PRODUCTION FACTS

Growing trees in Alaska can be difficult. This document addresses basic questions regarding growing tree seedlings as an agricultural crop. Whether growing a few seedlings or thousands, many of the basic production questions are the same.

From the standpoint of tree seedling production there are three basic regions in Alaska: Southeast, South Central, and the Interior. Producing high quality tree seedlings is achievable in all three regions however care must be taken to match tree species requirements with local environmental conditions. Through the efforts of the University of Alaska Fairbanks and the Agriculture and Forestry Experiment Station, many tree species have been evaluated over the past 100 years for their performance. Results from these species trials have led to the listing of tree species, growth characteristics, and site requirements found in Table 1.

DEMAND

Interest in tree production can vary from growing trees for your yard or property to full scale outdoor or greenhouse, bareroot, or container nurseries. Tree planting and tree sales continue to be of considerable interest to the public although there are no large-scale commercial tree nurseries currently operating in Alaska. A state tree nursery was once operated in the Matanuska Valley area, but it has been closed. Reasons for the closure were based upon the high cost of producing seedlings in Alaska versus what it would cost to import them from nurseries outside the state and also, the overall operational difficulties and risks associated with an Alaska nursery program. This has resulted in the demand for seedlings being met largely by Canadian and northwestern U.S. producers.

Estimates of annual planting demand are difficult to determine due to the number of nurseries contracted. Over 40,000 seedlings are estimated to be planted on private property (non-native corporation lands) in Alaska annually. The demand for seedlings has been further enhanced by the efforts of the Anchorage and Kenai boroughs to reforest forestland devastated by the spruce bark beetle. As a result, current contracts are underway to produce more than 1 million
seedlings. Additionally, it is estimated that more than 40,000 woody shrubs are planted annually in Alaska by private landowners based upon statistics from out-of-state nurseries.

In addition to tree seedlings for reforestation, Christmas tree sales account for over 50,000 trees sold each year, statewide. Christmas tree plantations have been attempted in Alaska with limited success. A typical Christmas tree of the 6-7 foot class will take about 8-12 years to develop. Christmas tree species for Alaska plantations include lodgepole pine, Scotch pine, jack pine, Siberian fir, and Colorado blue spruce.

Helpful References: (see reference #1, 2, 3, and 4)

**TREE PLANTING BY REGION**

Recent research has shown that northern latitudes such as those found in Alaska are particularly more impacted by global climate change than those found in the tropics. This climate change in Alaska has resulted in a substantial increase in growing season and growing conditions suited for non-local species. However, in spite of these increasing site temperatures and agricultural zone re-classifications, the phenological response of these plants to photoperiod has not changed since there has been no relative change in photoperiod. Plants from more southerly locations that may be now adapted to prevailing climate conditions but not to the extended summer daylight may find their phenological response to initiate the onset of winter hardiness is not being triggered as needed in order to enhance their winter survival ability. Consequently, for a given location, it is strongly suggested that a multi-year testing period be conducted in order to determine the survival and growth of non-local species. This is particularly true for species that are being moved from southern to more northern locations. Many non-local but boreal forest species such as Siberian larch, Lodgepole pine, and Siberian fir have performed exceptionally well in Alaska whereas Ponderosa pine and Douglas fir from more southern locations are not well adapted to Alaska although they can be found on cold sites in their native habitat which may reflect some photoperiod sensitivity. Although there may be substantial changes in local plant hardiness zones with warming climate conditions, phenological responses to prevailing photoperiods may limit our ability to establish some non-native tree species in Alaska.

Tree hardiness zones have been developed for Alaska and are summarized in the following diagrams. These hardiness zones can be used to help select tree species for your area by matching the hardiness zone recommendations with species of interest.
NON-NATIVE AND NATIVE TREE SPECIES GROWTH COMPARISONS

Considerable interest and concern has been expressed in recent years regarding the planting of non-native tree species in Alaska. Concern for the accidental release of invasive plants has lead to the development of Invasive Species Lists for Alaska. Although most tree species would not likely become noxious or invasive in nature it is helpful to know what species might be of concern. Dr. John Alden, in his report on Naturalization and Growth of Nonnative Conifers in Alaska, indicated that 20 year height and diameter growth of both lodgepole pine and western Siberian larch were significantly greater than that for white spruce when grown on the same site (Ref.#1). The average height growth of the white spruce was exceeded by Siberian larch, lodgepole pine, Scotch pine, jack pine, Dahurian larch, paper birch, and balsam fir. There is some evidence to suggest that the growth of white spruce may eventually exceed some of the early fast growing species, but more research is needed. Dr. Alden estimates that lodgepole pine and Siberian larch will soon become established as naturalized non-native conifers in Alaska. For a list of non-native and invasive plants in Alaska contact your local Alaska Cooperative Extension Service office or the web site established by the Alaska Committee for Noxious and Invasive Plants Management at www.cnipm.org.
Table 1: Listing of Trees Adapted to Alaska Environments (Ref #11)

