Appendix C—Detailed Propagation Methods for Beargrass, Heather, Huckleberry, and Partridgefoot

Beargrass (*Xerophyllum tenax)*

According to the literature reviewed, two methods were found to propagate seed from the coarse evergreen perennial, *Xerophyllum tenax* (figures C–1a and 1b):

Figure C–1a—Beargrass, *Xerophyllum tenax*, is a dominant and durable species in many mountainous areas throughout the Pacific Northwest, making it a desirable restoration species. Drawings courtesy of the University of Washington Press (Hitchcock and Cronquist 1976).

Figure C–1b—Beargrass blossoms brighten alpine meadows during early summer.

Method A (From the University of Idaho Forest Research Nursery)

Begin by soaking the seed in a running water bath for imbibition (when the seed absorbs water and swells). Sow the seed into copper-treated styrofoam blocks called Copperblock (45-cell, 12-ounce [340-milliliter] trays) (Silvaseed Co., Roy, WA) in a medium of 50-percent peat moss and 50-percent vermiculite, along with a top covering of No. 2 nursery grit.

Saturate the medium with water and place all trays in a walk-in cooler for a cold stratification period of 7 months at 31 to 42 degrees Fahrenheit (–0.6 to 5.5 degrees Celsius). After this cold stage, place all trays into a greenhouse with temperatures between 70 and 81 degrees Fahrenheit (21 and 27 degrees Celsius). Some seed may have begun to germinate at this point. After 8 weeks, thin and consolidate the seedlings, leaving four or five plants per cell in the Copperblock trays. These plants will create enough root mass to fill each 12-ounce (340-milliliter) cell by the end of the 7-month growing season.

Provide 24-hour lighting in the greenhouse with a 500-watt halogen light, suspended 6 feet (1.8 meters) above the plants. Fertilize plants twice weekly 3 weeks after germina-

tion with Peter's 7–40–17 Conifer Starter (42 parts per million of nitrogen). Increase the nitrogen at 7 weeks, using Peter's 20–7–19 Conifer Grower (192 parts per million of nitrogen) and CAN 17 calcium nitrate (162 parts per million of nitrogen) once a week.

Six weeks before outplanting, turn off extra lights to begin hardening off the seedlings. Taper off watering slightly. After each mild moisture stress, apply Peter's 4–25–35 Conifer Finisher (24 parts per million of nitrogen), alternating with calcium nitrate (51 parts per million of nitrogen). Move the seedlings to an outside shadehouse for further hardening 1 month before planting. Maintain the same fertilization regime during this period.

After this process, all seedlings should be at least 6 inches (150 millimeters) tall with ample root growth. To transport seedlings into the backcountry, cover their roots with a plastic bag to keep them moist and pack them in cardboard boxes. Separate seedlings with enough paper to eliminate shifting.

Method B (From the Olympic National Park Greenhouse)

For fall sowing, collect seed and sow directly.

For spring sowing, two methods have been successful:

- Soak the seed in distilled water for 24 hours, sow in flats of vermiculite, cover with vemiculite, and keep moist. Cold stratify for 112 days at 37 degrees Fahrenheit (3 degrees Celsius). After this period, place the flats in a growth chamber at 64 degrees Fahrenheit (18 degrees Celsius) for 12 hours during the day and 55 degrees Fahrenheit (13 degrees Celsius) for 12 hours at night.
- Soak the seed in distilled water for 24 hours, sow in flats of peat/vermiculite/perlite/pumice medium (2:2:2:1), and keep moist. Cover flats with a cloth that is permeable to water and air and place them outside in a sheltered place until the spring. Uncover the flats before germination in the spring. Move them into a warm spot in the greenhouse when germination begins. Because the seedlings are susceptible to damping off, keep a dry layer of perlite on the surface of the flats.

Transplant seedlings into deep pots with well-drained planting medium and cover the seedlings with a thin layer of perlite to prevent crown rot. When transplanting new plants, be careful not to injure young roots at the base of the crown.

