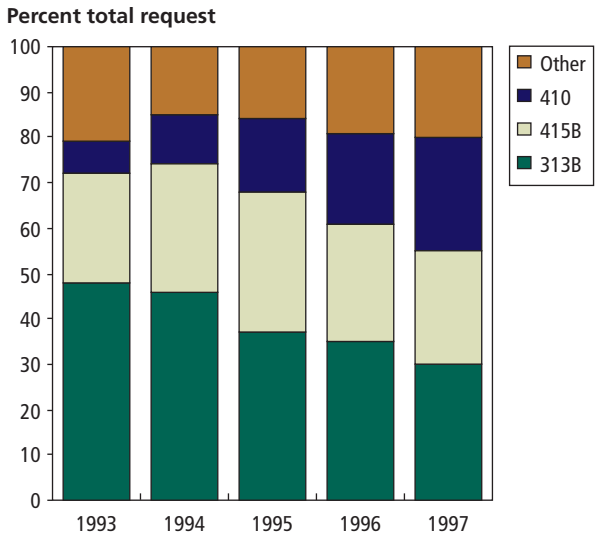



FIGURE 10. Percentage of stock group sown by year, 1993 to 1997.

by what is sown for lodgepole pine and interior spruce. Additional information regarding trends by individual species is provided in the section on "Current Stock Types by Species" (page 40).

There have been several conspicuous trends in the development of stock types and nursery culture:

- Decrease in total number of trees sown, but increased number of individual requests.
- Increased demand for early-sow greenhouse crops for summer planting.
- Increased numbers of site-specific requests.
- Increased diversity of container types.

- Increased request for larger container stock types, particularly in 1+0 container stock.
- Increased diversity of species being requested.
- Increased request for shallow-rooted stock types (PSB 410 and PSB 412A).
- Decreased requests for field-grown stock types (PBR and BBR).
- Decrease in 2+0 container stock, replaced with 1+0 container stock.

The trends illustrate the continuing development of stock types and nursery culture. Many factors have contributed to this development but the most important are:

- Seedling performance, survival, and cost.
- Incentives to achieve and reduce the time to achieve free growing stocking standards and green-up requirements.

## Stock Type Development

Many developments in stock types, morphological specifications, and nursery culture can be expected, as nurseries continue to improve on seedling quality. The eventual acceptance or rejection of a stock type or morphological specification for silviculture purposes will depend on the outcome of assessments of field productivity, reliability, and feasibility.

*Be sure that only a small percentage of your request is composed of new stock types.*

There are a number of experimental stock types that have been proposed for use in British Columbia (e.g., PSB 1015, PSB 1005). These stock types should be selected according to the suitability criteria discussed above. The morphological attributes of the seedlings should be used to match these stock types to appropriate site conditions.

The use of experimental stock types will require the purchase of new blocks at the nursery—an expensive undertaking for what could be a dead-end stock type. Be sure that only a small percentage of your request is composed of new stock. This will help minimize the cost at the nursery. In addition to cost considerations, the nursery also has to have time to develop acceptable cultural techniques and schedules for new stock types.

The reliability of an experimental stock type needs to be evaluated in the field and nursery for a number of years. In particular, field performance needs to be determined for a wide range of site conditions and weather, and morphological specifications.

*Any new stock type must prove to be worth making the change.*

# Ordering and Tracking Stock Types

## The Seed Planning and Registry System (SPAR)

The principal administrative tool for implementing a stock type selection is the Seed Planning and Registry System (SPAR). All seedlings being ordered to meet basic silviculture obligations on Crown lands must use SPAR. The essential steps in processing sowing requests, from licensee/district requests to the seed being sown at a nursery are shown in Figure 1, page 1.

SPAR provides on-line access to silviculture staff at district, regional, and branch levels, and to ministry clients. SPAR provides the following functions for selecting stock types and ordering seedlings:

- Application of nursery sowing rules.
- Automation of the seed transfer guidelines.
- Ability to enter requests up to five years in advance as a pending request for planning purposes.
- Assistance in the preparation of nursery contract tenders.

For a SPAR request to be actioned, it must be entered and approved. SPAR can also identify suitable seedlots for planting locations and provides the ability to do on-line queries and report submissions as well as other seedling-related activities.

The facilities for seed preparation are limited, and sowing requests made early provide the best assurance against scheduling disappointments. In particular, the seed processing requirements for Abies species and Cw, Yc, and Pw necessitate additional time at the Tree Seed Centre. Table 8 lists the number of weeks required for seed pretreatment. The actual dates will vary depending upon the experience and facilities of the individual nursery.

It is important to know the timelines required for the nursery production and cold-storage phases. The time required for production of the various stock types is shown in Figure 6.

Entering and approving the sowing request early will expedite the entire seed preparation process and assure that stock is available when it is needed. For example, if seed for summer stock is sown late, the delivery date could be later than desired or the stock might not be available at all.

TABLE 8. Seed pretreatment time requirements by species for a coastal nursery. Time maximums may vary with seedlot and nursery.

| Coastal nursery<br>Species | Pretreatment time prior to sow date* |
|---|---|
| **Long stratification species:** | |
| Ba, Bl, Bn | 12 wks |
| Pw, Yc | 12 wks |
| **Specialty seed preparation:** | |
| Cw pelletization | 6 wks |
| Incubation density separation (IDS) | 6 wks |
| **Intermediate stratification species:** | |
| Hm, Hw, Py | 4 wks |
| Pli, Bg, Plc | 4 wks |
| **Short stratification species:** | |
| Fdc, Fdi, Lw, Ss, | 3 wks |
| Sx | 3 wks |
| **No stratification species:** | |
| Cw | 0 wks |

* Confirm the actual sow date with SPAR.

*It is essential to commit yourself to a SPAR order—the sowing request is not the place for good intentions.*

Re-scheduling of a sowing request can jeopardize nursery crops and reforestation practices. If, at an early stage in the ordering process, a change must be made, these changes should, depending upon the contract obligations, be communicated directly to nursery services in Victoria; licensees must contact their nursery.

Once seed has been withdrawn from storage, soaked, and stratified, it must be used quickly. Prolonged storage of stratified seed prior to sowing is not recommended, as it may allow fungal infestation that decreases the germination percentage and the vigour of the seed. Late changes cannot be accommodated without incurring seed and crop losses. The costs of processing seed that is stratified but not sown will be charged to the requesting agency. All efforts must be made to ensure that stratified seed is used.

# Nursery and Shipping Administration (NSA) System

## Overview of data flow

NSA is a PC-based system that imports its original information from the mainframe SPAR data. The objective of NSA is to provide a database on seedlings throughout their life in the nursery until final shipment to the districts. Districts, regions and other ministry staff are able to view and utilize information on ministry-funded seedlings being grown throughout the province.

Seedling quality control information, inventory, pesticide, lift, and shipping data are entered at the ministry nursery sites (Skimikin, Surrey and Green Timbers nurseries) and at the nursery services sites (north, coast, and south zones) for the non-ministry nursery data. These data are currently compiled for each zone and then compiled for the province at nursery services headquarters in Victoria. Victoria creates a file for the district system, which is loaded onto the FTP server.

# Tracking

Regular communication between silviculturists and nursery growers is strongly recommended once a seedling order has been placed. Commitment to a given delivery date carries the responsibility of taking possession of stock, even if the area to be planted is not ready. This responsibility means that contingency plans need to be formulated and that operational staff be prepared to make decisions concerning stock suitability.

The ability to formulate and implement a contingency plan depends upon the silviculturists tracking the condition of both field sites and seedlings at the nursery. Up-to-date inventories, and seedling size and condition must be tracked.

## Inventories

The number of seedlings meeting the stock type specifications at shipping time may be greater or less than what was ordered. Nurseries sow up to 30% more seed than is needed to fill an order as insurance

against losses during the production phase. Losses occur due to such factors as poor germination, seedling mortality, and poor growth.

Seedling inventories of ministry funded requests are typically done twice for each crop. The second, or last, inventory is done just prior to the nursery extracting and packing seedlings (referred to as "lifting"); June to August for summer-plant orders, and November to December for spring orders. Silviculturists should reconcile inventory numbers against the number of seedlings requested to determine if contingency plans must be made. Inventory reports can be obtained directly from the nurseries. Reports for ministry-funded requests can be obtained from NSA as described in previous section.

## Size specifications

Size specifications for height and root collar diameter (Table 3) are usually part of the nursery contract. Silviculturists can adjust the size specifications for a request if the number of seedlings is less than the original order. Such adjustments will increase the number of acceptable seedlings, but will also affect seedling performance expectations. Review the site limiting factors these seedlings will encounter before changing size specifications. Scattergrams are used to graph the relationship between seedling height and diameter (Figure 11). They are easily produced and useful in estimating how many more seedlings could be made available through adjustments to the height and root collar diameter specifications.

## Seedling condition

It is important to track seedling condition, both from an inventory perspective, and also from an outplanting performance point of view. The readiness of seedlings for the rigours of handling and site conditions must be known well in advance of the scheduled planting date. The following section provides information regarding specific seedling health and condition issues.

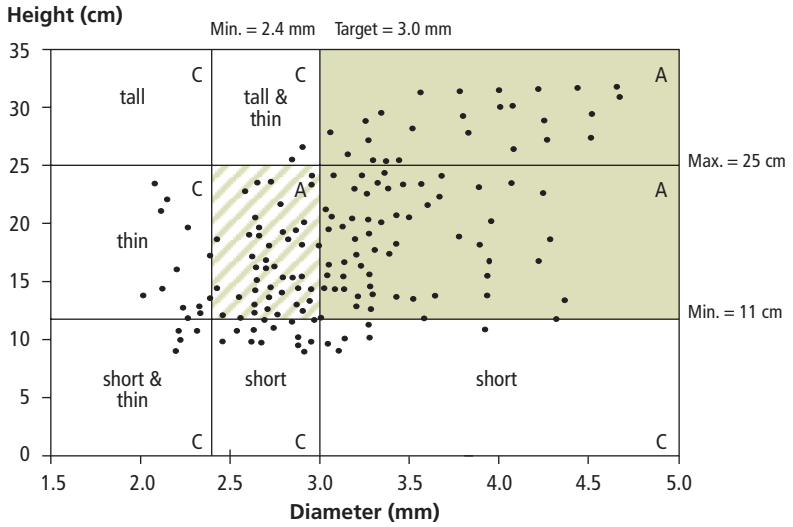



FIGURE 11. Scattergram of Sx PSB 313 1+0 Sp at lift, with interpretation. Dots indicate the dimensions of individual seedlings. The quadrants are defined from the stock specifications for Sx PSB 313B 1+0 Sp (Table 3). The ideal would be to have a sample of seedlings that all achieve but do not exceed the target height and diameter—the centre (cross-hatched) quadrant.

# Receiving and Handling Stock

## Stock Health and Condition

A complete review of stock quality is beyond the scope of this manual. However, certain aspects of stock health must be considered when selecting a stock type and when accepting stock for planting.

### Succulence, hardening-off, and reflushing

Orders of summer and late-summer planted stock should be inspected for succulence (Plates 6 and 7). Succulent stock is more sensitive to handling stress and planting shock than properly hardened stock and, therefore, should not be shipped. If stock is too succulent, the needles may be damaged, the stem may break during handling, the stem may be subject to sun scald and frost damage, and the entire plant may desiccate. There is almost always a small percentage of succulent stock in a crop—it becomes a concern when greater than 2% of the crop is affected. Table 9 proposes a classification of stock succulence for Pli, Sx/Ss, and Fdc/Fdi.

PLATE 6. Spruce seedling on left has hardened off while the seedling on right is still succulent. The light green stem and bud colour indicates that this stock would be too succulent to plant. See Table 9 for more information on succulence. Photo credit: Clare Kooistra.

TABLE 9. Proposed stock succulence classification. Stock succulence for Pli, Ss/Sx, and Fdc/Fdi is decided based on the condition of the foliage, stems, and buds. If any of the morphology is considered soft, do not use the seedlings—wait until they have hardened. If stock has reflushed, wait until it has hardened again. If stock is marginal, either wait or only plant sites with low soil moisture stress. For all other species, refer to the reforestation co-ordinator for guidance and assistance.

| Species/ Condition | Foliage | Stems | Buds | Plant? |
|---|---|---|---|---|
| **Pli** | | | | |
| Soft | Top 5–10 cm light green, soft, and flexible. | Top 2–5 cm lime green, soft, and breaking easily. | Terminal buds not noticeable. | **No** |
| Marginal | Top 2–5 cm light green, soft, and flexible. | Top 2 cm green and soft. | Terminal buds barely visible and green. | **Maybe** |
| Hardened | Top 2 cm dark green and stiff. | Top 2 cm mottled green-brown and firm. | Terminal buds straw-coloured and firm. | **Yes** |
| Reflush | | | Stem stretching under bud (candling). | **Maybe** |
| **Ss/ Sx** | | | | |
| Soft | Top 5–10 cm light green, soft, and flexible. | Top 2–5 cm green and soft. | Terminal buds not visible. | **No** |
| Marginal | Top 2–5 cm light green, soft, and flexible. | Top 2 cm green and soft. | Terminal buds barely visible and green. Lateral buds small and straw-coloured. | **Maybe** |
| Hardened | Top 2 cm blue-green and stiff. | Top 2 cm straw-coloured and firm. | Terminal buds straw-coloured and firm. | **Yes** |
| Reflush | | | Terminal bud scales separating. | **No** |
| **Fdc/ Fdi** | | | | |
| Soft | Top 5–10 cm light green, soft, and flexible. | Top 2–5 cm light green, soft, and flexible. | Terminal buds not noticeable. | **No** |
| Marginal | Top 2–5 cm light green, soft, and flexible. | Top 2 cm reddish green and soft. | Terminal buds barely visible and reddish green. Lateral buds small and straw-coloured. | **Maybe** |
| Hardened | Less than 2 cm dark green and stiff. | Top 2 cm brown and firm. | Terminal buds obvious, red-brown, and firm. | **Yes** |
| Reflush | | | Terminal bud scales straw-coloured, papery, and separating. | **No** |

PLATE 7. Ba container-grown seedling that has reflushed in the nursery. Note that new foliage is lighter green than older foliage. Stock that has reflushed in the nursery may be too succulent to be shipped.

*If in doubt about succulence, take a conservative strategy and delay planting.*

If succulent stock is received in the field, suspend further shipments of the same seedlot. If the nursery or nursery service specialist does not want to release the stock because they consider it to be too succulent, believe them—it is their job and reputation!

Double-sorting succulent stock (i.e., lifting only the hardy seedlings) is not recommended. Double-sorting a crop with a high incidence of succulence can damage the seedlings that are not lifted and is also a very expensive nursery operation. It is better to wait until the stock has hardened than to double-sort.

## Root dieback

Root dieback can occur in any container size, but there is an increased likelihood of its occurrence in small container sizes and 2+0 Sp container stock types.

Root dieback, due to *Cylindrocarpon*, *Pythium*, *Fusarium*, and *Phytophthora*, has been found in all nursery-grown crops (Plate 8). Root disease occurrence can be stock type dependent and, therefore, it must be considered when selecting among stock types. For any one stock type, the likelihood of a root disease can differ among species and nurseries. Root diseases are most prevalent in vigorously growing container species (e.g., Fdc, Fdi, Ss, Pli, Hw) due to their larger root systems impeding plug drainage. They are found more commonly in 2+0 container stock types and small containers compared to larger 1+0 stock types because of the large relative size of the root systems in relation to the container size and the length of time grown in the nursery. Root dieback should not be confused with mycorrhizae (see mycorrhizal fungi on nursery stock).

Root dieback can be carried into the field. It can persist on stock and cause delayed mortality and poor growth. Due to the potential for mortality and the difficulty in detecting the condition, a conservative strategy should be to reject stock that has been found to display root dieback symptoms—the seedlings with the symptoms will be the most severely affected, but seedlings apparently without symptoms can also display reduced vigour.