<table>
<thead>
<tr>
<th>Species</th>
<th>Common Name</th>
<th>Hardiness</th>
<th>Height (ft.)</th>
<th>Seeds per lb</th>
<th>Pre-germination</th>
</tr>
</thead>
</table>

**Conifers:**

- **Abies concolor** White fir SC, SE (Zone 3) 30–130 11,100 28 days on moist medium at 34–41˚F
- **Abies lasiocarpa** Subalpine fir SC, SE (Zone 2) 20–80 34,800 28 days on moist medium at 34–41˚F
- **Abies sibiric** Siberian fir INT, SC, SE (Zone 1) 80 unknown 28 days on moist medium at 34–41˚F
- **Chamaecyparis nootkatensis** Alaska yellow cedar SC, SE (Zone 4) 40–100 108,000 30 days at 68˚F followed by 30 days at 40˚F
- **Larix decidua** European larch SE, SC (Zone 2) 30–70 70,000 None required
- **Larix gmelinii** Dahurian larch INT, SC, SE (Zone 1) 60–70 120,000 None required
- **Larix laricina** Eastern larch INT, SC, SE (Zone 1) 40–80 318,000 None required
- **Larix sibirica (sibirica)** Siberian larch INT, SC, SE, W (Zone 1) 40–100 44,000 None required
- **Picea abies** Norway spruce SC, SE (Zone 2) 100–200 64,000 None required
- **Picea engelmannii** Englemann spruce SC, SE (Zone 2) 100–165 135,000 None required
- **Picea glauca** White spruce INT, SC, SE, W (Zone 2) 40–115 226,000 7 days at 41˚F in water.
- **Picea mariana** Black spruce INT, SC, SE, W (Zone 2) 15–70 404,000 7 days at 41˚F in water.
- **Picea pungens** Colorado Blue spruce SC, SE (Zone 2) 80–150 106,000 30 days at moist medium at 34–41˚F after soak for 24 hours
- **Picea sitchensis** Sitka spruce SC, SE (Zone 7) 80–225 210,000 None required
- **Pinus albicaulis** White-bark pine SC, SE (Zone 3) 20–100 2,600 90 days on moist medium at 34–41˚F
- **Pinus banksiana** Jack pine INT, SC, SE (Zone 2) 35–100 131,000 7 days on moist medium at 34–41˚F
- **Pinus cembra** Swiss Stone pine INT, SC, SE (Zone 4) 30–70 2,000 90 days on moist medium at 34–41˚F after mech. scarific.
- **Pinus contorta var. latifolia** Lodgepole pine INT, SC, SE, W (Zone 5) 30–80 94,000 30 days on moist medium
- **Pinus contorta var. contorta** Shore pine SE (Zone 7) 20–30 135,000 20 days on moist medium at 34–41˚F
- **Pinus flexilis** Limber pine INT, SC, SE, W (Zone 2) 20–80 4,900 30 days on moist medium at 34–41˚F
- **Pinus mugo** Mugo pine INT, SC, SE, W (Zone 2) 6–40 feet 69,000 90 days on moist medium at 34–41˚F
- **Pinus sibirica** Siberian stone pine INT, SC, SE, W (Zone 2) 50–90 feet 1,800 Cold moist stratification
- **Pinus sylvestris** Scotch pine INT, SC, SE, W (Zone 2) 60–130 75,000 30 days on moist medium at 34–41˚F
- **Pseudotsuga menziesii var. menziesii** Douglas fir SC, SE (Zone 4) 150–200 39,500 21 days on moist sponge at 32–41˚F
- **Thuja occidentalis** Northern white cedar SC, SE (Zone 2) 40–100 346,000 None required
- **Tsuga heterophylla** Western hemlock SC, SE (Zone 6) 100–150 260,000 21 days on moist medium at 34–41˚F
- **Tsuga mertensiana** Mountain hemlock SC, SE (Zone 4) 25–125 114,000 90 days on moist medium at 34–41˚F

**Deciduous:**

- **Acer glabrum var. douglasii** Douglas maple SC, SE (Zone 3) 20–30 13,400 Warm followed by cold strat.
- **Acer negundo** Boxelder maple SC, SE (Zone 2) 30–75 13,400 60 days on moist medium at 34–41˚F
- **Acer platanoides** Norway maple SC, SE (Zone 3) 40–100 2,800 90 days on moist medium at 34–41˚F
- **Acer rubrum** Red maple SC, SE (Zone 3) 40–90 22,800 None required
- **Acer saccharinum** Silver maple SC, SE (Zone 3) 50–90 1,780 None required
TREE NURSERY SITE ASSESSMENT — WHAT ARE THE CONDITIONS? (Ref. #9)

Selecting an outdoor bareroot nursery site requires attention to the environmental conditions and fluctuations that may occur year-round. Problems with seedling mortality caused by insects, diseases, and environmental conditions can be minimized by careful consideration of site conditions. To produce economical high-quality seedlings for sale to the public, careful attention to site conditions is essential. Tree seedlings can be impacted by both biological (biotic) and non-biological (abiotic) factors (Table 2). When considering a location for seedling production, concern should be given to these factors.

