Plant Propagation Protocol for *Linnaea borealis* L.
ESRM 412 – Native Plant Production

TAXONOMY	
Family Names	
Family Scientific Name:	Caprifoliaceae
Family Common Name:	Honeysuckle
Scientific Names	
Genus:	*Linnaea*
Species:	*Linnaea borealis*
Species Authority:	L.
Variety:	
Sub-species:	*americana*
Cultivar:	
Authority for Variety/ Sub-species:	(Forbes) Hulten ex R. T Clausen
Common Synonym(s) (include full scientific names (e.g., *Elymus glaucus* Buckley), including variety or subspecies information)	*Linnaea Americana* (Forbes) *Linnaea borealis* L. var. *americana* (Forbes) Rehder
Common Name(s):	Twinflower
Species Code (as per USDA Plants database):	LIBOA
GENERAL INFORMATION	

Geographical range (distribution maps for North America and Washington state)	Native to Canada, Alaska and many northern US states. West coast range extends south to California. (2,7,8,10)  (2)
Ecological distribution (ecosystems it occurs in, etc):	Occurs in Boreal, North-Temperate and Subalpine Forests. (1)
Climate and elevation range	It grows at various elevations, from sea level to timberline. Most sources stated that twinflower was shade tolerant and intolerant, but was found more often in shade than sunlight. (3)
Local habitat and abundance; may include commonly associated species	Twinflower can be found in dense moist forests to less dense dry forests to rocky shorelines. Although most references gave wide variability of habitat, one source suggested that it is an indictor for “moderately dry-fresh soils” and is part of the *Mahonia nervosa*-group. Once established, twinflower spreads as a groundcover, although is not considered aggresive. It is associated with *Cornus canadensis, goodyera oblongifolia, Hykocomium splendens, Kinbergia oregana and Vaccinium parviflora*. In addition twinflower is very important to diets of bighorn sheep, caribou and roosevelt elk (1,3,4,5,7,10)
Plant strategy type / successional stage (stress-tolerator, competitor, weedy/ colonizer, seral, late successional)	Establishes is various levels of disturbance. Percent occurrence for young, mature and old growth forests were 89, 80 and 98 percent respectively. Establishes well after fire via stolen of unburned plants. (3,10)

Plant characteristics (life form (shrub, grass, forb), longevity, key characteristics, etc)	Evergreen shrub grows as ground cover and is low and trailing. Plants often sprout from stolens. Stem start less woody, but become woody over time (up to 0.3 cm diameter). Plants flower last 7 days in July through August. Flowers are pink, and hang down from plant in pairs. The fruit is sticky, dry and one-seeded. The seed is nutlike. (3,4,5,6,8,10)
PROPAGATION DETAILS **Vegetative**	
Ecotype	Major reference for this section was propagated from cuttings in Lodgepole forests from West Glacial is Glacier National Park. Ele. 1100m. (9)
Propagation Goal	Cuttings (3,5,9)
Propagation Method	Vegetative (9)
Product Type	Plugs (9)
Stock Type:	800ml containers (9)
Time to Grow (from seeding until plants are ready to be outplanted):	15 months (9) 9-11 months (3)
Target Specifications (size or characteristics of target plants to be produced):	Established Root systems with 2-3 runners, 15 cm long. Height of 2.5 cm. (9)
Propagule Collection (how, when, etc):	One source used 30 cm cuttings, harvesting in late June. (9) Other sources took cuttings that were 3-5 cm. These cuttings were taken July through October. Alright if taken in January if kept in greenhouse till planted. (3)
Pre-Planting Propagule Treatments (cleaning, dormancy treatments, etc):	30 cm cuttings were placed horizontal on top of media (1:1, Perlite/Sand) with mist and bottom heat at 21C. After 7 weeks plants which had grown from nodes where separated and replanted. 9 Separate plants from eat cutting were propagated. (9) 3-5 cm stems were placed in cold frame with 1/3 of the stem above ground.
Growing Area Preparation / Annual Practices for Perennial Crops (growing media, type and size of containers, etc):	Media used across various propagation methods was 50% sand. The other 50% was Peat or Perlite. (3,9) Beds were covered with shadecloth to promote root growth. Plants were then moved to a shade house for the rest of the season.