## Foliage and stem diseases

Larch needle cast or *Meria* can severely affect the viability and outplant performance of Lw seedlings. Stock types with higher densities (e.g., PSB 313B) are generally more susceptible as the disease is enhanced by high humidity and reduced air movement. Field survival and performance has been shown to be significantly reduced with as little as one-third *Meria*-induced defoliation (Plate 9).

*Keithia* foliage blight is frequent and most debilitating on Cw PSB 2+0 Sp (Plate 10). If large Cw stock types are required to deal with site factors such as brush or browse, consideration should be given to using large 1+0 stock types rather than 2+0 stock types. Like the storage moulds, the disease may reduce the vigour or kill seedlings if it infects the stem.

Storage moulds (*Botrytis*, *Septonema*, etc.) can be found on all species. They are particularly common in stock types with high densities (PSB 211A, PSB313A), in 2+0 container crops, and on species

PLATE 8. Root dieback in Fdc PSB 313B 1+0. Notice the difference between the infested (on right) and healthy stock. The root tips of the root dieback stock are short, stubby, dark brown/black, and dead, while the unaffected stock has slender white root tips. Also note the poor cohesion of the tip of the infested plug. Photo credit: Rob Scagel.

with large, succulent, foliage biomass (Hw, Pli, Sx, Fdc). Damage from these diseases is frequently restricted to the foliage but when the disease infects the stem it may reduce the vigour or kill the seedling (Plate 11). If your stock is known to have a mould infection the following considerations will help to minimize the impact on outplant potential:

- Seedlings should be placed in freezer storage and then designated for a rapid thaw protocol. Recent studies have shown that seedlings may be planted out as soon as the frozen root plugs can be separated from a bundle. Care must be taken not to damage the root system and to ensure outplanting of the seedlings is done as soon as possible.

PLATE 9. *Meria* needle cast on container Lw PSB 415A. Note the considerable number of needles that have been shed as a result of the disease. Photo credit: Dave Trotter.

PLATE 10. Cw foliage infested with *Keithia*. This is an example of severe *Keithia* foliage infestation. There are some lesions on the stem. This seedling would not be expected to survive. Photo credit: Gwen Shrimpton.

PLATE 11. Severe storage mould (*Botrytis*) infestation on a bundle of Pli PSB 313B 1+0. The infestation has spread from the foliage to the stem. In such cases, the seedling would not be expected to survive. Storage mould does not occur on the roots (see Plate 17 for mycorrhizae). Photo credit: Dave Trotter.

- On the planting site, the storage boxes should be opened to increase air flow and reduce foliage wetness. The seedlings should be placed in the shade and checked periodically to maintain plug moisture.
- Seedling bundles should be packed vertically in the storage boxes to enhance airflow and reduce foliage press and wetness.

## Insects

Most insects problems are dealt with in the nursery but occasionally these can carry over into the field. Cutworms, marsh crane fly, and weevil larvae can build-up to significant numbers in a nursery due to high seedling densities, accelerated growth, and a favourable environment (Plates 12, 13, and 14). They may go undetected in the seedling plugs, surviving freezer storage and then appearing after the stock has thawed. Every effort should be made to contain the spread of these insects to the field and the source nursery advised of the situation.

One insect that may present difficulties to reforestation specialists concerned with the regeneration of *Abies* species is the balsam woolly adelgid or BWA (*Adelges piceae*) (Plate 15). In particular, *Abies lasiocarpa* is extremely vulnerable to attack resulting in severe canopy injury and mortality. The other *Abies* spp show comparatively less susceptibility to damage by BWA. Currently, a provincial quarantine zone is maintained to prevent the spread of the insect by human means. The regulations demand that all B.C. nurseries apply for a permit to grow any *Abies* spp. and any nursery in the zone is not permitted to ship seedlings outside the zone. The regulations are under review and the status of *Abies* production in B.C. may change in the near future.

## Mycorrhizal fungi on nursery stock

All conifers have evolved a dependence on certain beneficial fungi that form symbiotic "fungus roots" or mycorrhizae (Plate 16). The most commonly observed mycorrhizal association are ectomycorrhizae. They are easily recognized by the envelopment

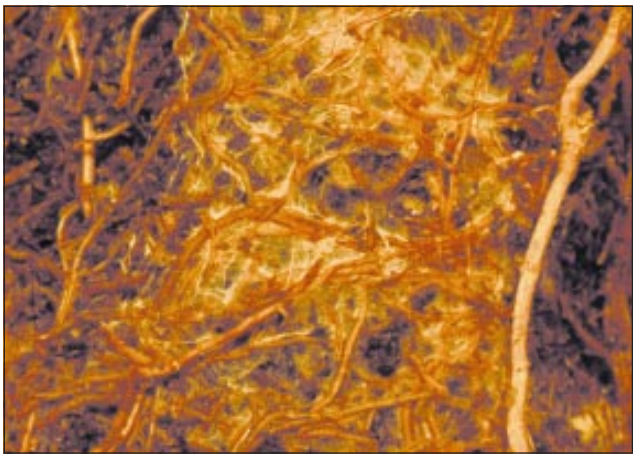
PLATE 12. Cutworm infestation found in a box of thawed 2+0 spruce seedlings. Photo credit: Dave Trotter.

PLATE 13. Larvae of the European marsh crane fly on damaged 2+0 Douglas-fir. Photo credit: Jack Sutherland.

PLATE 14. Larva of the black vine weevil feeding on the roots of a 1+0 container Douglas-fir seedling. Photo credit: Dave Trotter.

PLATE 15. Amabilis fir showing balsam wooly adelgid damage. Note stunted needles and galled buds. Photo credit: Dave Trotter.

PLATE 16. Close-up of ectomycorrhizae on a 1+0 spruce seedling.



of the seedling roots by a characteristic fungal sheath and the mycelium or thread-like mould growth over the plug. The result is the proliferation of the distinct swollen, forked appearance of the smallest feeder roots. These mycorrhizae can be brown, white, yellow, or black, depending on the colour of the fungus colonizing the root. These fungi are highly beneficial to their hosts by enhancing water and nutrient uptake. In contrast to pathogenic fungi, the development of mycorrhizal fungi is distinguished by their occurrence on seedling roots without the accompanying symptoms of decay. In general, nursery managers strive to develop mycorrhizae but their development can vary greatly depending on seedling species, nursery location, spore inoculum, fertilizer, irrigation, and media regimes (Plate 17).

PLATE 17. Two Sx 412A PSB 1+0 seedling root systems from the same container showing differences in the degree of mycorrhizal association.

## Morphology

Multiple tops, or aborted terminal buds, are commonly encountered on the true firs as illustrated for subalpine fir in Plate 18. Similar morphology may occur periodically in Sx and Fdc/Fdi, particularly when the stock has partially reflushed following blackout. Abnormal morphology can also be caused

PLATE 18. Morphology of Bl PSB 410 1+0. From left to right: "typical" conifer morphology, complete reflush, multiple top, and aborted apical bud with a subtending lateral assuming apical dominance.

by frost or Lygus bug damage. Unless these abnormalities are severe or due to nutritional deficiencies, the conditions do not persist in the plantation and should not be a cause for concern.

## Pesticide issues

As with most agricultural crops, the production of conifer seedlings for reforestation sometimes requires the responsible use of pesticides. In general, industry policy is to use pesticides only after other non-chemical methods of control have been ineffective. When pesticides are necessary, residues on the stock can be a concern to those handling the seedlings. Over the years, in consultation with reforestation specialists, tree planting companies and regulatory agencies, pesticide reporting guidelines have been developed to ensure forest worker safety. These include; the marking of seedling boxes with the last pesticide application date and chemical used; a list of all pesticides applied to the seedlings during the growing season; distribution of supporting

documents (e.g., MSDS, pesticide labels) to district and industry staff; and worker safety procedures. If no pesticides have been applied to the seedlings over a 12-month period then the seedling boxes may be labeled "pesticide-free."

### Interim storage

Without adequate interim storage, the quality and vigour of any stock type can be quickly compromised. Larger stock types require more space for interim storage than small stock types. Spring-shipped container stock types are the least sensitive to rapid deterioration of stock quality related to storage length and condition. The speed with which stock can be planted may be the deciding factor in stock type selection if reliable interim storage cannot be assured. Such a situation favours the smaller, more easily stored and transported, and more plantable stock types.

*Prolonged storage depletes carbohydrate reserves, reduces seedling vigour, and increases the likelihood of storage moulds.*

### Transportation

Summer shipment of seedlings is nearly twice as expensive as spring shipment because it involves more handling concerns, and includes fewer seedlings per shipment. If a summer shipment is selected, arrangements should be made early to ensure that overnight refrigerated transportation will be available. The crop should be cooled before packaging (10 to 15° C) to minimize heat buildup in the cartons. Refrigerated transportation of seedlings to remote sites can also be difficult to ensure.

If refrigerated transportation cannot be assured, the planting program may have to be run as a hot-plant operation with only small amounts of seedlings being lifted and shipped at a time. The cost of small shipments can be high. Arrangements should be made to have crops lifted and shipped throughout the planting program—even through the weekends. No prolonged storage under ambient conditions is recommended for summer-shipped stock. Storage up to one week is tolerable if the boxes are opened and well-ventilated, and if shaded storage such as under a heavy tree canopy can be provided. Seedlings must be misted and/or watered while in this interim storage.

### Planter availability and experience

Some late summer and fall planting projects may not be possible because of a shortage of planters. Because of the labour supply situation at this time of the year, you may have to pay a premium price for planting. Summer-planting programs can also be jeopardized because the planting contractor may be on a tight schedule to move on and may not stay if the seedlings are not available on time or if site conditions are not appropriate.

Availability of planters with experience planting BBR/PBR can be a major limitation to the use of these stock types. BBR/PBR stock types require special planting and handling practices. To plant BBR/PBR, planters need to be familiar with the care and interim storage of these stock types. Most planter experience is with container stock types. Availability of experienced planters is a necessary precondition to ordering either BBR or PBR stock types. If experienced planters are not available, anticipate the need for training and closer supervision.

## Physiological Test for Seedlings

To determine the physiological state of seedlings, use one of the following physiological tests.

### Root growth capacity

The prime test is the root growth capacity test. A sample of the seedlings is placed in an ideal growing environment for seven days before the new root growth is evaluated. If the new root development is very low, stock is re-tested. If it remains low in the second test, advice is given to plant seedlings at a

higher density, anticipating some mortality, or it may be recommended that the seedlings be discarded.

Note: For ministry seedlings, this test is performed on all spring-planted stock and results are available from nursery services.

This test is not available for the summer/fall programs as the seedlings are still in active root growth.

## Flushing test

A second test of the vigour of seedlings is a flushing test. This is usually a 14-day test in a growth chamber for cold-stored, spring-plant stock only. It is used to determine the nature and vigour of the stock's new growth flush. This test is useful if there is concern whether buds are matured sufficiently or to determine the effects of handling stress prior to planting.

## Outplanting trials

To determine the vigour of stock after storage or during summer planting programs, samples are taken and outplanted at a controlled nursery environment. This test is designed to provide information to the field staff on the health of their stock prior to planting (spring planting only) and to provide a check for field staff if plantation failures occur (spring and summer planting programs). Contact nursery services for more information.

## Pre-storage storability test

This test can have a major positive impact on the success of long-term overwinter storage because it determines the state of dormancy and frost hardiness of a seedling in relation to fall lift and the placement of seedlings into storage. It is recommended that representatives of all seedlings by species, elevation, and latitude be passed through this test and that lifting and storage only occur once the seedlings pass the storability criteria of the test.

## Variable fluorescence

During the growth phase of seedlings, few tests have been developed to determine seedling health. One method that has recently become available is a variable fluorescence determination. If it is suspected that seedlings have been damaged or appear in poor condition, this test can provide data on the vigour of the photosynthetic system of the plant. Nursery services and others can provide this test as the need arises.

# Troubleshooting

In spite of the best plans, problems can arise. The nature of some problems requires that contingency plans be formulated and that operational staff are required to make discretionary decisions concerning stock suitability. For ministry staff, in addition to consulting with the nursery services officer and regional reforestation specialist, decisions should consider the Nursery and Seed Branch *Seedling Supply and Distribution Policy*. At each stage in the planting program, the following questions must be answered regarding stock condition and suitability.

- Is this stock what I expected, and is it still suitable for the intended purpose?
- If the stock is not suitable, what can be done with it?
- If the stock is available early, can I use it now?

Good communication is essential between the nursery/cold storage, nursery services staff, and the requesting agency. Solicitation of second opinions from specialists or reforestation foresters is encouraged.

Some problems may originate at the nursery and in cold storage. The following are some common problems and examples of possible solutions:

- **Insufficient seedlings are available to meet the request.** This may arise due to a number of reasons, including inventory losses or a failure to meet morphological specifications (i.e., too short or tall and/or under-specified root collar diameter).
  *Solutions*
  1. Consider appropriateness of adjusting lift morphological specifications (see "Tracking," page 25) and/or feasibility of culling seedlings impacted by pests or disease.
  2. If available in suitable species and seedlots, pick up excess seedlings from other requests or purchase surpluses from other sources.
  3. Evaluate feasibility of reallocating stock to ensure highest priority blocks are planted.
- **Stock is required for planting but is still frozen.**
  *Solutions*
  1. If unfrozen stock is available, evaluate the feasibility of adjusting the planting schedule.
  2. Arrange for rapid thaw at nursery or storage facility, and then plant as soon as possible. For detailed guidelines on rapid thawing, refer to the *Thawing Guidelines for Tree Seedlings*, 1995 (C. Kooistra and S. Ostafew).

3. Negotiate conditions of a short-term work stoppage with the contractor.

- **Stock is still succulent at the proposed delivery date.**
  *Solutions*
  1. If the stock is too soft, it is not ready for planting. Delay shipment and evaluate suitability of projected revised planting start date. If acceptable with respect to planting window, delay shipping until stock is ready to plant. If not acceptable, cancel the project and evaluate options such as trading stock, holding stock over, transplanting, or destroying stock (see "Holding Over Container Stock" and "Transplanting," pages 38, 39).
  2. In some cases, it may be appropriate to plant stock that is marginally succulent if planting is restricted to sites with low moisture stress, no frost risk, and weather is not excessively hot. This decision should be assessed very carefully—if in doubt, delay planting.
- **Surplus stock is available from the ordered request.**
  *Solutions*
  1. Assess feasibility of utilizing surplus of other seedlots to offset drops in inventory or to add in additional planting blocks that may have been deferred due to shortage of stock.
  2. If stock cannot be accommodated in the project and is a definite surplus, promptly advise the nursery that it will not be used.

In addition to nursery problems, there are site conditions that can occur, or problems during storage and shipping, especially during hot-planting, that will require prompt decisions and decisive action.

- **Stock health is in question when shipped to site or interim storage location.** This may include observation of symptoms indicating serious seedling damage such as dry brittle roots discoloured below bark, mould on needles or stem, swollen or flushing buds, bark sloughing off the stem, stock refrozen during shipping. Specific action taken will depend on the severity and extent of the problem and may include:
  1. Implement actions to ameliorate the condition (see "Foliage and stem diseases," page 29);
  2. Provide best stock to planters to allow commencement of planting;
  3. If feasible, plant stock on sites with least stress conditions;
  4. On advice of the nursery services officer, ship stock to seedling testing facility for assessment of physiological condition and delay planting pending outcome of results;
  5. Assess possibility of culling stock by visual damage criteria; or
  6. If severely damaged, do not plant and arrange for destruction of the stock.
- **Hot-lift planting stock is still succulent when delivered to the planting site or interim storage facility.**
  *Solutions*
  1. If the stock is too soft, do not plant. Appropriate action will depend on specific circumstances and may include not unloading the truck and returning the stock to the nursery or a suitable interim storage facility where it can be properly tended until it is ready for planting.
  2. Evaluate suitability of delaying the planting start date. If acceptable with respect to planting window, delay shipping until stock is ready to plant. If not acceptable, cancel the project and evaluate options such as trading stock, holding stock over, transplanting, or destroying stock.
  3. In some cases, it may be appropriate to plant stock that is marginally succulent if planting is restricted to sites with low moisture stress and no frost risk. This decision should be assessed very carefully—if in doubt, delay planting.
- **Due to late snow melt or other factors, planting will be delayed.**
  *Solutions*
  1. For spring-plant, cold-stored stock, planting after June 21 is not recommended due to decreased stock vigour from prolonged storage. Usually this situation leads to destroying stock.
  2. For summer planting, the nursery (and nursery services officer for ministry-funded seedlings) must be notified as soon as possible of revised planting dates to adjust the blackout treatment (see "Blackout," page 19).