<table>
<thead>
<tr>
<th>Non-biological Factors:</th>
<th>Biological Factors:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold Temperatures: Cold or frozen soils and permafrost or partial permafrost conditions. Be concerned about slope aspect and elevation and precipitation patterns. Frozen soils at times of lifting or root pruning could result in damage to seedlings</td>
<td>Fungal infections including evidence of root rots, molds, and other related fungal conditions affecting roots and leaves. Avoid boggy wetlands or poorly drained soils.</td>
</tr>
<tr>
<td>Wind: Exposed areas with high wind potential should be avoided. Wind can be a cause of several problems including excessive moisture stress and mechanical damage to seedlings.</td>
<td>Bacteria and viruses that can cause mortality or defoliation. Avoid species that are known to be highly susceptible. Seedlings can be very susceptible to damping off disease and other disorders that can destroy large numbers of trees.</td>
</tr>
<tr>
<td>Soil Condition: Poor quality soils with nutrient deficiencies, high or low pH, salt. Be sure to do soil sampling for the entire plantation area. Soils low in N and other nutrients can be augmented if necessary. Be careful of poor drainage that may cause contamination such as by salt from roads. Avoid areas of low pH below 4.0 or exhibiting metal toxicity.</td>
<td>Areas of high moose browse can cause severe damage unless fenced and controlled. Damage by browsing animals can cause loss of trees and value. Consider how you will control pests, possibly by fencing.</td>
</tr>
</tbody>
</table>
Mechanical injury: Muddy or boggy soils may cause machinery problems that could cause damage to seedlings. Coarse textured sandy soils are best for lifting seedlings without damaging the root systems.

Birds that can consume seed and damage seedlings. Does the area have a bird problem?

Heat: Avoid sites with excessive heat exposure which may cause problems with costs for irrigation and associated plant moisture stress and loss of seedling growth.

Weeds and weed control measures. Be aware of herbicide and pesticide application limitations for the nursery area.

Avoid droughty or water logged soils: Excessive moisture stress a wet root condition can cause seedling mortality. Wet soils are also sources of fungal infections.

Alaskan forest soils can be prone to mosses and algae that can be damaging to seedlings or difficult to control.

Improper species selection for Alaskan day length. Variety not suitable for northern photoperiod.

AN EXAMPLE OF HIGH QUALITY SPRUCE SEEDLING PRODUCTION

If you are interested in producing commercial quality seedlings for sale in Alaska you should consult with the American Standards for Nursery Stock which was originally published in 1923 by the American Nursery and Landscape Association. The latest edition of the standards is ANSI Z60.1-1996 and is available upon request directly from the ANLA or their web site http://www.anla.org/.

Seeds for Planting: There are several national and international seed companies that can provide seed for growing seedlings. However, care must be taken to consider the source of the seed and whether or not it is certified seed. Certified seed has documentation for proof of source location to further assist in determination of seed origin and seed zone classification.

Variations in local and regional environmental conditions limit where seeds can be grown successfully. Variations in climate and environment throughout a region are the basis for the development of seed transfer zones. Some rules to follow regarding seed collection include:

1. Maintain a record of the source location of the seed used. Include the seed zone, latitude/longitude, aspect, and elevation of the seed source and keep this information on a tag with the seed storage bag at all times.

2. Collect seeds from at least 30 well distributed and high-quality trees throughout the area of collection.
3. Try to collect seeds from sites similar to where you will be planting them (features including elevation, soil type, latitude, amount of moisture available, and aspect).

4. Try to avoid transfer of seeds from upland areas to lowland or riparian sites and vice versa. Try to avoid transfer of seedlings beyond natural barriers such as mountain ranges or above tree line.

5. Restrict seed transfer to within 500 feet in elevation of the collection source.

COLLECTING SEEDS

White, Sitka, and black spruce cones all mature in the fall (late August through September) in Alaska. Squirrels collecting cones can be an indicator of seed ripeness. However, you can better estimate seed ripeness by cutting several cones in half lengthwise and examining a cross sectional cut through the seeds. Seeds with embryos extending at least 80-90 percent of the length of the seed cavity are considered to be sufficiently ripe to be viable.