(Olympic National Park Greenhouse cited in: Rose, R.; Chaculski C.E.C.; Haase, D. 1998. Propagation of Pacific Northwest native plants. Corvallis, OR: Oregon State University Press: 60–61.)

Propagation of Red Mountain-Heather (*Phyllodoce empetriformis*) and White Mountain-Heather (*Cassiope mertensiana*) in the Olympic Mountains

Seed Collection and Propagation

The date of snow release varies annually for *Phyllodoce empetriformis* (figure C–2), but usually occurs between mid-June and mid-July. In the Olympic Mountains, Olmsted (1975) found that the number of days between snow release and flowering varied from 21 to 35 in two succeeding years. About 45 days from flower wilting until seed shedding is typical. Seed collections should take place from early September until snowfall.

Figure C–2—Red mountain heather (*Phyllodoce empetriformis*). Drawings courtesy of the University of Washington Press (Hitchcock and Cronquist 1976).

When the capsules (which are umbellike and borne terminally) change color, the seed has reached maturity. Capsules turn from yellow-green to red as they swell and darken to purplish-black. In mid- to late-September, capsules dehisce at the apex and the minute seeds are dispersed by the wind. Before seed dispersal, entire inflorescences can be detached with the stem tips and stored in paper bags.

Because the capsules of *Phyllodoce empetriformis* dehisce from the apex, if the inflorescences have been stored upside down, the seeds will drop to the bottom of the bag in a few weeks, where they will look like fine, yellow-brown dust. Seeds of this species are tiny—about 0.04 inch (1 millimeter) in diameter. Batches of pure seed can be gathered by sifting the contents of the bag through a No. 30 screen. The inflorescences can be abraded over the screen to dislodge the remaining seeds from the capsules.

Olmsted (1975) concluded that stratification of seeds at 39 degrees Fahrenheit (4 degrees Celsius) for 14 days enhanced germination by 20 percent. We have seen prolific germination with seed lots stored dry in polyethylene bags at low temperatures. Cold, moist stratification is probably not necessary for this species. As with many subalpine and alpine species, seed may need to be exposed to light for germination. Among high-elevation plants that exhibit some form of dormancy, photosensitive seed dormancy is more common than temperature-controlled dormancy (Amen 1966).

At Olympic National Park, we have propagated this species from seed for a number of years successively. Although some suggested that it would take 5 to 10 years for seed propagation, we have grown *Phyllodoce* from seed to a branched, 6-inch (150-millimeter) plant in 3 years. Here are some important generalizations to keep in mind when growing *Phyllodoce* from seeds:

- Seeds probably need light to germinate and should be sown on the soil surface. Never cover seeds with any soil medium.
- The seedlings are minute and grow slowly, needing a full year to reach a sturdy size that will survive transplanting.
- The seeds are even more sensitive to temperature fluctuations, extremes, and low relative humidity than are rooted cuttings. Flats of seedlings must be protected from desiccation and direct sunlight during the summer and transplanted during the winter or spring. Some mortality is to be expected, but mortality can be reduced by storing the flats in a cool shady place.
- Without importation of native soil with their mycorrhizal symbionts, heather seedlings need supplemental phosphorus and trace elements.

Soil Medium for Seed Propagation

Material	Percent of soil medium
High-grade sphagnum peat moss	40 to 50
Fine, aged Douglas-fir bark	30 to 40
Propagation-grade perlite or high-grade, 3/8-inch- (9.5-millimeter-) minus white pumice	10 to 20

Selection of Cuttings

Cuttings from lateral shoots of *Phyllodoce* growing in shaded understory will root easily, and should be taken in the semiripened region between the distal softwood candle and the proximal mature secondary (hardwood) growth. Cuttings that are too soft will deteriorate quickly. Hardwood cuttings require special treatment for rooting. The ideal semiripe cutting is between 3 and 5 inches (about 80 to 130 millimeters) long. The cutting should be long enough so that the semiripened portion of the stem can be inserted in a flat of propagation soil.