- **A scheduled planting block is not ready for planting.** This may be due to the site not having been harvested or only partially harvested, or to site preparation being delayed.
  *Solutions*
  1. Possible solutions may include finding alternative planting sites, trading stock, assessing risks associated with planting partially harvested areas (e.g., risk of relogging, risk of escape fire from any planned burning, likelihood of yarding damage), reassessing the block with planned site preparation to determine if reforestation objectives can be achieved by raw planting.
- **Planting contractor is in persistent non-compliance or serious non-compliance of contract conditions.**
  *Solutions*
  1. For ministry-funded contracts, Forest Practices Branch supports the position that, in the case of serious or persistent non-compliance, the contract should be cancelled even at the cost of losing seedlings. At the time of cancellation, the feasibility of transferring the work to another contractor or trading the stock should be evaluated.

A decision to proceed with any of these options should be weighed against the possibility and costs of not achieving the goals and standards outlined in the SP.

# Holding Over Container Stock

If stock cannot be planted as scheduled, it may be necessary to consider holding stock over until the next available planting window (Table 10). Holding over is not recommended because stock health and vigour are compromised by continued growth of the root system causing excessive root binding in the cavity resulting in poor aeration and drainage. Holding over smaller (PSB 211 and PSB 313) and older (2+0) stock types increases the risk of contracting root disease. Rapidly growing species such as Fdc, Lw, Ss, Cw, and hardwoods are more easily compromised by holding over than slower growing species such as Bl. Every effort should be made to stay with the original crop growing and planting schedule as set out in the initial contract.

TABLE 10. The possibility of transplanting or holding stock over

| Stock type | Season | Holding over | Transplant |
|---|---|---|---|
| PCT 211A 1+0 | Su | No! | Possible |
| PCT 313B 1+0 | Sp | No! | Possible |
| PCT 313B 1+0 | Su | 1+0 Sp | Possible |
| PCT 415B 1+0 | Sp | No! | Not recommended |
| PCT 415B 1+0 | Su | 1+0 Sp | Not recommended |
| PSB 313B 1+0 | Sp | No! | Possible |
| PSB 313B 1+0 | Su | 1+0 Sp | Possible |
| PSB 313B 2+0 | Su | 2+0 Sp | Not recommended |
| PSB 410 1+0 | Su | 1+0 Sp | Possible |
| PSB 410 1+0 | Sp | No! | Possible |
| PSB 415B 1+0 | Sp | No! | Possible |
| PSB 415B 1+0 | Su | 1+0 Sp | Possible |
| PSB 415B 2+0 | Su | 2+0 Sp | Not recommended |
| PSB 415D 1+0 | Sp | No! | Not recommended |
| PSB 415D 1+0 | Su | 1+0 Sp | Not recommended |
| PSB 415D 2+0 | Su | 2+0 Sp | Not recommended |
| PSB 615 1+0 | Sp | No! | Not recommended |
| PSB 615 1+0 | Su | 1+0 Sp | Not recommended |
| PSB 615 2+0 | Su | 2+0 Sp | Not recommended |
| PBR .5+.5 | Su | .5+.5 Sp | Not recommended |
| PBR .5+.5 | Sp | .5+1.5 Sp | Not recommended |
| PBR .5+1.5 | Su | .5+1.5 Sp | Not recommended |
| BBR 2+0 | Sp | No! | Not recommended |

## Transplanting

Transplanting container stock to the field to produce a PBR is one method of holding over but should generally only be considered for smaller 1+0 stock types (Table 10). Spring is the ideal time to transplant stock. Transplanting later than June 15th (May 15th for coastal nurseries) does not allow enough time for adequate root egress and does not take full advantage of field culture. The 211 1+0 stock should not be held over by transplanting unless it is lightly rooted. Larger and older stock types are not recommended because they will produce excessively large seedlings that are difficult to manage at the nursery, will be expensive to store and plant. Transplants of 2+0 container stock may also develop root disease associated with being root-bound.

When holding stock over or transplanting, realize that seedling cost increases—in the case of Sx, a PBR costs 62% more than a 313B (Table 7). When making a cost decision to hold stock over, examine the impacts on the whole planting program (e.g., size of program next year, regeneration time frames, availability of plantable spots, and site accessibility). Also consider the requirement for increased logistical support (e.g., clearing snow and planter availability).

Plug to plug transplants (PPT) are another possibility when holding over is required. Other than when the initial sowing is as miniplugs (see plug transplants), this option is very labour intensive because it is unlikely that stock to be held over is in a container type for which transplanting machinery is available. It is also imperative that the plug to be transplanted is lightly rooted and small enough to fit into the preferred final cavity type. Cost of the final product will naturally have to increase as production inputs increase.

# Current Stock Types by Species

The following section outlines the stock types for British Columbia. There are several general guidelines that should be followed:

- PSB 2+0 Sp stock types are not recommended for any species except Ba and Bl. Substitute larger 1+0 stock types or use 2+0 Su stock types.
- PSB 211A 1+0 stock types are generally not recommended. Substitute PSB/PCT 313B 1+0 or larger stock types.
- PCT stock types are recommended for Pli and Py.
- Substitute PSB/PCT 313B stock types for PSB/PCT 313A.

The relative appropriateness of stock types and their applicable planting season are described for each species in relation to the major limiting factors. Those stock types that have not been listed are either not appropriate for that species or are suitable only under limited circumstances.

The recommended stock types listed in the tables, and the relative suitability of the different stock types, in terms of survival and initial growth, have been classed under three categories:

**POOR:** stock types that are not suited for a particular limiting factor.

**FAIR:** stock types that have some suitability for a particular limiting factor, although only low levels of the limiting factor can be tolerated by these stock types.

**GOOD:** stock types that have some suitability for moderate levels of particular limiting factors. For the most extreme levels of these limiting factors use the largest stock type.

Plate 19 indicates the range of variation that can be expected between and within nurseries. There can be considerable variation between seedlots and/or nurseries from year-to-year. Some of the variation is stock type dependent. For example, 1+0 Sx stock types are typically more uniform compared to 2+0 Sx. However, Bl stock types are more variable as 1+0 than as 2+0.

Consideration was given to height, root collar diameter, foliage colour, branching, and plug cohesiveness in selecting representative samples for the photographs of stock types by species. Stock types were selected based on the 1997 sowing statistics. A standard 5 × 5 cm reference grid was used in every plate. Target heights based on 1997 morphological specifications have been noted.

PLATE 19. Variation of Sx stock types within and among nurseries. Pairs of seedlings are from the same nursery illustrating little within-nursery variation, and greater between-nursery variation. The six seedlings on the left are Sx PSB 410 1+0; the six on the right are Sx PSB 415D 2+0. Note variation in plug cohesiveness, seedling height, stem diameter, and branchiness.

# Spruce (Sx)

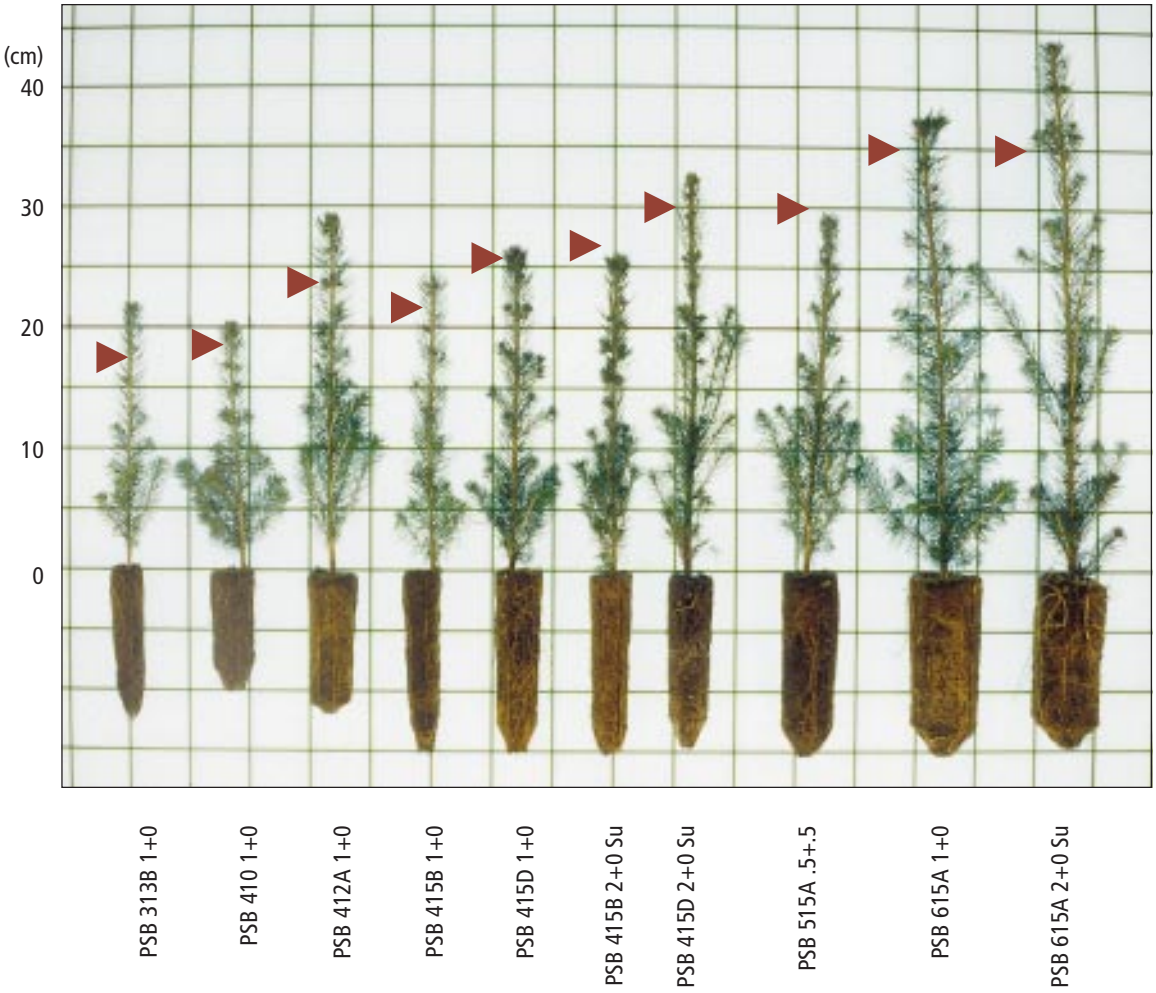
The relatively short, cool growing season for most spruce sites and its sensitivity to frost requires careful attention to timing of planting, spot preparation, and selection of planting microsites. Check the species prescription for spruce is suitable for the site conditions after logging. Consider the risk of frost, winter desiccation, terminal weevil, and seasonal drought before finalizing the species selection. If in doubt about the acceptability of Sx, consider substituting or augmenting the planting with Pli or Bl, consider the potential for site preparation, and make the best use of microsites to protect the seedlings.

**Sowing Trends – 1993/1998**
Species: Spruce (Sx)

| | 1993 | 1998 |
|---|---|---|
| **% of total sowing of Sx** | | |
| 1 + 0 | 64 | 80 |
| BBR/PBR | 8 | 1 |
| copper treated | 3 | 4 |
| **# of stock types** | 18 | 15 |
| **Dominant container types** | 415B/313B | 415B/410 |
| **Smallest container type** | 211A | 211A |
| **Largest container type** | 615A | 615A |
| **Quantity sown (K)** | 90 886 | 56 484 |

New stock types since 1993: 412A/512A/515A/PAP

PLATE 20. Sx stock types. (Arrowheads indicate target heights.)



The major limiting factors that Sx stock type selection can address are vegetation competition (herbs, shrubs, and grasses), snowpress, and duff depth. Vigorous seedling performance is crucial to overcoming these limiting factors. To address vegetation competition and/or snowpress, select stock types with a high sturdiness ratio (see page 8) and do not accept reductions in the root collar diameter specifications.

For the most severe vegetative competition, the PSB 415D 1+0 Sp and/or 2+0 Su or larger stock types are recommended. The compact top and good sturdiness ratio of the PSB 410, PSB 412, and PSB 512 1+0 stock types may be advantageous for sites prone to snowpress.

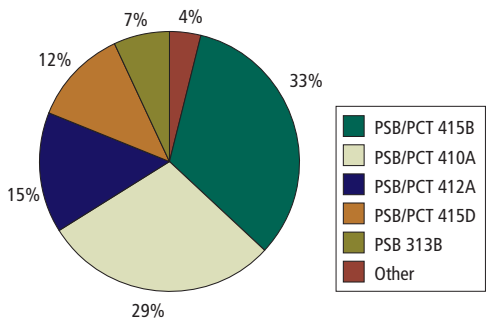
Sx is often planted on sites with a high frost heaving hazard (exposed moist fine-textured soils) (see page 9). Growing Sx in PCT containers to promote upper plug rooting may be advantageous in areas of high frost heaving and/or winter dessication hazard.

**Sx stock type suitability.**

| Sx | | Limiting factors | | | | | |
|---|---|---|---|---|---|---|---|
| | Season | Vegetation competition | Snow-press | Animal damage | Soils: Shallow | Soils: Fine-textured | Winter dessication* |
| **Recommended stock types:** | | | | | | | |
| PSB 313B 1+0 | Sp, Su | Poor | Poor | Poor | Fair | Fair | Fair |
| PSB 410 1+0 | Sp, Su | Poor | Fair | Poor | Good | Poor | Good |
| PSB 415B 1+0 | Sp, Su | Fair | Fair | Fair | Poor | Good | Poor |
| PSB 412A 1+0 | Sp, Su | Fair | Good | Fair | Good | Fair | Good |
| PSB 415D 1+0 | Sp, Su | Good | Fair | Good | Poor | Good | Poor |
| PSB 512A 1+0 | Sp, Su | Good | Good | Good | Good | Fair | Poor |
| PSB 515A 1+0 | Sp, Su | Good | Good | Good | Poor | Good | Poor |
| PSB 615A 1+0 | Sp, Su | Good | Good | Good | Poor | Good | Poor |
| PSB 415B 2+0 | Su | Fair | Fair | Fair | Poor | Good | Poor |
| PSB 415D 2+0 | Su, Sp | Good | Good | Good | Poor | Good | Poor |
| PSB 515A 2+0 | Su, Sp | Good | Good | Good | Poor | Good | Poor |
| PSB 615A 2+0 | Su, Sp | Good | Good | Good | Poor | Good | Poor |
| PBR .5+1.5** | Su, Sp | Good | Good | Good | Poor | Good | Poor |
| PPT 515A .5+.5 | Su, Sp | Good | Good | Good | Poor | Good | Poor |

* Particularly significant in boreal forest areas with low snow cover (e.g., Peace River).
** Suitable stock type if a) handling requirements can be met, and b) soil depth is greater than 30 cm.

**Sx stock type profile, 1998 sowing**
(56 484 K seedlings total)



# Lodgepole Pine (Pli/Plc)

Pli withstands drought and frost better than Fdi, Py, or Sx. The drought tolerance of Pli enables its use under site and planting conditions unacceptable for other species. Pli also can endure browsing and trampling—better than Fdi. It is, however, very prone to snow damage.