Care in collecting tree seed is important since molds and excessive moisture and/or high temperatures can damage the ability of seeds to germinate. Also, care should be taken to assure that the cones are not collected too early, since this can significantly reduce seed viability. If the cones are collected too late, many of the good seeds may have already been shed, since the cone scales open during cone ripening releasing the seeds.

Tree seeds can be collected from standing trees, felled trees, or from squirrel caches. The seeds can be stored on racks in open mesh bags such as gunny sacks that allow the cones to dry while limiting the formation of molds. Each bag should be carefully tagged with information about the species, location of collection, and date of collection of the cones. The bags of cones should be filled only half full and should be stored in a covered, dry, well-ventilated location. A few weeks to a month of drying, depending on environmental conditions, will be required before the cones open to release the seeds. Collect and cleanse the seeds using a screen box to sift debris from the cone bags and isolate the tree seeds.
Seeds should be dewinged and stored in dry plastic bags or sealed containers and refrigerated. The containers must be sealed against moisture.

**SEEDLING PRODUCTION**

Tree seedling producers must make a choice whether to produce bareroot seedlings using native soils in an outdoor environment or whether to produce container seedlings planted in artificial medium usually under controlled environmental conditions in a greenhouse. Bareroot seedlings will tend to have larger, more developed root systems and can be grown in-place for two or more years before outplanting. Culturing techniques such as bed wrenching and root pruning can be used with bareroot stock to enhance the quality and mass of roots and modify the shoot to root ratios. However, Alaskan environments can create problems for bareroot nurseries due to the short growing seasons and cold soils, which can make it difficult to manage and lift seedlings at needed times.

Container seedlings have several advantages over bareroot stock. These include ease of processing seedlings for mass production and development of uniform seedlings that are easier to plant in harsh environments and the convenient, controlled application of mycorrhizal inoculation of root systems. Container seedlings are more easily grown inside greenhouses where it is easier to control day and night temperature regimes, day length and light intensity, watering and fertilizing, and carbon dioxide concentrations. Some drawbacks of container seedlings are that they are more prone to frost heave, they tend to be a smaller seedling at outplanting than bareroot seedlings, they have a higher potential for root binding, and they may be prone to more transplant shock and moisture stress.

There are a number of forest tree seedling containers on the market, several of which have been used in Alaska and generally occur in the form of either: 1) plastic tubes, 2) styrofoam blocks, or 3) pre-formed plugs. Nurseries and greenhouses can be contacted to purchase supplies of these container types. Tree containers vary greatly in size and design depending upon the size of the seedling being produced, root system developed, and planting medium being used. Commonly used tree containers include the Ray Leach Single Cell (tubes), plastic dibble tubes, styrofoam blocks, and Spencer-Lemaire Root Trainers.

When transferring the container seedlings to the field for planting, it is common to remove the tree seedlings from their containers, wrap them in plastic wrap and transport them in a damp and shaded enclosure or bag to the field for planting.

**GROWING MEDIUM FOR CONTAINER SEEDLINGS**

There are many alternative potting mixtures available for planting seed or seedlings in
containers. Commercially prepared media are available in convenient bulk wrapped cubes but are more expensive than self-prepared media which can be easily made from ingredients available at most commercial nursery/greenhouse retailers. Commonly used mixtures include 1 to 3 parts of medium textured peat moss to 1 part coarse to medium horticultural grade vermiculite mix. Also use of 0.3 to 0.5 parts Perlite can be added to the mixture, as well as fertilizer and micronutrients. The addition of magnesium sulfate or Dolomitic lime may also be needed, however too much can cause seedling nutrition problems. Conifer species prefer an acidic soil pH which also helps to reduce seedling losses to damping-off disease. Growers are cautioned that mineral soil should never be used for container media.

**SEEDLINGS AND TEMPERATURE CONTROL**

Cold stratification of tree seeds, a practice used to enhance germination success has been found to not be necessary for white and black spruce and fresh lodgepole pine seeds (stored lodgepole pine are recommended to have a 30 day pretreatment of 33° to 41°F on moist medium).

Conifer seeds will germinate best in 60 °F to 70° F conditions. Germination of seed will be inhibited if temperatures exceed 75°F. After the seedlings emerge, the recommended temperatures for seedling growth are 75°F to 80°F during the light period (day), and 65°F to 70°F during the dark period (night). Temperatures above 85°F to 90°F will inhibit seedling growth and survival. Care must be taken to assure that sufficient air circulation is provided for greenhouse environments. For guidance on germinating tree seeds consult the pre-germination requirements shown on Table 1 or consult Ref #4.