Avoid taking actively flowering or fruiting shoots, or shoots with newly set buds. Latent buds appear as small protuberances along the terminus of the softwood shoot. Tall specimens of *Phyllodoce empetriformis*, revealing the flush of etiolated, vegetative growth, which is valuable for stem propagation, occur abundantly in shaded areas under the canopy of *Abies lasiocarpa, Chamaecyparis nootkatensis*, and *Tsuga mertensiana* in high montane and subalpine plant communities. Heavily shaded ravines and streambanks with northwest and northeast aspects are good collection sites. In general, plants growing in full sun will be stunted and woody, and are less valuable for obtaining propagules. Shoots that develop in full sun also will have a shorter zone of semiripe wood.

Preservation of Cuttings

Keep fresh cuttings cool, moist, and aerated. Mature leaves of *Phyllodoce empetriformis* are frost resistant, but the new growth required for semihardwood propagation will burn (turn brown) if the temperature drops much below freezing.

1. Heavy 1-gallon (3.8-liter), zip-seal bags can be used for collecting cuttings in the backcountry. Fill each bag about half full. Thoroughly moisten the cuttings before sealing the bags for transport.
2. Store cuttings in the shade and put them under cover at night if the temperature will approach freezing. In the field, bags of cuttings can be stored by filling them with water and weighing them down with rocks in pools or along lakeshores.
3. When carrying cuttings from backcountry areas, leave an air cushion in the zip-seal bag to help keep the cuttings from being damaged. Carry the cuttings in a daypack strapped to the outside of your overnight gear. Bear-resistant food canisters work well for transporting cuttings.
4. Heather stem cuttings can be preserved for several weeks or longer with little loss of viability if they are handled properly at the greenhouse. Rinse the cuttings with fresh water and arrange them in bags so that air can circulate around them. Seal zip-seal bags to prevent cuttings from being desiccated in frost-free refrigeration systems. Cuttings deteriorate rapidly under anaerobic conditions, so they should never be stored in completely air-tight containers.
5. Store the bags in a refrigerator at 33 to 42 degrees Fahrenheit (0.6 to 5.6 degrees Celsius).
6. Rinse the cuttings regularly—every few days if possible—and inspect them for deterioration or desiccation. When cuttings are preserved for several months in this manner, they may begin to form roots in the bags. Cuttings should be treated and propagated as soon as possible after collection.

Treatment: Dilute Solution Presoaking

1. If the *Phyllodoce empetriformis* cuttings have been refrigerated for longer than a week or two, recut them, slicing a few hundredths of an inch (a few millimeters) from the proximal end (the end that was cut straight) with a razor blade or sharp pruner to remove any callus that may have formed and to open the vascular tissue. This will help rooting hormone be drawn into the stem.
2. Remove leaves within half of an inch of the basal end of each cutting.
3. Keep the cuttings in a bucket of cold water during preparation.
4. Mix the dilute soaking solution at a ratio of 1 tablespoon (15 milliliters) Dip n' Grow to 1 quart (0.95 liter) of water in a 1-gallon (3.8-liter) plastic bucket.
5. Make bundles of cuttings using 10-inch (250-millimeter) twist-ties and suspend the bundles in the solution to the depth required. We put 50 to 60 cuttings in a bundle, the number of cuttings that will be planted in a 10- by 20-inch (254- by 508-millimeter) flat. A quicker method is to place a standard 10- by 20-inch (254- by 508-millimeter) flat underneath an inverted plastic hemidome cover, which holds the solution. Insert the cuttings through the slots in the flat. You may use any other method that allows the proximal ends of cuttings to soak, but prevents the distal parts from contacting the solution.
6. Soak the cuttings for at least 24 hours.

Propagation Medium for Cuttings

Adequate drainage is the primary concern with soil media when propagating stem cuttings under intermittent mist systems. Cuttings media should contain enough fine sphagnum peat to lower the pH and give structure to the finely branched roots of *Phyllodoce, Cassiope*, and other ericaceous seedlings. Use equal parts fine sphagnum peat, fine aged bark and perlite for cuttings of these species under mist propagation. If sand is used for propagation, sharp quartz (blasting) sand is best, because it stimulates rooting and is less likely to compact. Small amounts of pumice may be substituted for perlite or sharp sand. One proven formula is described below.