The major limiting factors Pli stock type selection can address are animal damage, vegetation competition, snowpress, and shallow soils or droughty conditions.

**Sowing Trends – 1993/1998**
Species: Lodgepole pine (Pli)

| | 1993 | 1998 |
|---|---|---|
| **% of total sowing of Pli** | | |
| 1 + 0 | 95 | 98 |
| BBR/PBR | 5 | 5 |
| Copper treated | 57 | 67 |
| **# of stock types** | 23 | 20 |
| **Dominant container types** | 313B | 313B/410 |
| **Smallest container type** | 211A | 211A |
| **Largest container type** | 415D | 615A |
| **Quantity sown (K)** | 102 048 | 83 551.5 |

New stock types since 1993: 412A/615A

## Pine leaf morphology

Container-grown Pli seedlings can be produced with two types of needle morphology. Primary needles are the first single needles produced by Pli (Plate 21a). Depending upon the species, this morphology may quickly change into secondary needles or, as in the case of Pli, may continue until the end of the first growing season. On Pli, primary needles seldom persist on the seedling beyond the first year of outplanting. Secondary needles are the first true fascicle needles (Plate 21b). Secondary needles can be induced by nursery cultural techniques. The development of secondary needles in Pli is

PLATE 21. Pli needle morphology: a) Pli primary needle morphology; b) Pli secondary needle morphology. Secondary needles (fascicled) originate in the axils of the primary needles.

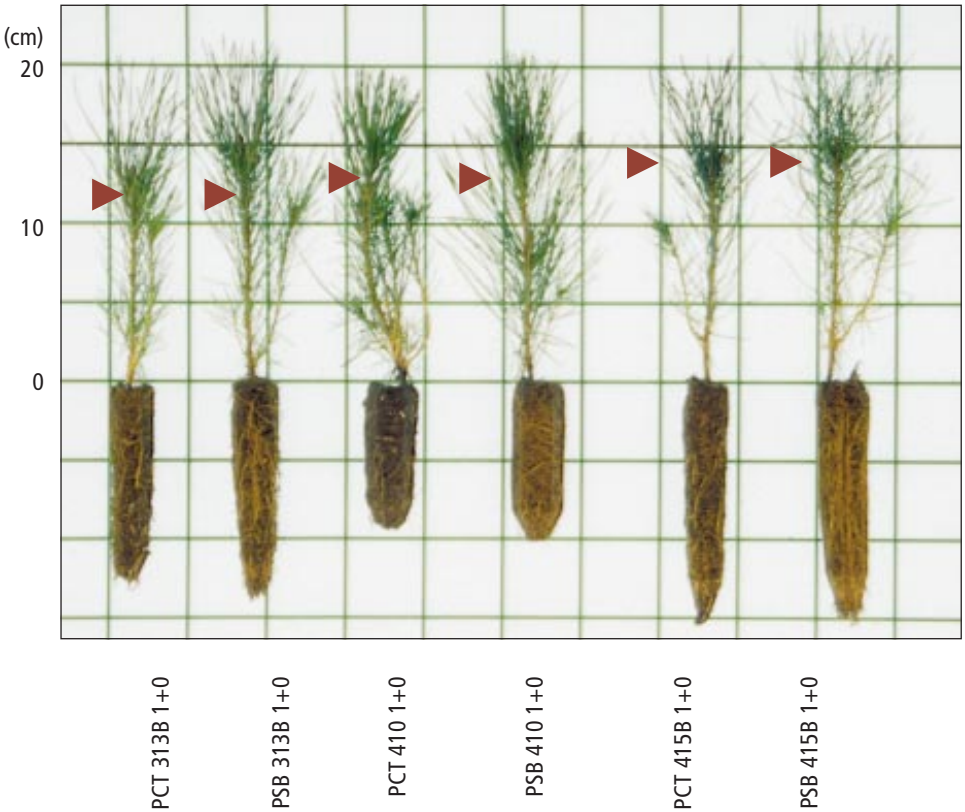
Plate 21a.

Plate 21b.

accompanied by differences in bud morphology (Plate 22) and larger stem diameters. Secondary needle Pli is considered to be more drought resistant than primary needle Pli, a possible advantage for droughty sites. However, a recent trial comparing survival and growth of primary- versus secondary-needle pine produced no evidence of benefits associated with secondary needles (C. Hawkins, pers. comm.).

PLATE 22. Bud morphology of secondary-needle (left) and primary-needle (right) Pli. Primary-needle Pli usually has a single terminal bud. Secondary-needle Pli generally has multiple buds in the terminal position.

PLATE 23. Pli/Plc stock types. Note the differences between the copper-treated plugs and the non-treated plugs. PCT roots end at the plug wall and have no secondary roots. The PSB roots show branched rooting morphology. (Arrowheads indicate target heights.)



Container-grown Pli has, historically, been grown in British Columbia as primary needle seedlings. Although primary needles are still the most common morphology, container-grown Pli with secondary needles has been planted since 1990. BBR 2+0 Pli seedlings have only secondary needles. The relative field performance and nursery cultural controls for achieving secondary needles are still poorly known. Silviculturists should be aware of the form of Pli that they are receiving and determine the relative merits of these different morphologies.

PCT stock types are recommended for Pli (see "Copper-treated containers," page 19). For mesic Pli sites, the PCT 313B 1+0 or PCT 410 1+0 is recommended. The PCT 415B 1+0 or larger stock types are rarely necessary under such conditions. The PCT 410, PCT 412A, and PCT 512A are appropriate on shallow soil and/or droughty sites.

Due to its vigorous nursery growth, never order Pli as 2+0 container stock. Although not generally recommended, Pli is still grown in PCT 211A containers. The PCT 313B or PCT 410 are preferred alternatives.

BBR 1+0 and 2+0 are no longer widely used due to the easier handling requirements of container stock.

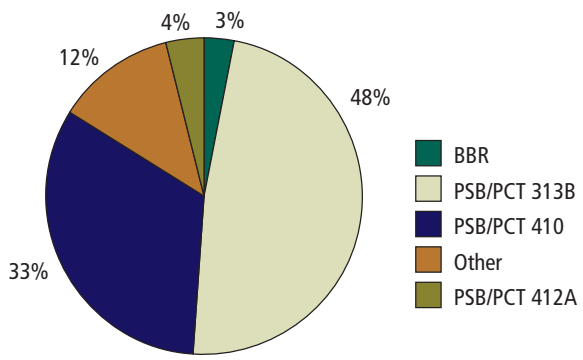
**Caution:** Pli is often planted on sites with a high frost heaving hazard (exposed moist fine-textured soils). See "Frost and winter dessication," page 9.

**Pli/Plc stock type suitability.**

| Pli/ Plc | | Limiting factors | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Animal | | | Soils | |
| | Season | Vegetation competition | Snow-press | Trampling | Browse | Drought | Shallow | Fine textured |
| **Recommended stock types:** | | | | | | | | |
| PCT 211A 1+0 | Sp | Poor | Good | Fair | Poor | Fair | Good | Poor |
| PCT 313B 1+0 | Sp | Fair | Good | Fair | Poor | Fair | Fair | Poor |
| PCT 410 1+0 | Sp, Su | Good | Good | Fair | Fair | Fair | Good | Fair |
| PCT 415B 1+0 | Sp, Su | Good | Fair | Fair | Fair | Fair | Poor | Good |
| PCT 412A 1+0 | Sp, Su | Good | Good | Fair | Fair | Fair | Good | Good |
| PCT 415D 1+0 | Sp, Su | Good | Fair | Good | Good | Fair | Poor | Good |
| PCT 512A 1+0 | Sp, Su | Good | Good | Good | Good | Fair | Good | Good |
| BBR 2+0* | Sp only | Good | Fair | Fair | Good | Poor | Poor | Fair |

* Suitable stock type if: a) handling requirements can be met; and b) soil depth is greater than 30 cm.

**Pli stock type profile, 1998 sowing**
(83 551.5 K seedlings total)



# Western Redcedar (Cw)

Cw is most susceptible to browse as it is a preferred species by deer, moose, and elk.[1] In areas where Cw browsing is severe, even larger stock types have not been cost-effective, and protective devices or different species may be the only alternative. The species is prone to snow (basal crook or sweep) and frost damage.

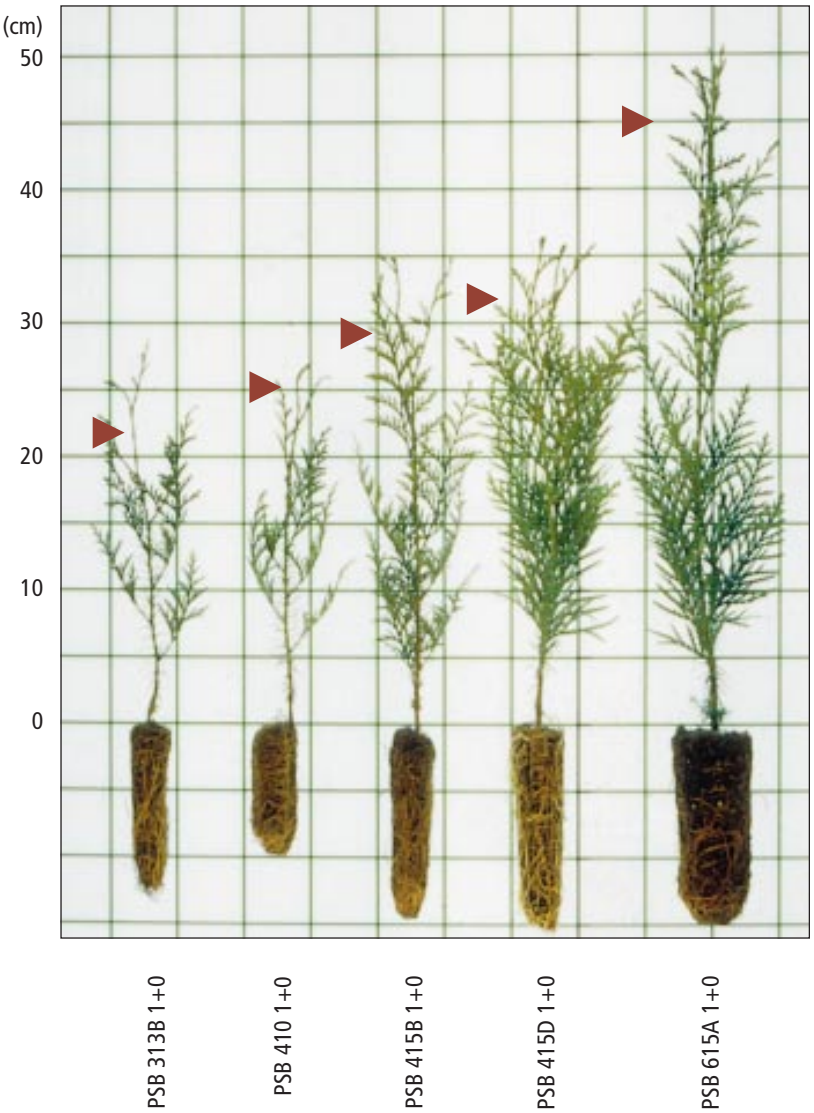
The major limiting factors that stock type selection can address are vegetation competition and moderate levels of animal damage.

**Sowing Trends – 1993/1998**
Species: Western redcedar (Cw)

| | 1993 | 1998 |
|---|---|---|
| **% of total sowing of Cw** | | |
| 1 + 0 | 96 | 98 |
| BBR/PBR | 2 | 1 |
| **# of stock types** | 13 | 13 |
| **Dominant container types** | 313B/415B | 313B/410/ 415B/415D |
| **Smallest container type** | 310B | 313B |
| **Largest container type** | 615B | 1015 |
| **Quantity sown (K)** | 12 092 | 9520 |

New stock types since 1993: 412A/512A/1015

PLATE 24. Cw stock types. None of the stock illustrated were top-pruned. (Arrowheads indicate target heights.)




[1] *Seedling Barrier Protection from Deer and Elk Browse*, Feb. 1996.

Large stock types should be used for severe vegetative competition. If a larger stock type than the 1+0 PSB 415D is required, then the 1+0 PSB 512A or 515A may be cost-effective alternatives to the more expensive PSB 615A 1+0.

The substantial foliage and lateral branching produced on the PSB 512A/515A/615A 1+0 stock types can increase resilience to low to moderate levels of browsing.

Cw grows vigorously under nursery conditions and can become excessively tall. Top-pruning of this species is an acceptable practice provided that pruning is performed before mid-July. Holding the stock over or growing it as 2+0 container or field crop is not recommended because of the increased likelihood of *Keithia* infestation (Plate 10).

The PSB 415D 1+0 is large enough to be an alternative for previously requested 2+0 containers.

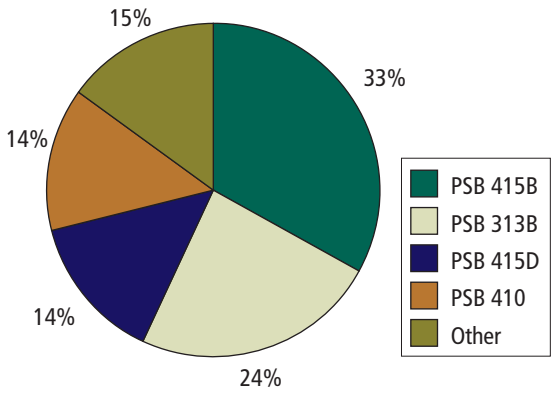
Cw is not recommended as a summer plant stock type due to the difficulty in inducing sufficient hardening off.

**Cw stock type suitability.**

| Cw | | Limiting factors | | | |
|---|---|---|---|---|---|
| | Season | Vegetation competition | Snow-press | Animal browse | Shallow soils |
| **Recommended stock types:** | | | | | |
| PSB 313B 1+0 | Sp, Fa | Poor | Poor | Poor | Fair |
| PSB 410 1+0 | Sp, Fa | Fair | Poor | Poor | Good |
| PSB 415B 1+0 | Sp, Fa | Fair | Poor | Poor | Poor |
| PSB 412A 1+0 | Sp | Good | Good | Fair | Good |
| PSB 415D 1+0 | Sp | Good | Fair | Fair | Poor |
| PSB 512A 1+0* | Sp | Good | Good | Good | Good |
| PSB 515A 1+0* | Sp | Good | Good | Good | Poor |
| PSB 615A 1+0* | Sp | Good | Good | Good | Poor |

* Used for major limiting factors; special handling requirements.

**Cw stock type profile, 1998 sowing**
(9520 K seedlings total)



# Coastal Douglas-fir (Fdc)

Coastal Douglas-fir is one of the more widely planted coastal species. The vigorous growth of the species makes it desirable for many reforestation programs.

The major limiting factors that stock type selection can address are vegetation competition and animal damage. At the extremes of its elevational range, snow damage, and vegetation press may also be limiting factors.

Correct seedlot selection, attention to seed transfer, and timing of planting are critical for coast-interior transition Fdc where drought is a major limiting factor.