Maintaining proper temperatures for growing seedlings is especially critical for young seedlings. Excessive temperatures can lead to plant moisture stress along with the shutting down of photosynthesis under higher temperatures and increased respiration energy costs. Higher temperatures in greenhouses can be controlled by venting (by convection or fan driven or by use of a water-cooled baffle system) to draw moist air into the greenhouse which provides cooling by evaporation. Alternatively, cooling can also be achieved by use of shading or use of shade cloths to cover the seedlings or greenhouses to increase reflectance of solar radiation. A variety of materials can be used to provide shade including wooden lath and shade cloths.

Examples of temperature control are provided by Table 3 (Ref. #7).

**Table No. 3 : Example of Temperature Control by Use of a Shade Cloth**

<table>
<thead>
<tr>
<th>Shading Type</th>
<th>Light Intensity (Micromoles/s/m²)</th>
<th>Light Intensity (ft-candles)</th>
<th>Air Temp. (°C)</th>
<th>Air Temp. (°F)</th>
<th>Leaf Temp. (°C)</th>
<th>Leaf Temp. (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Shading</td>
<td>1,370</td>
<td>70,200</td>
<td>36</td>
<td>97</td>
<td>40</td>
<td>105</td>
</tr>
<tr>
<td>50% Shade Cloth</td>
<td>525</td>
<td>27,000</td>
<td>32</td>
<td>90</td>
<td>32</td>
<td>90</td>
</tr>
</tbody>
</table>

Additionally, cooling of seedlings especially within greenhouses can be achieved by use of a short burst of mists during the hottest period of the day. Combining misting with the use of
light colored mulch rock or material can effectively help to control heat damage to the stem area of the seedling.

Young seedling losses due to damping off syndrome can be a serious problem resulting in significant losses of seedlings (see pest control section).

Once the seedlings have grown to 8 inches tall, gradually reduce the growing temperatures 5 to 10 degrees per week (especially if possible during the dark period) in order to prepare them for being transplanted. Reduced temperatures, shorter day lengths (photoperiod), and perhaps lower light intensities are necessary to induce dormancy and the hardening of seedlings for eventual transplantation. Cool temperatures and even mild frost during the night periods can be beneficial to completion of the hardening process for over-wintering container grown seedlings.

ILLUMINATION REQUIREMENTS

Conifer seeds germinate well at low light intensities and germination can even occur in full darkness. The minimum photoperiod and light intensity recommended for the seedling emergence phase at latitudes north of 60° are 20 hours at 350 micromoles/m²/sec or 1/3rd full sun light. Optimum average light intensities are likely in the 900-1200 micromoles/m²/sec range during the period of rapid seedling growth. Maximum outdoor light intensity on a clear day in mid June at Fairbanks is about 1800 micromoles/m²/sec. Consequently, if possible, it is recommended that some form of shading be used to control light intensity by as much as 30%. Various shade cloth materials are available for use in shading which vary depending upon the thickness and color of the cloth. Germinating seedlings are especially susceptible to high light intensities and may require additional shading to further reduce light down to the level of 200-350 micromoles/m²/sec before being placed under higher light intensities during their rapid growth phase.

Once the seeds have germinated and the seedlings begin the period of rapid elongation (usually lasting about 60 days) it will be necessary to maintain a 20 to 22 hour light period. As the time approaches for outplanting or hardening it will be necessary to reduce the photoperiod back to between 12 and 16 hours. Most nurseries harden seedlings under natural conditions of light and temperatures. Artificial darkness is often required to reduce photoperiods and harden low latitude seedlings (seeds derived from southern latitudes) during late summer at high latitudes (60° to 68° North). The problem of growth cessation, dormancy, and winter hardening of stock in the nursery is avoided if the seedlings can be transplanted to the field by June or early July (Ref. #11).

FERTILIZER RECOMMENDATIONS

Bareroot seedlings (seedlings grown and managed in field soils): Fertilizing seedbeds is very important to maintain the health and vigor of your seedlings. Applications of fertilizer can be made either by top dressing over the seedbed or by incorporating it directly into the planting media. You will need to determine how much and what kind of fertilizer is needed. Both nitrogen (N) and potassium (K) are soluble and
can be carried to the root zone of the seedlings via the irrigation water and consequently can be spread on the surface of the seedbed. Phosphorus (P) is much less soluble and so must be incorporated into the soil in granular form or applied as liquid fertilizer.

Once the seedlings have emerged and grown beyond 8 centimeters (3 inches) you will need to apply an application of a balanced formula fertilizer such as 10:10:10 (N:P:K) at the recommended rate of 7 ounces per 100 square feet of bed space (Ref.#1). This should be applied twice in the summer (ie. June and July) but discontinued after July 15th. You will need to apply water immediately after fertilizing to flush off any fertilizer adhering to the foliage and facilitate its transport to the root zone. Intensive fertilization schedules are available for bareroot seedlings, depending upon soil pH. For soils that are acidic or have pH’s less than 7.0 you should select ammonium phosphate (11:52:0) If you have basic soils with pH’s higher than 7.0 then you should use ammonium sulfate (21:0:0:26) as your nitrogen source which will also help to lower the soil pH over time.