Cuttings Medium for Mist Propagation

- One part fine sphagnum peat
- One part fine, aged Douglas-fir bark
- Two parts horticultural perlite ($\frac{3}{8}$-inch- [9.5-millimeter-] minus pumice or coarse, sharp sand)

Phyllodoce empetriformis, Cassiope mertensiana, and most ericaceous species root well in this mix and can be maintained for as long as 6 months before transplanting. *Phyllodoce* cuttings require longer than 3 months under mist propagation to develop root systems large enough to survive being transplanted into containers. The fine root structure in this species does very poorly in a saturated substrate. Most ericaceous species require soils that are moist but well drained, with high organic content and low pH.

Fifty to 60 cuttings fill a 10- by 20-inch (254- by 508-millimeter) flat efficiently, while allowing enough room for root development. Using a fixed number of cuttings allows the yield ratio to be calculated easily for the flat when the cuttings are potted.

Greenhouse Environment

The propagation environment should be designed to prevent high heat and low relative humidity, increasing the survivability of cuttings during rooting. Intermittent mist systems greatly increase the likelihood of rooting. Use a propagation bench with heating cables or hot water pipes to maintain an optimum bottom temperature of 65 degrees Fahrenheit (18 degrees Celsius).

Transplanting and Hardening Off

Stem cuttings of *Phyllodoce empetriformis* take 3 to 4 months to root. Cuttings are ready for transplanting when their root systems occupy most of the soil in a 10-by-20 flat and are poking out the bottom. Seedlings can be transplanted during the fall when cool weather arrives.

1. Seedlings grown under greenhouse conditions will need to be exposed to sunlight slowly and intermittently in a shaded area outdoors to prevent ultraviolet burn (that would cause the seedlings to turn brown).
2. Use pots that are 2 1/4 inches (57 millimeters) square by 2 1/2 inches (64 millimeters) deep for cuttings and seedlings. The root systems of some plants may require 3 1/2-inch (89-millimeter) deep pots.
3. The potting soil described at the end of this protocol works well for native heathers and other ericaceous shrubs.
4. The roots of heathers are sensitive to desiccation and disturbance. Transplanting is most successful when the air is cool and damp. Take care to minimize root handling. Use a table fork to lift the plants from the rooted or seeded flats. When transplanting from seeded flats, never attempt to transplant individual seedlings; always transplant small clumps of seedlings into pots.
5. Place the soil loosely around the root ball in the pot, and gently tap the bottom of the pot to settle the soil.
6. Water the plants immediately after transplanting with a solution of 9–45–15 water-soluble plant-starter fertilizer diluted to half strength. Maxicrop liquid seaweed can be added to the solution to provide trace elements.
7. Keep transplanted heathers in complete shade for several weeks. These species seem to tolerate moist soil conditions better than dry conditions, but plants that are overwatered or constantly inundated with rain do not fare well.
8. When warm weather arrives, spread wood shavings or bark over the potted heathers to keep the soil shaded and cool.
9. Apply a light watering in the morning to wet the mulch without inundating the soil; evaporation throughout the day will humidify the plants.

Continue a fertilizing regimen of 9–45–15 plant starter diluted to half the recommended strength and applied every 2 weeks. This mix should be supplemented with Maxicrop liquid kelp (at about one-quarter the recommended strength) to provide trace elements that are lacking in commercial soluble fertilizers. As in the formula given below, high-phosphorus bonemeal (3–15–0) should be added to the potting mix to bolster soil phosphate levels. As the growing season progresses, fertilize every 2 weeks with a water-soluble formula of:

Material	Percent in formula
Alaska Fish Fertilizer 5–1–1	60
20–20–20 water-soluble fertilizer	30
Maxicrop Liquid Seaweed	10