**Sowing Trends – 1993/1998**
Species: Coastal Douglas-fir (Fdc)

| | 1993 | 1998 |
|---|---|---|
| **% of total sowing of Fdc** | | |
| 1 + 0 | 91 | 99 |
| BBR/PBR | 7 | 1 |
| **# of stock types** | 16 | 11 |
| **Dominant stock types** | 313B/415B | 415B/415D |
| **Smallest container type** | 310B | 313B |
| **Largest container type** | 615A | 1015 |
| **Quantity sown (K)** | 7753 | 7746 |

New stock types since 1993: 412A/1015

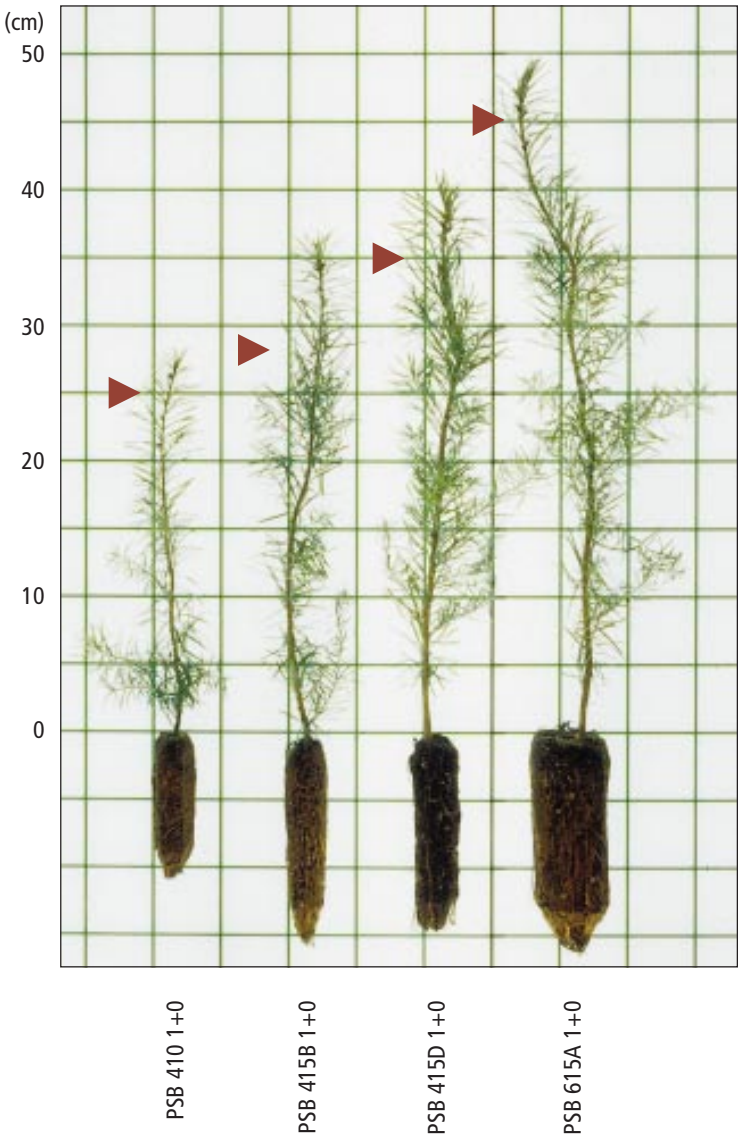



PLATE 25. Fdc stock types. Note the increased size and number of lateral branches on the 415D and 615A. (Arrowheads indicate target heights.)

Coastal Douglas-fir grows extremely quickly in the nursery and should never be requested in small containers or as 2+0 containers because of the increased incidence of foliage and root disease, and height management problems.

For summer planting, the vigorous nursery growth demands that this species be taken to the field for planting as soon as the buds have been set. The vigorous growth also limits the ability to hold summer-plant stock over for spring planting. Holding the plants too long in the nursery will result in reflushing. Top-pruning is not recommended, but if operationally required, it must be performed in June. If the tops are pruned in July after buds have been initiated, the plants may completely reflush.

For hot lift planting in the fall, it is critical that seedlings be fully hardened off or else they will be prone to reflushing, with an increased probability of reduced survival.

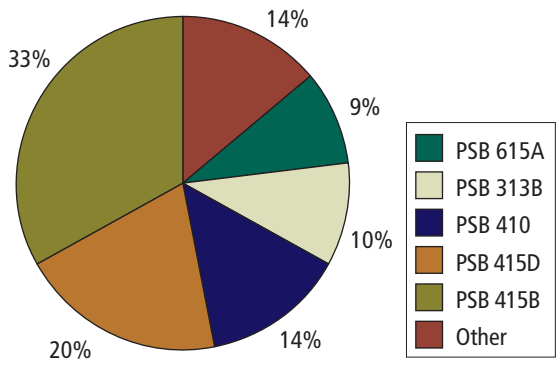
If the handling requirements associated with large stock types can be met, PBR .5+1.5 and BBR 2+0 are appropriate stock types for low elevation sites with soils at least 30 cm deep. The large, specialty stock types are appropriate for the most severe brush competition and browsing conditions. The PSB 313B, 410 and 412A stock types may be at a slight advantage under droughty site conditions in the coast-interior transition due to their reduced shoot/root ratios.

**Fdc stock type suitability.**

| Fdc | | Limiting factors | | | |
|---|---|---|---|---|---|
| | Season | Vegetation: shrub, herb | Snow-press | Animal damage | Drought |
| **Recommended stock types:** | | | | | |
| PSB 313B 1+0 | Sp, Fa | Poor | Poor | Poor | Fair |
| PSB 410 1+0 | Sp, Fa | Fair | Fair | Poor | Fair |
| PSB 415B 1+0 | Sp, Fa | Fair | Fair | Fair | Fair |
| PSB 412A 1+0 | Sp, Fa | Good | Good | Fair | Fair |
| PSB 415D 1+0 | Sp, Fa | Good | Good | Good | Fair |
| PSB 512A 1+0 | Sp | Good | Good | Good | Fair |
| PSB 515A 1+0 | Sp | Good | Good | Good | Fair |
| PSB 615A 1+0* | Sp | Good | Good | Good | Fair |
| BBR 2+0* | Sp only | Good | Good | Good | Poor |
| PBR .5+1.5* | Sp only | Good | Good | Good | Poor |

* Used for major limiting factors; special handling requirements.

**Fdc stock type profile, 1998 sowing**
(7746 K seedlings total)



# Interior Douglas-fir (Fdi)

Of the major reforestation species used in the interior, Fdi is more sensitive to browsing than Pli, less tolerant to drought than Pli, and more sensitive to frost than Pli and Sx. As Fdi is the least resistant to *Armillaria*, in areas where available, Lw may be a preferred species.

The major limiting factors that can be addressed by stock type selection are vegetation competition and animal damage (browsing and trampling).

The correct selection of seedlot and attention to seed transfer and site preparation is particularly important for dry-belt Fdi where drought from grass competition and shallow soils are limiting factors.

**Sowing Trends – 1993/1998**
Species: Interior Douglas-fir (Fdi)

| | 1993 | 1998 |
|---|---|---|
| **% of total sowing of Fdi** | | |
| 1 + 0 | 98 | 100 |
| BBR/PBR | 1 | 0 |
| **# of stock types** | 13 | 9 |
| **Dominant container types** | 415B/313B | 415B/410/ 313B |
| **Smallest container type** | 313B | 313B |
| **Largest container type** | 515A | 515A |
| **Quantity sown (K)** | 7489 | 7950.2 |

New stock types since 1993: 412A

PLATE 26. Fdi stock types. Like Fdc, the larger stock types have increased size and number of lateral branches. (Arrowheads indicate target heights.)

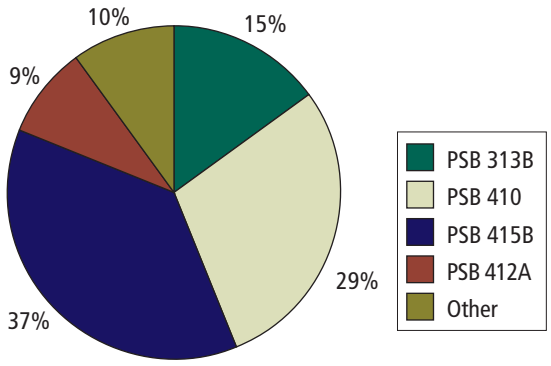
Interior Douglas-fir shares the same cultural limitations on stock type selection as Fdc. It should not be ordered in small containers nor as 2+0 Su containers. Unlike Fdc, the species may have poor cohesion in the upper part of the plug.

Summer 1+0-planted stock may require blackout and should be inspected for succulence and reflushing. However, summer planting is not recommended due to the difficulties in promoting and maintaining budset. Stock larger than the PSB 415D 1+0 is only recommended for severe brush competition and animal browsing. The PSB 512A/515A 1+0 may be cost-effective alternatives to the more expensive PSB 615 1+0.

**Fdi stock type suitability.**

| Fdi | | Limiting factors | | | | |
|---|---|---|---|---|---|---|
| | Season | Vegetation competition | Snow-press | Animal damage | Drought | Shallow soils |
| **Recommended stock types:** | | | | | | |
| PSB 313B 1+0 | Sp | Poor | Poor | Poor | Poor | Fair |
| PSB 410 1+0 | Sp | Fair | Fair | Fair | Fair | Good |
| PSB 415B 1+0 | Sp | Fair | Fair | Fair | Fair | Poor |
| PSB 412A 1+0 | Sp | Good | Good | Good | Fair | Good |
| PSB 415D 1+0 | Sp | Good | Good | Good | Fair | Poor |
| PSB 512A 1+0 | Sp | Good | Good | Good | Fair | Good |
| PSB 515A 1+0 | Sp | Good | Good | Good | Fair | Poor |
| PSB 615A 1+0 | Sp | Good | Good | Good | Fair | Poor |

**Fdi stock type profile, 1998 sowing**
(7950.2 K seedlings total)



# Sitka Spruce (Ss and Sxs)

The major limiting factors that Ss stock type selection can address are vegetation competition and animal damage, and snowpress in the north of its range. Rapidly growing, robust seedlings are crucial to dealing with these limiting factors.

Sitka spruce is the most vigorous species grown in nurseries and may become too tall. Sitka spruce should never be requested in small containers or as 2+0 because of the increased incidence of foliage and root disease and height management problems. Due to the tendency for Ss to become very tall and top-heavy, it is recommended not to accept any reduction in the root collar diameter.

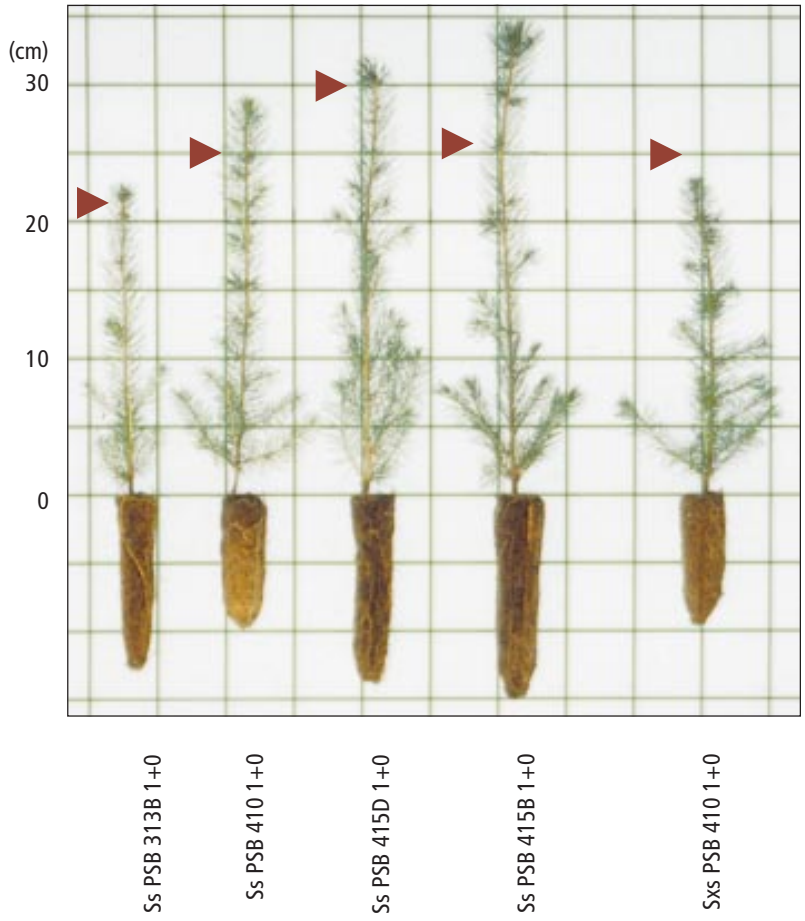
Sowing requests for Ss dropped substantially several years ago due to its vulnerability to the white pine leader weevil. Research is underway with field-testing of putatively weevil-resistant Ss embryogenic lines that may enable increased planting of Ss in areas of higher weevil hazard.

**Sowing Trends – 1993/1998**
Species: Sitka spruce (Ss and Sxs)

| | 1993 | 1998 |
|---|---|---|
| **% of total sowing of Ss** | | |
| 1 + 0 | 93 | 99 |
| BBR/PBR | 2 | 2 |
| **# of stock types** | 7 | 7 |
| **Dominant container types** | 313B/415D | 313B/415B/ 415D |
| **Smallest container type** | 313B | 313B |
| **Largest container type** | 615B | 615A |
| **Quantity sown (K)** | 1582 | 1741 |

New stock types since 1993: 410/412

PLATE 27. Ss and Sxs stock types. (Arrowheads indicate target heights.)

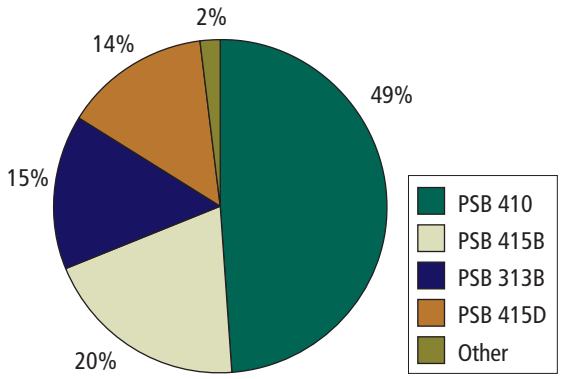


Stock types larger than the PSB 415 1+0 should only be used for the most severe vegetation competition. Although not currently requested, the PSB 512A/515A 1+0 may be cost effective alternatives to the more expensive PSB 615 1+0.

**Ss stock type suitability.**

| Ss | | Limiting factors | | | |
|---|---|---|---|---|---|
| | Season | Vegetation competition | Snow-press | Animal damage | Shallow soils |
| **Recommended stock types:** | | | | | |
| PSB 313B 1+0 | Sp | Poor | Poor | Fair | Good |
| PSB 410 1+0 | Sp, Su | Fair | Poor | Fair | Good |
| PSB 415B 1+0 | Sp, Su | Fair | Poor | Fair | Poor |
| PSB 412A 1+0 | Sp, Su | Fair | Fair | Fair | Good |
| PSB 415D 1+0 | Sp, Su | Good | Good | Good | Poor |
| PSB 512A 1+0 | Sp, Su | Good | Good | Good | Good |
| PSB 515A 1+0 | Sp, Su | Good | Good | Good | Poor |
| PSB 615A 1+0 | Sp, Su | Good | Good | Good | Poor |

**Ss stock type profile, 1998 sowing**
(1741 K seedlings total)



# Western Larch (Lw)

The rapid initial height growth of Lw, and its resistance to *Armillaria*, makes it an attractive alternative to Fdi for many reforestation projects in the southern interior. The same characteristics make it attractive as an exotic species in the coast-interior transition. Although the species is more drought-tolerant than Fdi/Fdc, it is not as drought-tolerant as Pli/Py.

It is important to remember that good site preparation, such as scarification, is essential for any larch plantation because of the sensitivity of the species to vegetation competition, even after the first few years following planting. Careful attention should be given to planting spot selection in order to avoid shading. On sites where a mixed planting or under planting has been prescribed, it may be more cost-effective to use a larger stock type.

The major limiting factors that Lw stock type selection can address are vegetation competition and animal damage.

Although less so than Fdi, Lw grows vigorously in the nursery and therefore should never be ordered as 2+0 stock.