Container Seedlings:
Fertilizer recommendations for container seedlings can vary depending upon the soil medium characteristics such as pH. Commercially prepared soil mediums commonly include a starter fertilizer incorporated in the medium.

For preparing self-mixed growing medium, slow release fertilizers such as Osmocote (17-7-12) are suggested along with additions of MagAmp and Micromax for macronutrient and micronutrient needs. The practice of nutrient loading is commonly used to reduce transplanting shock by apply fertilizer after the seedlings enter dormancy and before being outplanted.

SEEDBED DEVELOPMENT AND PLANTING RECOMMENDATIONS

Bareroot tree nurseries generally use raised seed beds (ie. 4 feet wide and raised 3 to 6 inches). This approach promotes better soil drainage and soil warming. Wet soils can contribute to damping off and other diseases for the developing seedlings.

Seeds are usually sown in rows at a density such that each seedling will be able to grow without excessive competition. This approach also makes it easier to monitor and achieve uniform seedling survival and growth. Seedling rows are commonly planted at 6 inches or 12 inches between rows for the production of 2+0 seedlings (trees grown for two years in the same seed bed without being transplanted to a transplant bed). A general goal for seed bed density is to achieve approximately 25 seedlings per square foot with seedling spaced about 1 to 1.5 inches apart. Consideration must be given seed germination rates that are less than
100% so that additional seeds are planted to account for losses in seed germination. For example, if seed germination rates are only estimated to be about 65% then instead of planting 25 seed per square foot as would be used for 100% germination, you would need to plant about 38 seeds per square foot. You may need to test your seed to determine germination rates before planting your nursery beds (Ref #8). Germination rates can decline rapidly with older stored seeds.

**IRRIGATION OF SEEDLINGS**

To maximize seedling growth, photosynthesis, and seedling vigor it is necessary to minimize the level of plant moisture stress in the seedlings caused by inadequate irrigation, high temperatures, and excessive seedling transpiration. Watering is important, but don’t over-saturate the soil, as excessively wet soil can promote pathogenic fungi, especially “damping-off”. Initially, it is best to provide repeated light mistings. Once the seedlings have emerged and grown approximately one month, you can begin to irrigate the soil deeper, but not excessively. Watering can be done with an oscillating yard sprinkler as long as a consistent application of water is achieved. Drip irrigation and permanent sprinkler systems can be more effective in giving even applications of water, but may involve more cost and maintenance. A soaker hose can also be effective at providing irrigation water to the seedlings, although their delivery is often uneven at best.

Transpiration losses increases rapidly as the seedlings grow larger, increasing the potential for moderate to heavy plant moisture stress. It will become necessary to irrigate more frequently with multiple applications per day. As you begin to get closer to the time of transplanting or outplanting, you will want to develop some hardiness in the seedlings to limit transplanting shock. Hardiness can be developed by reducing the growth of the trees which may require lower temperatures, light, and water. Full dormancy and hardiness are not required for seedlings outplanted in late June or July, but to avoid stem breakage during the handling of the seedlings it would be helpful to partially harden them off so they are not as succulent and tender.

For container seedlings you need to keep the growing medium between field capacity (standing water at the surface) down to 70 percent of field capacity. As the seedlings grow, much more transpiration occurs, and you may have to water as often as several times daily. To initiate hardening of the seedlings it may be necessary to reduce water, temperatures, and light.

It is best to water seedlings early in the day with a deep watering. This will stimulate better root development and a better root to shoot ratio. During hot days, brief light misting during peak afternoon temperatures can lower the risk of damage to seedlings by high temperatures. Having a good mulch cover for the soil or container media can also improve water retention and uptake by the seedlings.

**HARVESTING AND TRANSPORT**

When harvesting seedlings the following guidelines should be observed. (Ref.# 2 and #3)

1. Be careful when lifting and handling the seedlings to make sure they are not exposed to excessive warm temperatures or drying of the roots. Preferred lifting temperatures (removal from the seed bed) should be
in the 40 to 50°F range.

2. Seedlings should be stored and transported in protective bags such as polyethylene bags, waxed boxes, or open-ended peat moss bales. The interior of the bags should be kept moist by adding wet sphagnum moss.

3. Keep the seedlings cool or refrigerated during transport and while awaiting planting. Once the seedlings have broken bud do not refreeze them. (Storage temperature should be kept around 35 to 40°F)

The use of high tunnels in Alaska may also assist in the production of high quality seedlings in non-heated plastic structures having lower cost per tree than that produced in heated greenhouses. Living tree sales are undergoing research and may prove to be viable for our climate.