Establishment Phase (from seeding to germination):	30 cm cuttings took 6 weeks to establish in beds. (9) 3-5 cm cuttings established roots within 3-6 weeks. (3)
Length of Establishment Phase:	8 weeks (9)
Active Growth Phase (from germination until plants are no longer actively growing):	30 cm cuttings – Separated and planted in 800ml plugs with well draining media of 50% 6:1:1 milled sphagnum peat, perlite and vermiculite and 50% well fertilized sand. After growing in shade house and receiving 4 grams Osmocote and 2 grams Micromax per container through irrigation, the plants had reached maximum growth per container after 15 weeks. Plants flowered during 2nd spring and runners had formed.(9) For the stem cuttings that were 3-5cm long, stolens did not form for 5-10 years. (3)
Length of Active Growth Phase:	16 weeks (9)
Hardening Phase (from end of active growth phase to end of growing season; primarily related to the development of cold-hardiness and preparation for winter):	To harden plants, irrigation slowly reduced with time for 6 weeks. (9)
Length of Hardening Phase:	6 weeks (9)
Harvesting, Storage and Shipping (of seedlings):	Plants take 1.5 years to Harvest (sept.), and should be stored in an outdoor nursery from that is insulated and protected from snow. (9)
Length of Storage (of seedlings, between nursery and outplanting):	Typically stored for 5 months until spring. (9)
Guidelines for Outplanting / Performance on Typical Sites (eg, percent survival, height or diameter growth, elapsed time before flowering):	They can be outplanted in Spring or Fall. They can grow horizontally up to 30 cm in single year. Five (5) year survival rate is 33%. They flower in first year of outplanting.(9)

Other Comments (including collection restrictions or guidelines, if available):	Layering is another vegetative propagation method. This is usually done in gardens to increase concentration of individual plants, or create new plants for outplanting. To layer, plants are bent over and held down with a rock and the tip is put into the ground. This works best if the stem is cracked. After two years, the roots will have established and plants can be uprooted and transplanted. (3) Another method is to leave a flat filled with good soil next to a bed of *Linnaea borealis* L. in the Spring. Linnaea will spread into the flat and root. In the fall, the flat is ready to be harvested. Each individual can be separated and outplanted. (3) Both of these methods should only be done on a small scale.
PROPAGATION DETAILS SEED	
Ecotype	Major reference for this section was propagated from seed in Lodgepole forests from West Glacial is Glacier National Park. Ele. 1100m. (9)
Propagation Goal (Options: Plants, Cuttings, Seeds, Bulbs, Somatic Embryos, and/or Other Propagules):	Plants with established root system and runners(9)
Propagation Method (Options: Seed or Vegetative):	Seed (9)
Product Type	Plugs (9)
Stock Type:	160ml conetainers (9)
Time to Grow (from seeding until plants are ready to be outplanted):	9 months (9)
Target Specifications (size or characteristics of target plants to be produced):	Established root systems with 2-3 runners that are about 7 cm long. Height 2.5 cm. (9)

Propagule Collection (how, when, etc):	Fruits mature 36 days after flowering. Collection usually happens in Late July through September. To collect seeds, one can take bare hand and run it over plants. Seeds will stick to hand and can be scraped off into paper bag for storage before cleaning. This method only collects 1g per 10 minutes of work. (3,9)
Propagule Processing/ Propagule Characteristics (including seed density (# per pound), seed longevity, etc):	Germination rate is typically 50%. (9)
Pre-Planting Propagule Treatments (cleaning, dormancy treatments, etc):	Seeds can be cleaned through running them through sieves. Most references recommend a 60 cold stratification at 21 C. Some references found no difference between refrigeration and no refrigeration. Other sides recommended planting in fall for natural stratification in outdoor nursery after 60 day cold stratification. (1,3,9)
Growing Area Preparation / Annual Practices for Perennial Crops (growing media, type and size of containers, etc):	Seeds can be directly sown into pots in late fall. They should be surface sown in order to get light requirement. Medium used was 6:1:1 milled sphagnum peat, perlite and vermiculite. Media should also have slow-release fertilizer that can last the winter stratification phase. Seeds should be irrigated up to winter stratification. (9)
Establishment Phase (from seeding to germination):	Plants will germinates in late May. Most of the plants will germinate within one month following. (9)
Length of Establishment Phase:	4 weeks (9)
Active Growth Phase (from germination until plants are no longer actively growing):	Seedlings should be fertilized during active growth phase with 20-20-20 NPK at 100 ppm. Although lack of major root growth, shoot growth is very high and within the first 8 weeks many seedlings produced 2-3 stems. (9)
Length of Active Growth Phase:	12 weeks

Hardening Phase (from end of active growth phase to end of growing season; primarily related to the development of cold-hardiness and preparation for winter):	NPK should be changed to 10-20-20 at 100 ppm during hardening phase in fall months. Irrigation should also be greatly reduced during September and October and stopped during winterization.
Length of Hardening Phase:	4 weeks. (9)
Harvesting, Storage and Shipping (of seedlings):	Plants are ready for harvest in 9 months in September. This plant can be stored over winter in outdoor nursery with protection from cold. (9)
Length of Storage (of seedlings, between nursery and outplanting):	5 months (9)
Guidelines for Outplanting / Performance on Typical Sites (eg, percent survival, height or diameter growth, elapsed time before flowering):	Plants can grow up to 30 cm horizontally per year. (9)
Other Comments (including collection restrictions or guidelines, if available):	