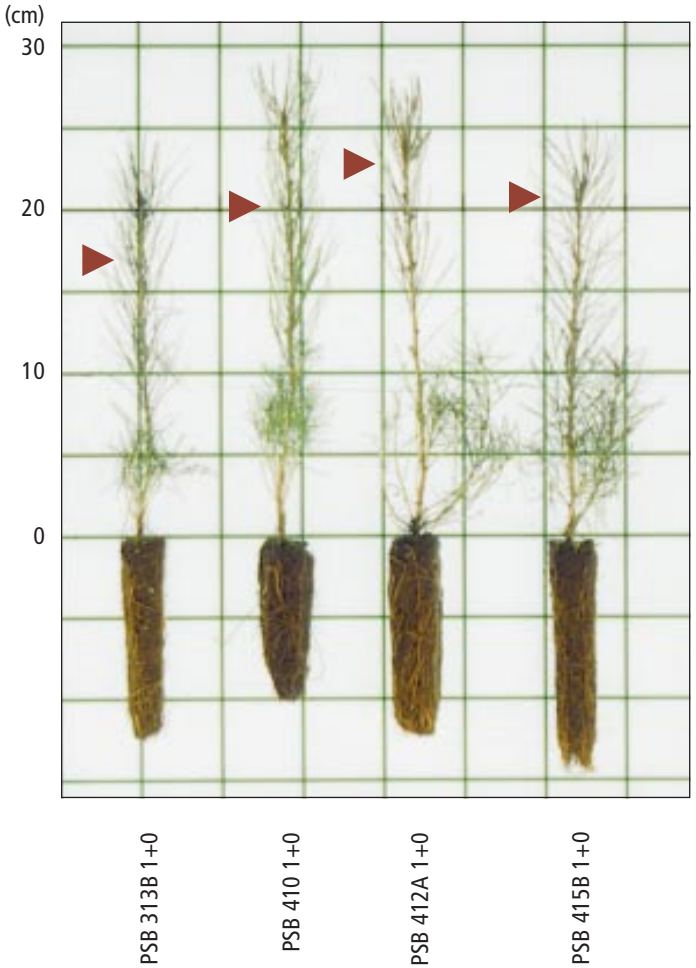
Lw may have poor cohesion in the upper part of the plug. It is not recommended as a summer stock type due to difficulties in promoting and maintaining budset.

**Sowing Trends – 1993/1998**
Species: Western larch (Lw)

| | 1993 | 1998 |
|---|---|---|
| **% of total sowing of Lw** | | |
| 1 + 0 | 99 | 100 |
| BBR/PBR | 0 | 0 |
| Copper treated | 0 | 3 |
| **# of stock types** | 5 | 9 |
| **Dominant container types** | 313B | 410/313B/ 415B |
| **Smallest container type** | 310B | 310B |
| **Largest container type** | 415D | 615A |
| **Quantity sown (K)** | 3149 | 5008.9 |

New stock types since 1993: 412A/313D/512A/PCT

PLATE 28. Lw stock types. Photograph taken in the fall; seedlings are starting to shed their needles. (Arrowheads indicate target heights.)

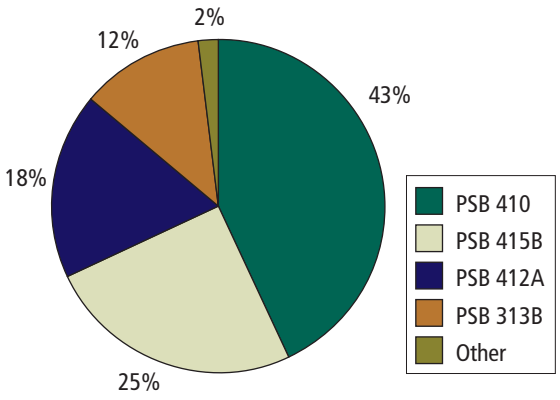


Lw stock type suitability.

| Lw | | Limiting factors | | | | |
|---|---|---|---|---|---|---|
| | Season | Vegetation competition | Snow-press | Animal damage | Drought | Shallow soils |
| **Recommended stock types:** | | | | | | |
| PSB 313B 1+0 | Sp | Poor | Poor | Poor | Poor | Fair |
| PSB 410 1+0 | Sp | Fair | Fair | Fair | Fair | Good |
| PSB 415B 1+0 | Sp | Fair | Fair | Fair | Fair | Poor |
| PSB 412A 1+0 | Sp | Good | Good | Good | Fair | Good |
| PSB 415D 1+0 | Sp | Good | Good | Good | Poor | Poor |
| PSB 512A 1+0 | Sp | Good | Good | Good | Fair | Good |
| PSB 515A 1+0 | Sp | Good | Good | Good | Poor | Poor |
| PSB 615A 1+0 | Sp | Good | Good | Good | Poor | Poor |

**Lw stock type profile, 1998 sowing**

(5008.9 K seedlings total)



# Western White Pine (Pw)

The use of Pw is restricted by blister rust, which cannot be moderated by stock type selection. For this reason, blister-rust resistant seed should be used. Use of non-resistant seed may require a commitment to pruning.

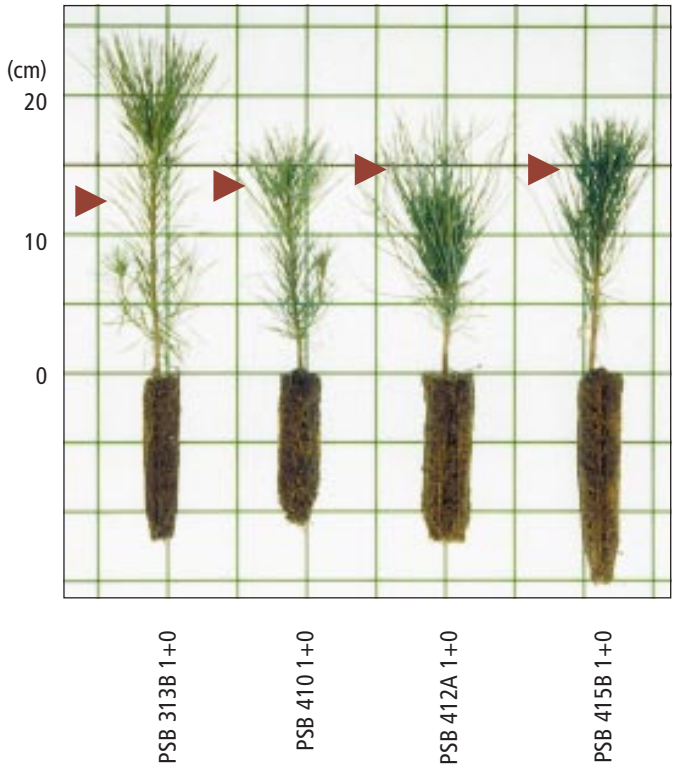
The major limiting factors that stock type selection can address for Pw are animal damage and vegetation competition.

**Sowing Trends – 1993/1998**
Species: Western white pine (Pw)

| | 1993 | 1998 |
|---|---|---|
| **% of total sowing of Pw** | | |
| 1 + 0 | 95 | 95 |
| BBR/PBR | 0 | 1 |
| **# of stock types** | 7 | 5 |
| **Dominant container types** | 313B | 415B/410 |
| **Smallest container type** | 313B | 313B |
| **Largest container type** | 415D | 415D |
| **Quantity sown (K)** | 518 | 981 |

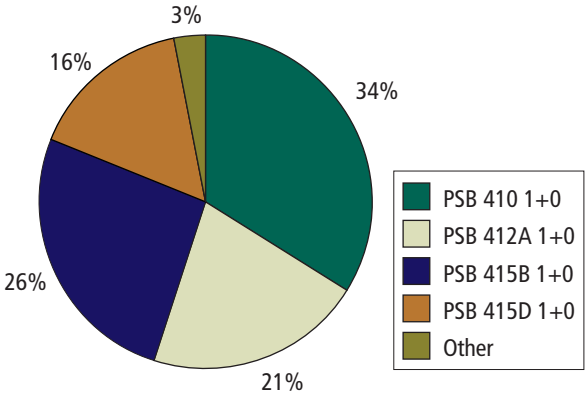
New stock types since 1993: 412A/615A

PLATE 29. Pw stock types. All stock types display secondary needle morphology. (Arrowheads indicate target heights.)




Western white pine produces prolific roots in the nursery and should never be ordered as 2+0 container or in containers smaller than 313B. It is almost always available with secondary needle morphology. Significant advances have occurred in nursery culture practices making more high-quality seedlings available for planting.

**Pw stock type profile, 1998 sowing**
(981 K seedlings total)




Pw stock type suitability.

| Pw | | Limiting factors | | |
|---|---|---|---|---|
| | Season | Vegetation competition | Snow-press | Animal damage |
| **Recommended stock types:** | | | | |
| PSB 410 1+0 | Sp | Fair | Good | Fair |
| PSB 415B 1+0 | Sp | Fair | Fair | Fair |
| PSB 412A 1+0 | Sp | Good | Good | Fair |
| PSB 415D 1+0 | Sp | Good | Good | Fair |

# Yellow Pine (Py)

Once established, Py is a very drought-tolerant species. On Py sites, the planting window is often limited to the short period in the early spring when sufficient soil moisture is available.

The major limiting factors that can be addressed by stock type selection are animal damage and vegetation competition.

The species is available with both primary and secondary needle morphology.

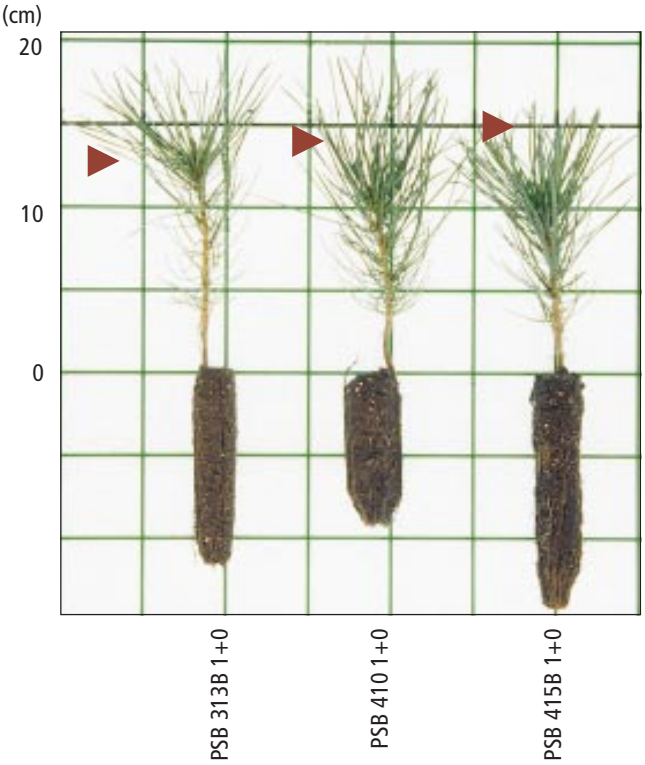
PCT containers are recommended for Py. Py produces prolific roots in the nursery and should never be ordered as 2+0 container or in containers smaller than a 313B.

**Sowing Trends – 1993/1998**
Species: Yellow pine (Py)

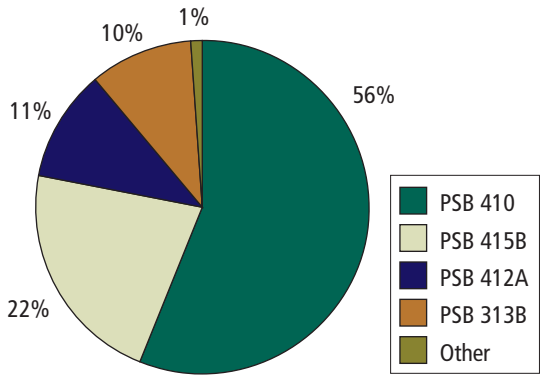
| | 1993 | 1998 |
|---|---|---|
| **% of total sowing of Py** | | |
| 1 + 0 | 98 | 100 |
| BBR/PBR | 7 | 0 |
| Copper treated | 4 | 48 |
| **# of stock types** | 9 | 10 |
| **Dominant container types** | 313B/415B | 410/313B/ 415B |
| **Smallest container type** | 313B | 211A |
| **Largest container type** | 415D | 415D |
| **Quantity sown (K)** | 943.2 | 808.3 |

New stock types since 1993: 412A

PLATE 30. Py stock types. All stock types exhibit mixed needle morphology with mostly primary needles and a few secondary needles toward the tip of the shoot. (Arrowheads indicate target heights.)




**Py stock type profile, 1998 sowing**
(808.3 K seedlings total)




**Py stock type suitability.**

| Py | Season | Limiting factors: Vegetation competition | Animal damage | Drought | Shallow soils |
|---|---|---|---|---|---|
| **Recommended stock types:** | | | | | |
| PCT 313B 1+0 | Sp | Poor | Poor | Fair | Fair |
| PCT 410 1+0 | SP | Good | Good | Fair | Good |
| PSB 415B 1+0 | Sp | Fair | Poor | Fair | Poor |
| PCT 412A 1+0 | Sp | Good | Good | Fair | Good |
| PCT 512A 1+0 | Sp | Good | Good | Fair | Good |

# Subalpine Fir (Bl)[2]

Its frost tolerance and resilience to snowpress make Bl an important species for reforestation of high elevation (ESSF) and northern forests.

Improvements in nursery culture have made spring planting of 1+0 stock types possible. However, 2+0 stock is the recommended option for summer planting. 1+0 summer stock is being assessed on a trial basis and may become an option as nursery cultural knowledge improves. Requesting Bl in stock types larger than the PSB 410 or 415 is not recommended as wide seedling spacing in the nursery results in unacceptable height variability. Bl inherently tends to have a low sturdiness ratio making it more resilient to snow damage than Sx.

PLATE 31. Bl stock types. (Arrowheads indicate target heights.)

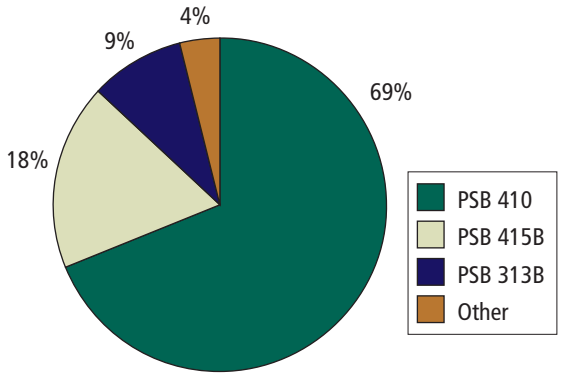

**Sowing Trends – 1993/1998**
Species: Subalpine fir (Bl)

| | 1993 | 1998 |
|---|---|---|
| **% of total sowing of Bl** | | |
| 1 + 0 | 12 | 81 |
| BBR/PBR | 0 | 0 |
| **# of stock types** | 4 | 5 |
| **Dominant container types** | 313B | 410A |
| **Smallest container type** | 313B | 313B |
| **Largest container type** | 615A | 415D |
| **Quantity sown (K)** | 1264 | 3603 |

New stock types since 1993: 412A/415D/PCT

Nursery production of Bl can be severely hampered by poor seed germination. This is often attributable to *Caloscypha*, a seed-borne fungus that can be easily controlled by ensuring, during cone collection, that the cones are not exposed to soil contact or dusty environments.

**Bl stock type profile, 1998 sowing**
(3603 K seedlings total)




[2] The transfer of *all* true firs is restricted by law because of the possibility of infestation by the balsam wooly aphid. See "Insects," page 31.