Potting Soil for Ericaceous Shrubs

1 cubic foot (0.03 cubic meter) of high-grade sphagnum peat moss

7 cubic feet (0.2 cubic meter) of fine, aged Douglas-fir bark

1 to 2 cubic feet (0.03 to 0.06 cubic meter) of high-grade, 3/8-inch- (9.5-millimeter-) minus white pumice

1 cup (0.24 liter) steamed bonemeal

or

Material	Percent of potting soil
Fine, aged Douglas-fir bark	70 to 80
High-grade, sphagnum peat moss	10 to 15
High-grade, 3/8-inch- (9.5-millimeter-) minus white pumice	10 to 15
Bonemeal	<1

Additional Considerations for *Cassiope mertensiana*

White mountain-heather occupies slopes with northerly and westerly aspects. Luxuriant specimens can be found in damp, shadowy ravines where it may be mixed with *Luetkea pectinata*. It layers readily in the field. Semiripe heel cuttings (where a little older wood is left at the base of the cutting) taken from nonflowering branches root strongly when hormone treatment is used.

The procedure for propagating *Cassiope mertensiana* (figure C–3) is similar to that for *Phyllodoce empetriformis*, using the same soaking solution, soil medium, potting treatment, and fertilizing regimen. Take 4- to 6-inch (100- to 150-millimeter) sprigs of *Cassiope* with several branches in the field and subdivide them at the greenhouse. Trim material that is excessively woody and clean just enough of the lower leaves or branches to immerse cuttings in the soaking bath and insert them in the cutting medium. Roots form abundantly along the lower branches at the leaf axils. If humidity is high, the cuttings may form aerial roots above the soil surface.

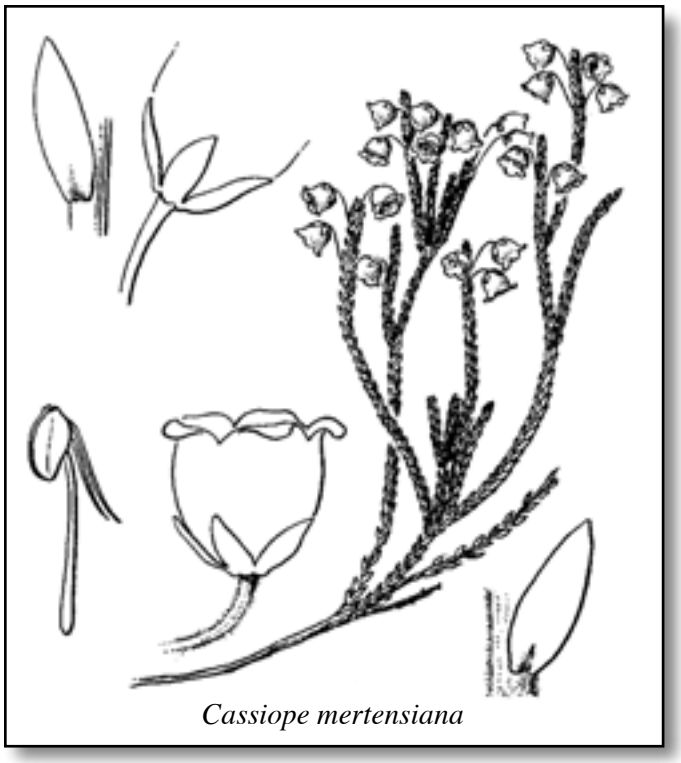

Figure C–3—White heather (*Cassiope mertensiana*). Drawings courtesy of the University of Washington Press (Hitchcock and Cronquist 1976).

Wilderness Impacts of Propagation With Cuttings

Cuttings taken from wilderness areas for front-country greenhouse propagation programs can have a significant impact. The goal should be to maximize greenhouse yield while minimizing impacts in the wilderness, such as trampling off trail and excessive pruning of localized populations of a given species. Surveys for good sources of cuttings near the revegetation area should be done early in the season, after

snow release. Try to locate as many collection areas as possible to spread the impact of pruning and to increase the genetic variability of the selected stock plants.