INFORMATION SOURCES

References:	1) Baskins, Ferry M., Baskins, Carol C. Seeds; Ecology, Biogeography, and Evolution of Dormancy and Germination. San Diego: Academic Press, 1998. 2) USDA Plants database. <plants.usda.gov> 3) Potast, Laura L., Aubry, Carol A. Nature Plant Notebook; 2nd ed. Mt. Baker-Snoqualmie National Forest, North Cascade Institute, 1997. 4) Gilkey and Dennis. Handbook of Northwestern Plants. Corvallis: Oregon State University Bookstore, 1969. 5) Kruckebury, Arthur R., Gardening with Native Plants of the Pacific Northwest. Seattle: University of Washington Press, 1982. 6) Robson, Kathleen A., Richter, Alice S., Filbert, Marianne. Encyclopedia of Northwest Native Plants for Fargens and Landscapes. Portland: Timber Press, 2008. 7) Klinka, K., Krajina, V., Ceska, A., Scagel, A. Indicator Plants of Coastal British Columbia. Vancouver: University of British Columbia, 1989. 8) Pojar, J., McKinnon, A. Eds. Plants of the Pacific Northwest Coast: Washington, Oregon, British Columbia and Alaska. British Columbia: Lone Pine Press, 1994 9) Native Plant Journal <nativeplantjournal.org> 10) National Seed Laboratory <www.fs.fed.us>
Other Sources Consulted (but that contained no pertinent information) (full citations):	Young & Young. Seeds of Wildland Plants; Collecting, Processing and Germinating. Portland: Timber Press, 1986. The Royal Botanic Gardens. Seed Conservation; turning science into pratice. 2003. Ed. Roger Smoth, John Dickie, Simon Linington, Hugh Pritchard and Robin Probert. Great Britain: The Bromwell Press Ltd., 2003.
Protocol Author :	Joanne Pontrello
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Linnaea borealis Twinflower

Range
L. borealis is a circumboreal species, that occurs south to California, Arizona, New Mexico, South Dakota, Indiana, and West Virginia in open to dense woods.

Climate, elevation
Shoreline up to timberline

Local occurrence (where, how common)
Twinflower occurs in several grassland and many hardwood and coniferous forest types. In western Washington, it is named as a dominant understory or indicator species in montane forest community types.

Habitat preferences
Partial shade; open or dense forest; shrub thickets; boggy or rocky shorelines

Plant strategy type/successional stage (stress-tolerator, competitor, weedy/ colonizer, seral, late successional)
L. borealis is described as a pioneer species which spreads through the surface ash layer devoid of humus following a fire. Also described as a facultative seral species.

Associated species
In western Washington, *L. borealis* is associated with Douglas-fir/alder/maple forests, as well as wetland/bog communities containing *Pinus contorta*, *Pinus Monticola*, *Thuja plicata* and *Rhamnus purshiana*.

May be collected as: (seed, layered, divisions, etc.)
Division, cuttings, seeds

Collection restrictions or guidelines
Flowers from June to Sept., and seeds mature in 36 days.

Seed germination (needs dormancy breaking?)
L. borealis does not set very much seed, and its germination rate is about one in thirty. This makes propagation from seed, though it should be attempted as a parallel technique, prohibitive as a basic nursery approach to this species.

Seed life (can be stored, short shelf-life, long shelf-life)
Does not persist in seedbanks.

Recommended seed storage conditions
Air dry the seeds, and plant in fall.

Propagation recommendations (plant seeds, vegetative parts, cuttings, etc.)
Easy to propagate by division from young, rooted sections of runner, carefully detached from parent plants. Can also be grown from hardwood cuttings. If planting seeds in the spring, cold stratify for 60 days.

Soil or medium requirements (inoculum necessary?)
Sandy, acid soil (pH 5 to 6)

Installation form (form, potential for successful outcomes, cost)
Seed: germination rate is about one in thirty.
Divisions are most successful.

Recommended planting density
Not found

Care requirements after installed (water weekly, water once etc.)
Not found

Normal rate of growth or spread; lifespan
Less than 10cm tall. Very slow to establish; it takes seedlings about thirteen years to bloom. Vegetative reproduction by stolons is the primary method of regeneration. First produces stolons at 5-10 years of age. It is reported to spread as much as a 30 cm (1 ft) per year in lowland revegetation sites.

Sources cited

- Leigh, M. 1999. Grow You Own Native Landscape. Native Plant Salvage Project ; WSU Cooperative Extension—Thurston County.
- Pojar, J. and A. MacKinnon. 1994. Plants of the Pacific Northwest Coast Washington, Oregon British Columbia & Alaska. BC Ministry of Forests and Lone Pine Publishing, Vancouver, British Columbia, Canada 527 p.
- http://www.rook.org/earl/bwca/nature/shrubs/linnaea.html
- http://www.nwplants.com/plants/perennials/linnaea/linnaea_borealis/
- http://www3.sympatico.ca/oldfieldgarden/list.html
- http://www.nativeplantnetwork.org/network/view.asp?protocol

- http://www.fs.fed.us/database/feis/plants/shrub/linbor/all.html

Data compiled by Mike Cooksey, 30 April 2003