INTEGRATED PEST MANAGEMENT PRACTICES

Although commercial spruce tree seedling production does not currently exist in Alaska, many woodlot managers, foresters and landscapers utilize some form of IPM practices. Alaskan forests are relatively free of many major pests that persist in lower 48 forests, however due to Alaska’s expansive spruce monocultures; the destructive pests that are present have caused extensive damage. Spruce plantations in Alaska risk potential infestation and damage by the following agents. Careful monitoring and prescribed pesticide applications can provide control of damage and reduction of potential tree losses. In addition to insects and disease found in Alaska, trees also can be damaged or destroyed by moose, vole, hares and porcupines. These indigenous vertebrates should be considered when planting. Fencing, arbor guard, and other exclusion practices will benefit new and established plantings

The quarantining of new plant materials and the monitoring of existing stands for newly introduced pest species continues to provide timely information in helping to avoid damage and subsequent reduction of valuable plantings. Thoughtful site selection for future stand
development, combined with careful thinning and pruning practices add value to healthy forest plantings.

**DISEASES**

- **Damping Off**
- **Spruce Needle Rust**
- **Rhizosphaera Needlecast**

**Damping Off** – (*Pythium*/Phytophthora): Although damping off syndrome can be caused by either fungal infections or abiotic factors such as chemicals and fertilizers, their symptoms are somewhat similar in that seedlings tip over at ground level (root collar). It is important to monitor young seedlings for evidence of damping off syndrome and remove any dying or dead seedlings in order to reduce the risk of further contamination. Fertilizer applications and watering may need to be reduced if losses by damping off are not controlled. Contaminated or moldy seedlots exhibiting high germination losses to damping off disease may need to have the seeds treated with a 3% solution of hydrogen peroxide for four hours prior to germination to increase seedling survival. In some cases, a preplant chemical treatment may be required to minimize the effects of damping off disease.

**Spruce Needle Rust** (*Chrysomyxa ledicola* Lagerh.): This is a fungal disease that infests only the current years’ spruce needles but requires an alternate host to complete its life cycle. The infections are characterized by the presence of pale orange spore masses which erupt from the needles. The spruce needle rust (SNR) has an alternative host, Labrador tea *Ledum spp*, which must be present in the environment for the lifecycle of the rust organism to be completed. Control of Labrador tea within the ground vegetation around the trees out to about 1000 feet will provide some protection from further infections. The SNR can cause trees to be weakened and defoliation to occur but the infections are cyclical and dependent upon cool moist conditions for spore formation. Control is possible by fungicides for high value trees or seedlings where appearances are of concern.

**Spruce Needle Blight or Needle Cast**: There are three diseases in this class of needle fungal infections that affect spruce needles: (*Lirula macrospera* (Hartig) Darker), (*Lophodermium picea* (Fcl.) V.Hohn.) and (*Rhizosphaera pini* (Corda) Maubl.). Spruce needle cast or blight is usually not fatal to trees unless there are several successive years of attack. Outbreaks follow wet weather patterns that allow the spores to spread via rain splash. Infected trees are often localized but if control becomes necessary, carefully timed applications of fungicides have been shown to be effective. Nurseries may need to limit the time that the needles are wet.

**Spruce Needle Cast**: Spruce needle cast is a fungal infection that usually only appears on one year old needles, however, older needles on trees under stress can also be infected. The infection actually begins with an initial infection of the new-year’s growth of needles by spores which then don’t become pronounced until after the needles are one year old. Symptoms usually first appear on the tree’s lower branches and then progressively move upward in the tree. Black
Fruiting bodies will appear as dark spots or patches on the underside of the needles. Fungicide control of needle cast can be successful, but careful timing is required to apply the fungicide just as the needles are starting to emerge after bud break. Delayed application of fungicides will likely be much less successful in controlling the infection. Control may require planting alternative tree species that are not susceptible to spruce needle cast.

### Table 5. Chemical Options for Control of Spruce Needle Cast or Blight

<table>
<thead>
<tr>
<th>Fungicide</th>
<th>Product Rate</th>
<th>a.i. Rate</th>
<th>REI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bravo Weather Stik</td>
<td>2-5.5 pt/A</td>
<td>1.5-4.125 lb/A</td>
<td>12 hours</td>
</tr>
<tr>
<td>Kocide 2000</td>
<td>1.5-3 lb/A</td>
<td>0.81-1.61 lb/A</td>
<td>24 hours</td>
</tr>
<tr>
<td>Protect D/F</td>
<td>1-2 lbs/100 gal</td>
<td>2.4-4.8 lb/100 gal</td>
<td>24 hours</td>
</tr>
<tr>
<td>Spectro 90 WDG</td>
<td>1-2 lb/100 gal</td>
<td>0.9-1.8 lb/100 gal</td>
<td>12 hours</td>
</tr>
</tbody>
</table>

Note: Although rusts and needlecast typically attack older trees there is evidence to suggest that they can be a problem in plantations and nurseries. A more detailed description of spruce container diseases and insects can be found in Ref#6.