Emulating Field Conditions

Our primary recommendation on cultural treatments for increasing rooting, seedling establishment, and survival of difficult-to-grow ericaceous species is to try to reproduce the soil properties and climatic conditions that are observed in the field. This does not require mining wilderness sites for mycorrhizal fungi or replicating the exact nutrient content of native soils. Modest increases of native heathers, *Vacciniums*, and other ericads can be gained by paying attention to soil organic content, soil acidity, soil drainage, greenhouse environment, and plant nutrition. Use mist propagation systems, shade structures, bark soil amendments, and mulches. All of the local resources for soil ingredients should be investigated with the goal of replicating the conditions of native soil.

Figure C–4—Cascade huckleberry (*Vaccinium deliciosum*). Drawings courtesy of the University of Washington Press (Hitchcock and Cronquist 1976).

Huckleberry (*Vaccinium* spp.)

Vaccinium (figure C–4) *deliciosum* berries can be kept refrigerated in zip-seal bags or preserved in the freezer for extended periods until they are ready for processing.

Berry Forage and Processing

1. Process berries in a blender, using a 1:1 ratio of berries to water, until the berries are thoroughly macerated. Nongerminative seeds and pulp will float or sink slowly, so pour off some solution after a minute of settling to obtain a clean batch of seeds.
2. Spread the mixture of seeds, skins, and pulp, with some additional water, in a thin layer on ramey cloth fixed over a screen. Ramey cloth, also called raw cover, is a thin, white fabric often used to moderate temperatures and keep insects off plantings. Leave the cloth in the rain for 1 or 2 days to clean seed and rinse away saccharides and pectic substances or spray the cloth lightly with water from a garden hose. Do not allow the cloth to bake in the sun, because the seeds may stick to the ramey.
3. When the cloth has air-dried for a few hours, the seeds and remaining dry pulp can be scraped into paper bags and kept in a drying room for several weeks.
4. The dried seeds and excess material can be sifted through a screen to collect batches of pure seed.

Pretreatment

Vacciniums vary in their pretreatment requirements: *Vaccinium deliciosum* seed may not require cold stratification, while the seed of *Vaccinium membranaceum* and *Vaccinium ovalifolium* germinate inconsistently and very slowly without stratification. Chill the seeds in sealed plastic bags in the refrigerator for 1 to 3 months. Many *Vaccinium* species require stratification to break temperature-related dormancy.

The edaphic and other environmental conditions favoring the cultivation of *Vacciniums* are similar to those for *Phyllodoce empetriformis* and *Cassiope mertensiana*. Native *Vacciniums* exhibit a type of heterophylly, having evergreen leaves in the first season and deciduous leaves after the second season. *Vacciniums* prefer extremely acidic soil (pH 4.2 to 5.0).

For propagation of *Vaccinium* species, follow the same procedures described for *Phyllodoce empetriformis*. However, because *Vaccinium* seeds are much larger, sow them at a rate of 1/4 to 3/8 teaspoon (1.2 to 1.9 milliliters) in an 11- by 22-inch (280- by 560-millimeter) flat. As with heathers, never attempt to transplant individual seedlings; always transplant small clumps of seedlings into pots. Transplant the seedlings during cool weather and keep the new transplants in a shaded area for several weeks. The seedlings will still be small (1.6 to 2.4 inches, 40 to 60 millimeters) at the end of the first season and should be transferred from shade to sun over a period of 6 months.

Growing Partridgefoot (*Luetkea pectinata*) and Spiraea (*Spiraea splendens*) in the Olympic Mountains

Collect seed heads of these species when the follicles of dry fruit are beginning to open and the floral structure turns red-brown. Detach floral stems (racemes) down to the basal tuft with florist shears and store them in paper bags for one to several weeks at about 20-percent humidity or lower. Sift seeds through a No. 12 screen and store them in a zip-seal bag inside another zip-seal bag in the freezer.