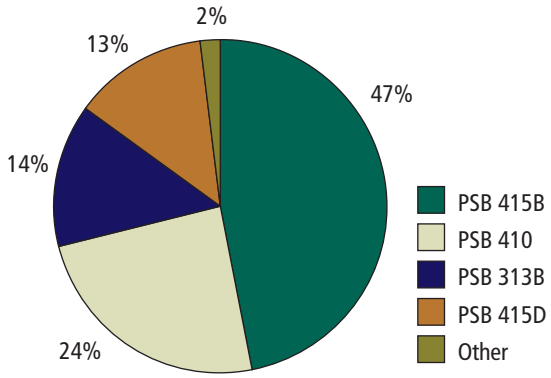
Bl stock type suitability.

| Bl | | Limiting factors | | | |
|---|---|---|---|---|---|
| | Season | Vegetation competition | Snow-press | Animal damage | Shallow soils |
| **Recommended stock types:** | | | | | |
| PSB 313B 1+0 | Sp, Su | Poor | Fair | Poor | Fair |
| PSB 410 1+0 | Sp, Su | Fair | Good | Fair | Good |
| PSB 415B 1+0 | Sp, Su | Fair | Good | Fair | Poor |
| PSB 313B 2+0 | Sp, Su, Fa | Fair | Fair | Fair | Fair |
| PSB 410 2+0 | Sp, Su, Fa | Fair | Good | Fair | Good |
| PSB 415B 2+0 | Sp, Su, Fa | Good | Good | Good | Poor |

# Amabilis fir (Ba)

Important characteristics of Ba for reforestation are its high shade tolerance, resilience to snowloading, and resistance to dwarf mistletoe. However, the high moisture and nutritional requirements of Ba and a tendency to slow initial height growth limit its use.

**Ba stock type profile, 1998 sowing**
(3622 K seedlings total)




**Sowing Trends – 1993/1998**
Species: Amabilis fir (Ba)

| | 1993 | 1998 |
|---|---|---|
| **% of total sowing of Ba** | | |
| 1 + 0 | 42 | 81 |
| BBR/PBR | 0 | 0 |
| **# of stock types** | 5 | 6 |
| **Dominant container types** | 313B/415B | 410/415 |
| **Smallest container type** | 313B | 313B |
| **Largest container type** | 415D | 615A |
| **Quantity sown (K)** | 4010 | 3622 |

New stock types since 1993: 412A/615A

PLATE 32. Ba stock types. (Arrowheads indicate target heights.)


Ba stock type suitability.

| Ba | | Limiting factors | | | |
|---|---|---|---|---|---|
| | Season | Vegetation competition | Snow-press | Animal damage | Shallow soils |
| **Recommended stock types:** | | | | | |
| PSB 313B 1+0 | Sp, Su, Fa | Poor | Fair | Poor | Fair |
| PSB 410 1+0 | Sp, Su, Fa | Fair | Good | Fair | Good |
| PSB 415B 1+0 | Sp, Su, Fa | Fair | Good | Fair | Poor |
| PSB 412A 1+0 | Sp, Su, Fa | Fair | Good | Fair | Good |
| PSB 415D 1+0 | Sp, Su, Fa | Good | Good | Good | Poor |
| PSB 410 2+0 | Sp, Su, Fa | Fair | Good | Fair | Good |
| PSB 415B 2+0 | Sp, Su, Fa | Good | Good | Good | Poor |
| PSB 412A 2+0 | Sp, Su, Fa | Good | Good | Good | Good |
| PSB 415D 2+0 | Sp, Su, Fa | Good | Good | Good | Poor |
| PSB 615A 2+0 | Sp, Su, Fa | Good | Good | Good | Poor |

# Noble Fir (Bn)

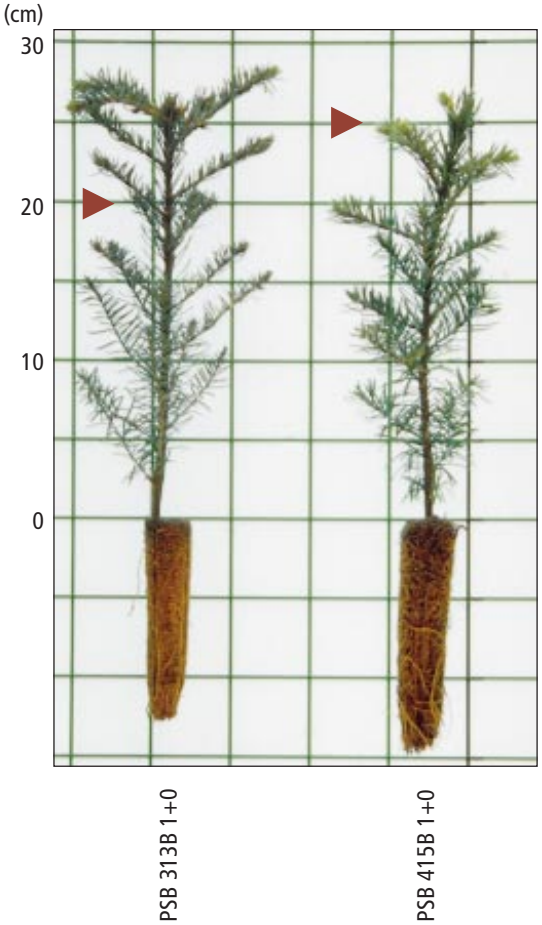
Noble fir is an exotic species with planting currently restricted to Vancouver Island and the adjacent coast mainland. Although less frost resistant and shade tolerant than Ba, it is more resilient to crown deformation from winds and snowloading than other high elevation species.

**Sowing Trends – 1993/1998**
Species: Noble fir (Bn)

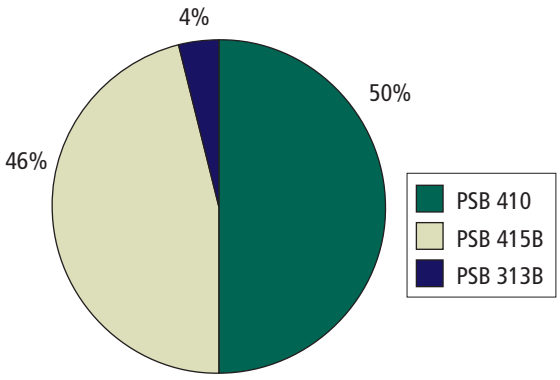
| | 1993 | 1998 |
|---|---|---|
| **% of total sowing of Bn** | | |
| 1 + 0 | 83 | 100 |
| BBR/PBR | 0 | 0 |
| **# of stock types** | 2 | 3 |
| **Dominant container types** | 313B | 410/415B |
| **Smallest container type** | 313B | 313B |
| **Largest container type** | 415B | 415D |
| **Quantity sown (K)** | 29 | 89.5 |

New stock types since 1993: 410/415D

PLATE 33. Bn stock types. (Arrowheads indicate target heights.)




**Bn stock type profile, 1998 sowing**
(89.5 K seedlings total)




**Bn stock type suitability.**

| Bn | | Limiting factors | | | |
|---|---|---|---|---|---|
| | Season | Vegetation competition | Snow-press | Animal damage | Shallow soils |
| **Recommended stock types:** | | | | | |
| PSB 313B 1+0 | Sp, Su | Poor | Fair | Poor | Fair |
| PSB 410 1+0 | Sp, Su | Fair | Good | Fair | Good |
| PSB 415B 1+0 | Sp, Su | Fair | Good | Fair | Poor |
| PSB 412A 1+0 | Sp, Su | Good | Good | Fair | Good |

# Grand Fir (Bg)

On many coastal sites and on low elevation moist sites in the lower Kootenay Lake and Arrow forest districts, the species is an attractive alternative to the more browse-prone Cw. The high shade tolerance of the species makes it a suitable replacement to Fdc on many brush-prone sites.

The major limiting factors that stock type selection can address for Bg are vegetative competition and animal damage.

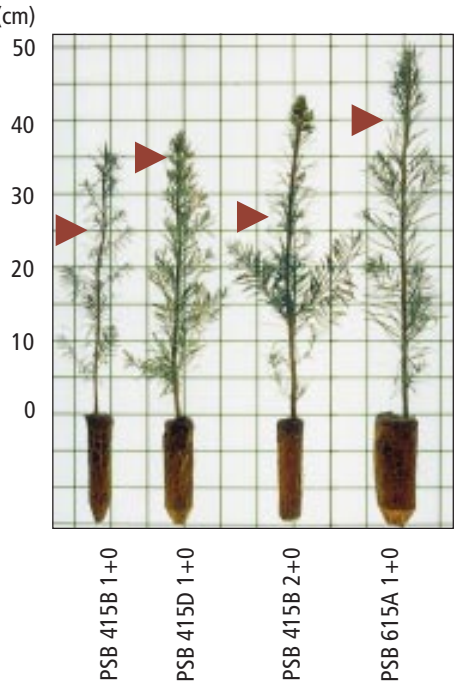
Grand fir produces prolific roots and should be ordered in larger container sizes. If the handling requirements of large stock can be met, BBR 2+0 is a recommended stock type if planting depths of at least 30 cm are available. If a larger stock type than the 1+0 PSB 415D is required, then the 1+0 PSB 512 or 515A may be a cost-effective alternative to the more expensive PSB 615 1+0.

**Sowing Trends – 1993/1998**
Species: Grand fir (Bg)

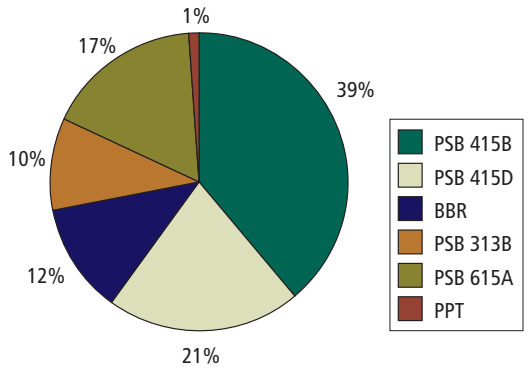
| | 1993 | 1998 |
|---|---|---|
| **% of total sowing of Bg** | | |
| 1 + 0 | 54 | 86 |
| BBR/PBR | 15 | 12 |
| **# of stock types** | 5 | 6 |
| **Dominant container types** | 415B | 415B/415D |
| **Smallest container type** | 313B | 313B |
| **Largest container type** | 615A | 615A |
| **Quantity sown (K)** | 202.3 | 160 |

New stock types since 1993: 412A/415C

PLATE 34. Bg stock types. (Arrowheads indicate target heights.)




**Bg stock type profile, 1998 sowing**
(160 K seedlings total)




Bg stock type suitability.

| Bg | | Limiting factors | | | |
|---|---|---|---|---|---|
| | Season | Vegetation competition | Snow-press | Animal damage | Shallow soils |
| **Recommended stock types:** | | | | | |
| PSB 313B 1+0 | Sp | Poor | Poor | Poor | Fair |
| PSB 410 1+0 | Sp | Fair | Fair | Fair | Good |
| PSB 415B 1+0 | Sp | Fair | Fair | Fair | Poor |
| PSB 412A 1+0 | Sp | Good | Good | Good | Good |
| PSB 415D 1+0 | Sp | Good | Good | Good | Poor |
| PSB 512A 1+0 | Sp | Good | Good | Good | Good |
| PSB 515A 1+0 | Sp | Good | Good | Good | Poor |
| PSB 615A 1+0 | Sp only | Good | Good | Good | Poor |
| BBR 2+0 | Sp only | Good | Fair | Good | Poor |

# Western Hemlock (Hw)

At the upper elevational extreme of Hw, snowpress and frost damage may limit the suitability of the species. Mountain hemlock is better suited to these conditions although it may also be vulnerable to snowpress.

The major limiting factors that stock type selection can address are vegetation competition and animal damage.

Western hemlock may have a higher incidence of foliage disease than other species due to the dense canopies and tender shoots. It may be better to order larger container types in order to minimize the problem.

**Sowing Trends – 1993/1998**
Species: Western hemlock (Hw)

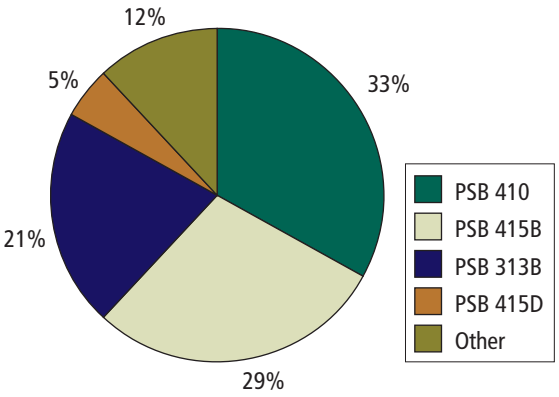
| | 1993 | 1998 |
|---|---|---|
| **% of total sowing of Hw** | | |
| 1 + 0 | 98 | 99 |
| BBR/PBR | 1 | 1 |
| **# of stock types** | 11 | 10 |
| **Dominant container types** | 313B | 410/313B/ 415B |
| **Smallest container type** | 310A | 313B |
| **Largest container type** | 615A | 1015 |
| **Quantity sown (K)** | 7983 | 6376 |

New stock types since 1993: 1015/412A

**Hw stock type suitability.**

| Hw | | Limiting factors | | | |
|---|---|---|---|---|---|
| | Season | Vegetation competition | Snow-press | Animal damage | Shallow soils |
| **Recommended stock types:** | | | | | |
| PSB 313B 1+0 | Sp, Su, Fa | Poor | Poor | Poor | Fair |
| PSB 410 1+0 | Sp, Su, Fa | Fair | Fair | Fair | Good |
| PSB 415B 1+0 | Sp, Su, Fa | Fair | Fair | Fair | Poor |
| PSB 412A 1+0 | Sp, Su, Fa | Good | Good | Good | Good |
| PSB 415D 1+0 | Sp, Su, Fa | Good | Good | Good | Poor |
| PSB 512A 1+0 | Sp, Su, Fa | Good | Good | Good | Good |
| PSB 615A 1+0 | Sp, Su, Fa | Good | Good | Good | Poor |
| PBR 211A 2+0 | Sp | Good | Good | Good | Poor |

**Hw stock type profile, 1998 sowing**
(6376 K seedlings total)



# Mountain Hemlock (Hm)

This species is important in reforestation of coastal and southern interior wet high elevation forests, although it is susceptible to drought, Armillaria, and branch and stem breakage from the combined effects of snow and vegetation. The major limiting factors that stock type selection can address for Hm is vegetative competition and snowpress. Hm may have a higher incidence of foliage disease than other species due to the tender shoots and dense foliage. It may be better to order larger container types to minimize the problem.

**Sowing Trends – 1993/1998**
Species: Mountain hemlock (Hm)

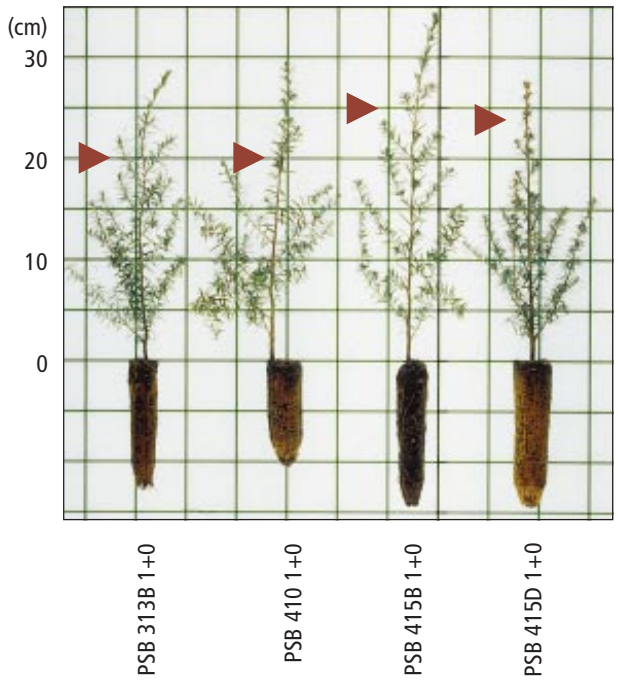
| | 1993 | 1998 |
|---|---|---|
| **% of total sowing of Hm** | | |
| 1 + 0 | 93 | 100 |
| BBR/PBR | 0 | 0 |
| **# of stock types** | 3 | 5 |
| **Dominant container types** | 313B | 410A |
| **Smallest container type** | 313B | 313B |
| **Largest container type** | 415B | 415D |
| **Quantity sown (K)** | 63 | 245 |

New stock types since 1993: 415D

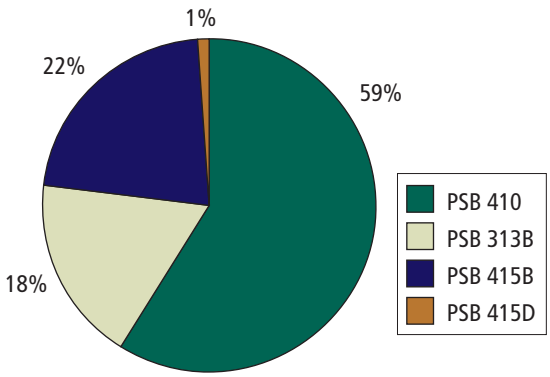
**Hm stock type suitability.**

| Hm | | Limiting factors | | | |
|---|---|---|---|---|---|
| | Season | Vegetation competition | Snow-press | Animal damage | Shallow soils |
| **Recommended stock types:** | | | | | |
| PSB 313B 1+0 | Sp, Su, Fa | Poor | Poor | Poor | Fair |
| PSB 410 1+0 | Sp, Su, Fa | Good | Good | Good | Good |
| PSB 415B 1+0 | Sp, Su, Fa | Good | Good | Good | Poor |
| PSB 412A 1+0 | Sp, Su, Fa | Good | Good | Fair | Good |
| PSB 415D 1+0 | Sp, Su, Fa | Good | Good | Good | Poor |

PLATE 35. Hw and Hm stock types. Note the shorter, darker needles and larger buds on the Hm. (Arrowheads indicate target heights.)