### MITES & INSECTS

- Spruce Spider Mite
- Spruce Budworm
- Spruce Aphid

**Spruce spider mite** (*Oligonychus ununguis*): The presence of spruce spider mites is indicated by yellow or bronzish stippling beginning near the needle bases. Infestations usually begin on older needles of the lower branches and spread upward as the mite population increases. Damaged needles may turn brown or reddish-brown. Fine webbing may cover the needles and twigs. The actual spider mites are very small and vary in color from greenish to orange, dark green or black, with orange legs. Spruce spider mites attack many species of conifers. They are usually spread by wind. These mites are often found on dusty roadside trees.

### Table 6. Chemical Options for Control of Spruce Spider Mites

<table>
<thead>
<tr>
<th>Insecticide</th>
<th>Product Rate</th>
<th>a.i. Rate</th>
<th>REI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insecticidal soap</td>
<td>2.5 fl oz/gal</td>
<td>0.16 lb/gal</td>
<td>12 hours</td>
</tr>
</tbody>
</table>

**Spruce Budworm** (*Lepidoptera: Tortricidae; Choristoneura*): This is a pest found throughout Alaska. They feed on foliage and buds of true firs, spruce, and Douglas fir. Mature larvae are green-brown and up to an inch in length. They destroy buds, new foliage, cones, and seeds. They typically attack the newer needles but repeated infestations can result in damage to older needles as well. Symptoms include defoliation or thinning of the upper canopy of the tree. Brown caterpillars emerge in mid-May and begin feeding on new needles. Large infestations show reduction in radial growth with top kill being common. Monitoring population buildups through trapping and visual observation along with a timely application of chemical controls if needed can be used to control defoliation and cone reduction.

Although this is not a common problem for seedling production in Alaska, it was felt that it would be beneficial to include control measures for existing trees ranging from seedling to fully mature. The present epidemic of eastern spruce budworm has caused considerable concern for landowners that are interested in planting and growing spruce seedlings.
Table 7. Chemical Options for Control of Spruce Budworm

<table>
<thead>
<tr>
<th>Insecticide</th>
<th>Product Rate</th>
<th>a.i. Rate</th>
<th>REI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biobit HP</td>
<td>0.25-0.75 lb/100 gal</td>
<td>0.145-0.436 lb/100 gal</td>
<td>4 hours</td>
</tr>
<tr>
<td>Sevin SL</td>
<td>0.75 fl oz/1000 sq ft</td>
<td>0.02 lb/1000 sq ft</td>
<td>12 hours</td>
</tr>
</tbody>
</table>

Spruce Aphids (Homoptera: Aphididae; Elatobium abietinum ) and Spruce gall aphids (Homoptera: Phylloxeridae; Adeligidae) are found in southeast Alaska up through the Interior. Population increases are directly related to mild winter temperatures and available soluble nitrogen. Stressed trees are more susceptible to damage, so with careful production practices the populations could be kept at a reasonable level. Removal of galls from high value trees is an efficient control method if done before adult emergence in summer. Commercially available insecticides are also effective.

Table 8. Chemical Options for Control of Spruce Aphids

<table>
<thead>
<tr>
<th>Insecticide</th>
<th>Product Rate</th>
<th>a.i. Rate</th>
<th>REI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azatin XL</td>
<td>21 fl oz/A</td>
<td>0.04 lb/A</td>
<td>4 hours</td>
</tr>
<tr>
<td>Talstar</td>
<td>5-10 fl oz/A</td>
<td>0.025-0.05 lb/A</td>
<td>12 hours</td>
</tr>
<tr>
<td>Tempo</td>
<td>1.5-5.4 oz/100 gal</td>
<td>0.012-0.042 lb/100 gal</td>
<td>Till dried</td>
</tr>
<tr>
<td>Insecticidal soap</td>
<td>3-5 fl. oz gal</td>
<td>0.014-0.024 lb/gal</td>
<td>12 hours</td>
</tr>
<tr>
<td>Endeavor 50WG*</td>
<td>2.5-5 oz/100 gal</td>
<td>0.078-0.156 lb/100 gal</td>
<td>12 hours</td>
</tr>
</tbody>
</table>

*Do not apply more than 48 oz./A per year.

Note: A more comprehensive review of insects and diseases of Alaska tree species can be found in: Insects and Diseases of Alaskan Forests, 2009. R10-TP-140. USDA Forest Service publication

REFERENCES