Stratification Requirements and Seed Treatments

Because there appears to be no temperature-related dormancy in this species, cold stratification is unnecessary. We have seen prolific germination in both of these species without stratification. The seeds may need light to germinate and should be sown on the surface of the medium.

1. *Luetkea pectinata* (figure C–5) seed is sown during February and March on the surface of the seed germination mix. See the soil medium for ericad seed propagation. Follow this protocol for *Spiraea splendens* (figure C–6).
2. Press the seeds by hand or with a flat piece of plastic on the surface of the germination mix in 10- by 20-inch (254- by 508-millimeter) propagation flats at a rate of 3/8 teaspoon (1.9 milliliters) of seed per flat. As with the seed of high-elevation ericaceous shrubs, sow *Luetkea* seed on the soil surface.
3. Mist the flats generously and place them on heating mats outfitted with hemidomes or place them under intermittent mist with heating mats. Keep the soil moist until germination.
4. Maintain the soil temperature at 70 degrees Fahrenheit (21 degrees Celsius).
5. Germination will occur in 7 to 10 days (same as for *Spiraea splendens*).
6. When all the seeds have germinated, take the flats off the heating mats and remove the hemidomes during the day. Transition the flats of seedlings to ambient greenhouse temperature and relative humidity.

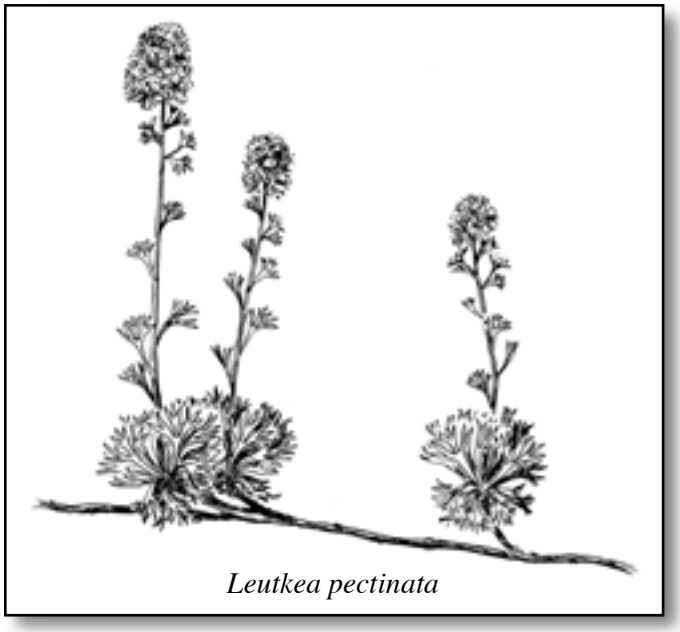

Figure C–5—Partridgefoot (*Leutkea pectinata*). Drawing courtesy of the University of Washington Press (Hitchcock and Cronquist 1976).

Figure C–6—Spiraea (*Spiraea splendens*). Photo courtesy of J.S. Peterson@USDA-NRCS PLANTS Database.

7. Apply a foliar fertilizer once every 2 weeks after the seedlings have developed true leaves, using a solution of 9–45–15 plant starter that has been diluted to one-fourth strength. Apply the fertilizer with a hand-pump applicator or pressure-tank sprayer as a fine mist until the seedlings are hardy and can support themselves. If the fertilizer is applied at high concentration or too early, the seedlings may burn (turn crispy brown), or excessive moss scum may proliferate in the flats. High nitrogen levels foster fungal pathogens, so never add nutrients to the soil media. Never fertilize seedlings while cotyledons are present. Wait until mature foliage has developed. Fertilize sparingly during the first 3 months of development.

Losses

Most losses of *Leutkea pectinata* occur after the onset of warm weather, when aphid infestations increase rapidly on seedlings stressed from transplanting. Aphid infestations also can occur rapidly. Green aphid species, common on *Luetkea* and *Spiraea*, sometimes can be detected only by using a hand lens. Aphids are commonly found on the underside of new foliage. Patches of wilting foliage and leaf curl are common symptoms of aphid infestation.

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