**Hm stock type profile, 1998 sowing**
(245 K seedlings total)



# Yellow-cedar (Yc)

The major limiting factors that can be addressed by stock type selection for Yc are snowpress, and light browsing. In areas where browsing is severe, even larger stock types may not be effective.

Like the *Abies* species, Yc requires a 12-week seed treatment. Because seed supply is lower than demand, the species is also raised as rooted cuttings (CRC). In the nursery, CRC may display juvenile foliage and poor stem form, but these do not persist in plantations.

**Sowing Trends – 1993/1998**
Species: Yellow-cedar (Yc)

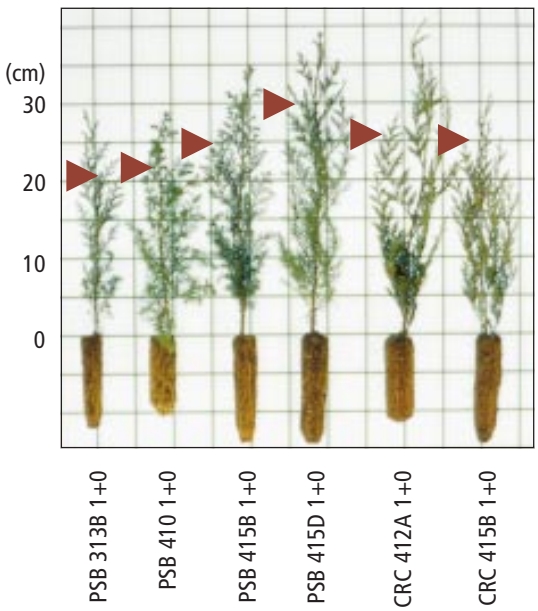
| | 1993 | 1998 |
|---|---|---|
| **% of total sowing of Yc*** | | |
| 1 + 0 | 85 | 96 |
| BBR/PBR | 0 | 1 |
| **# of stock types** | 5 | 13 |
| **Dominant container types** | 313B | 313B/410 |
| **Smallest container type** | 313A | 313B |
| **Largest container type** | 615A | PPT 615A 1+1 |
| **Quantity sown (K)*** | 628 | 1701 |

New stock types since 1993: 410/412A
* Includes cuttings.

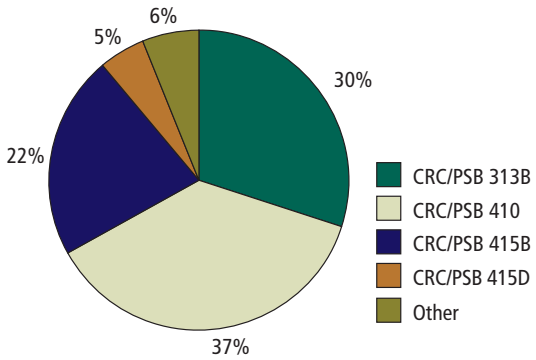
**Yc stock type suitability.**

| Yc | Season | Limiting factors: Vegetation competition | Snow-press | Animal damage | Shallow soils |
|---|---|---|---|---|---|
| **Recommended stock types:** | | | | | |
| CRC/PSB 313B 1+0 | Sp, Su, Fa | Poor | Poor | Poor | Fair |
| CRC/PSB 410 1+0 | Sp, Su, Fa | Fair | Fair | Fair | Good |
| CRC/PSB 415B 1+0 | Sp, Su, Fa | Fair | Fair | Fair | Poor |
| CRC/PSB 412A 1+0 | Sp, Su, Fa | Good | Good | Fair | Good |
| CRC/PSB 415D 1+0 | Sp, Su, Fa | Good | Fair | Good | Poor |

PLATE 36. Yc stock types. Note the mature needles on the rooted cuttings. (Arrowheads indicate target heights.)




**Yc stock type profile, 1998 sowing**
(1701 K seedlings total)*




* 39% of sowing request is for rooted cuttings (CRC)

# Hardwoods

Sowing requests for hardwood species have increased in recent years. This is associated with a growing recognition of the value of hardwoods for short rotations, biodiversity, wildlife habitat, riparian area management, their contribution to nutrient cycling, utility for sites difficult to manage for conifers, conifer nurse crops, and their resilience to root rots.

## Paper Birch (Ep)

Establishment of planted paper birch seedlings is influenced by a number of limiting factors including brush competition, excessively dry conditions, sunscald, and animal browsing. Because of the difficulties of initial establishment it is desirable to plant stocky seedlings with a vigorous root system and buds along most of the stem. The presence of leaves on the lower stem is important for preventing sunscald damage. Pruning in the nursery is not recommended.

Plate 37 shows birch seedlings in greenhouse production. PSB 515A 1+0 stock type has so far proven to be acceptable to date for both spring and summer plants. The PSB 415D appears to be suitable for summer plant, but is not recommended for spring plant as seedlings become too crowded in the blocks during the longer nursery growing cycle. Smaller container sizes and bareroot stock are not recommended for paper birch.

Detailed information about all aspects of paper birch management is provided in the *Paper birch manager's handbook for British Columbia*, FRDA Report (1997).

## Black Cottonwood (Ac)

Initial establishment of cottonwood is strongly influenced by brush competition, drought, late spring and early fall frosts, animal browsing, and foliage diseases.

Stock type selection is influenced by the combined consideration of management regime and limiting factors. Unrooted cuttings are a common stock type for intensive poplar farming. Cuttings are typically 40 to 50 cm in length, planted up to 30 cm deep. Genetically superior hybrids play an important role in poplar farming.

For fill planting of poplar farm plantations, or planting on less intensively managed plantations, large unrooted whips from 100 to 250 cm are often used. These larger whips develop leaves above the competing vegetation, but are prone to "planting shock" in the first growing season as the root system establishes.

Unrooted cuttings obtained from managed stool beds tend to be significantly more vigorous than cuttings obtained from wild stock.

PLATE 37. Birch seedlings growing in styroblocks at the Ministry of Forests, Kalamalka Research Station, Vernon. Photo credit: Andrea Eastham.

PLATE 38. Black cottonwood PSB 412A 1+0 seedling. Photo credit: Clare Kooistra.

Cottonwood can also be established successfully from stock grown in large styroblock containers (515A, 615A) from seed, or from cuttings rooted in the block. Experience gained by the Kalamalka Research Station suggests that the PSB 515A may be the optimal container size for black cottonwood rooted cuttings. PSB 412A or 415D appear optimum for stock types grown from seed (Plate 38).

Planting should occur a few weeks before bud burst. Microsite selection should avoid both dry and inundated microsites and ensure full light conditions. Cottonwood is very shade intolerant and will succumb quickly to overtopping vegetation.

Stored cuttings and plug stock are frozen for overwinter storage. One to two weeks prior to planting, storage of whips or cuttings in black plastic bags at 2 to 5°C is recommended to improve moisture content and promote initiation of root primordia.

Detailed information about all aspects of cottonwood management is provided in the *Black cottonwood and balsam poplar manager's handbook for British Columbia*, FRDA Report 250 (1996).

## Red Alder (Dr)

Establishment of red alder is strongly influenced by a number of limiting factors including brush competition, excessively wet or dry conditions, late spring and early fall frosts, sunscald, animal browsing, and insect damage. Because of the difficulties of initial establishment, it is desirable to plant stocky seedlings with a vigorous root system and buds along most of the stem. The presence of leaves on the lower stem is important for preventing sunscald damage.

Considerations of nursery cultivation influence stock type selection. Growing red alder in high density nursery beds leads to etoliation (tall spindly stock), increased watering requirements, which may result in foliage diseases (e.g., *botrytis*), and reduced branch and bud development on the lower stem.

It is anticipated that preferred stock types will become clear as nursery managers and silviculturists gain more experience with this species. The PSB 412A and PSB 415D may prove to be an acceptable stock type when limiting factors are not severe. For sites with high brush potential or animal browsing pressure, the extra expense of a 512A or 615A may be warranted. However, results to date from planting in B.C. suggest that plug transplant (05+05 PBR 410) stock will provide consistently better survival and early growth than container stock.

Planting precautions for red alder include the following:

1. Plant in spring after risk of frost but before the soil dries (recommended general planting window is from March 15 to April 30);
2. Plant deep (2–5 cm below root collar) on dry sites to offset drought impacts;
3. Do not plant in poorly drained microsites; and
4. Minimize storage time as alder dehardens rapidly and breaks bud soon after outplanting.

Due to the limited experience with red alder plantation establishment in B.C., the current stock types have not been rated with respect to ability to overcome limiting factors.

Detailed information about all aspects of red alder management is provided in the *Red alder manager's handbook for British Columbia*, FRDA Report 240 (1996).

## Trembling Aspen (At)

Small amounts of aspen have been grown in the past few years. Aspen is best propagated from seed since it does not root well from cuttings. Seed should be collected and sown in the same year because it quickly loses viability.

Aspen grows rapidly in the nursery, developing large amounts of foliar mass. PSB 415D is recommended as a container size.

# Native Shrubs

In the past few years, there has been an increasing interest in the propagation of native shrubs for forest environments. The reason for this has been primarily the implementation of the Forest Practices Code and its emphasis on the need to rehabilitate disturbed lands (e.g., roads, landings, and riparian areas), as well as the need to maintain biodiversity through species richness.

Native shrubs have been produced from a variety of species such as willow, dogwood, rose, Saskatoon berry, Oregon grape, and ninebark.

PLATE 39. A selection of native shrubs growing in styroblocks at the Ministry of Forests, Kalamalka Research Station, Vernon. Photo credit: Andrea Eastham.

Nursery cultural regimes for these species are being developed at several forest seedling nurseries across B.C. (Plate 39). Native plant production research is ongoing at the Ministry of Forests Kalamalka Research Station, Vernon.

Production systems and stock types for native shrubs are similar to those used for growing conifers (Plate 40).

For aid in selecting native plants for reforestation projects, contact regional reforestation staff, nursery services staff, nurseries who have grown these plants, and research staff. Other publications will be forthcoming soon to aid in this area.

PLATE 40. *Rosa woodsii* and *Physocarpus capitatus* (ninebark) grown in styroblocks.

# For More Information

Other sources of information that may be useful for making a stock type selection can be found in:

- Planting spot selection: Matching seedlings with microsite. Video. Ministry of Forests, Silviculture Branch. 1992.
- Seed planning and registry (SPAR) seedling information and seedling request user guide. Ministry of Forests, Silviculture Branch. 1992.
- Seed planning and registry (SPAR) – operating instructions. Ministry of Forests, Silviculture Branch. 1992.
- Stock handling. Video. Ministry of Forests, Silviculture Branch. 1989.
- Nursery to planting site: a team effort. Brochure. Ministry of Forests, Silviculture Branch. 1990.
- Working with your forest seedling nursery: Tips to selecting, ordering, and inspecting stock. FRDA Memo 176. 1991.
- Fundamentals of mechanical site preparation. FRDA Report 178. 1992.
- Diseases and insects in British Columbia forest seedling nurseries. FRDA Report 065. 1990.
- Tree seed centre – A guide to cone and seed services. Ministry of Forests, Silviculture Branch, Tree Seed Centre. 1992.
- Stock trading procedures. Ministry of Forests, Silviculture Branch. 1992.
- Regenerating British Columbia's forests. University of British Columbia Press. 1990.
- Establishment to free growing guidebooks. Province of British Columbia. 1995.
- Summer frost in young forest plantations. FRDA Report 073. 1989.
- Identification and management of summer frost-prone sites in the Cariboo Forest Region. FRDA Report 157. 1990.
- Planter screefs may increase frost heaving. Ministry of Forests, Forest Practices Branch. Regeneration Note 4. 1994.
- Measures to reduce overwinter injury to planted spruce in the boreal forest of B.C. FRDA Report 254. October, 1996.
- Static tests of lodgepole pine stability in the central interior of British Columbia. M.J. Krasowski, C. Hawkins, H. Coates, and P.K. Ott. Can. Jour. For. Res. 26. pages 1463–1472. (Erratum published CJFR 27, page 6018, 1997).

- Water relations, survival and growth of Douglas-fir seedlings at a pinegrass dominated site in south-central British Columbia. FRDA Memo No. 121, 1989.
- Seedling microclimate. FRDA Report 130.1990.
- High elevation regeneration strategies for subalpine and montane forests of coastal British Columbia. FRDA Report 229. 1995.
- Field performance of several tree species and stock types planted in montane forests of coastal British Columbia. CFS Information Report BC-X-347. 1994.
- Forest regeneration in the ESSFa subzone: a problem analysis. FRDA Report 118. 1990.
- Forest regeneration in the ESSF zone of north-central British Columbia. CFS Information Report BC-X-351. 1994.
- Ecology and silviculture of interior spruce in British Columbia. FRDA Report 220. 1994.
- Thawing guidelines for tree seedlings. Ministry of Forests Nursery Services. 1995.
- Seedling barrier protection from deer and elk browse. Ministry of Forests. 1996.
- Aspen managers' handbook for British Columbia. FRDA Report No. 230. 1995.
- Red alder manager's handbook for British Columbia. FRDA Report 240. 1996.
- Paper birch manager's handbook for British Columbia. FRDA Report. 1997.
- Black cottonwood and balsam poplar manager's handbook for British Columbia. FRDA Report 250. 1996.
- A field guide to regeneration of salal-dominated cedar-hemlock (CH) sites in the CWHvm1. University of British Columbia. 1996
- Ministry of Forests silviculture manual. Chapter 6 – Planting. 1995.
- Reducing mammal damage to plantations and juvenile stands in young forests of B.C.; Operational Summary. FRDA Report 153. 1990.
- Effectiveness of reflective tarpaulins in protecting tree seedlings against heat stress. Feric Report TR115. April 1996.
- Seedling transportation: Effect of mechanical shocks on seedling performance. Feric Report TR114. January 1996.

## Internet Sites

- Oregon State University – Forest Regeneration (For 442) Notes. http://www.fsl.orst.edu/cof/teach/for442/f422.htm
- Forest Practices Branch web site. http://www.for.gov.bc.ca/hfp/hfp.htm
- Ministry of Forests, Forestry Division Services Branch – provides an online publications catalogue with search and ordering features. http://www.for.gov.bc.ca/scripts/hfd/pubs/HfdCatalog/Index.asp
- Little Cabin Books – provides planting related information and links to other planting related web sites. http://www.netshop.net/~littlec/home.html
- Canadian Forests Home Page – provides links to forestry related sites including research and educational institutions. http://www.canadian-forests.com/