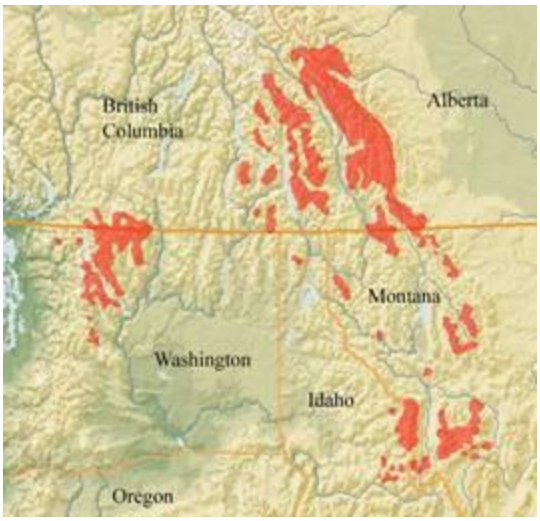

Plant Propagation Protocol for *Larix lyallii*
ESRM 412 – Native Plant Production

TAXONOMY	
Family Names	
Family Scientific Name:	Pinaceae
Family Common Name:	Pine
Scientific Names	
Genus:	Larix
Species:	lyallii
Species Authority:	Parl. (8)
Variety:	Apparent natural hybridization of alpine larch and western larch has been documented in western Montana (8,9,10 in (3).
Sub-species:	
Cultivar:	
Authority for Variety/Sub-species:	
Common Synonym(s) (include full scientific names (e.g.,	*Larix lyallii* Parl *Larix lyallii* Palatore tamarack (Peattie 1950); (5) mélèze de Lyall [French] (Parker 1993) (5,6).

Elymus glaucus Buckley), including variety or subspecies information)	
Common Name(s):	subalpine larch and Lyall larch (3), Alpine larch (4), meleze de Lyall (7).
Species Code (as per USDA Plants database):	LALY
GENERAL INFORMATION	
Geographical range (distribution maps for North America and Washington state)	See map above (1) and also map at (11). L.lyallii is found on talus slopes from 1800 to 2400 m elevation; from Alberta and British Columbia south to Washington, Idaho and Montana (4). From Alberta and British Columbia south to Washington, Idaho and Montana. (4). Specimen locations noted in (7). Generally near timberline, often on north facing slopes; southern BC to central Cascades and Wenatchee Mts, WA, east to southwest Alberta, north Idaho, and western Montana (10). It is locally common on exposed northern subalpine slopes to timberline, often with very rocky soils. It has very low shade tolerance and, due to its thin bark, low fire tolerance (Parish *et al.* 1996; See alsoThompson *et al.* 1999 in (5). Alpine larch occupies a remote and rigorous environment, growing in and near the timberline on high mountains of the inland Pacific Northwest. Although alpine larch is found in both the Rocky Mountains and the Cascades, the two distributions are separated at their closest points by 200 km (125 mi) in southern British Columbia. This and smaller gaps in the species' distribution generally coincide with an absence of suitable high mountain habitat. (3) In the Rocky Mountains alpine larch extends from the Salmon River Mountains of central Idaho, latitude 45° 28' N. northward to latitude 51° 36' N. several kilometers past Lake Louise in Banff National Park, AB. [A fossil larch, probably of this species, grew between 1000 and 1250 A.D. near the Athabasca Glacier (Columbia Icefield) 90 km (56 mi) northwest of today's northernmost known isolated alpine larch tree (18 in 3).] Within this distribution, alpine larch is common in the highest areas of the Bitterroot, Anaconda-Pintler, Whitefish, and Cabinet Ranges of western Montana. It is also found in lesser amounts atop numerous other ranges and peaks in western Montana and northern Idaho. In British Columbia and Alberta, alpine larch is common along the Continental Divide and adjacent ranges, and in the Purcell and southern Selkirk Ranges (3).

	In the Cascade Range alpine larch is found principally east of the Cascade Divide and extends from the Wenatchee Mountains (47° 25' N.) in central Washington northward to about 21 km (13 mi) inside British Columbia (49° 12' N.). Within this limited distribution covering a north-south distance of only 193 km (120 mi), alpine larch is locally abundant in the Wenatchee, Chelan, and Okanogan ranges. (3). in Larch Lakes Basin, where the largest and tallest known alpine larches grow (5).
Ecological distribution (ecosystems it occurs in, etc):	Alpine larch exhibits a highly discontinuous distribution, which is believed to be a remnant of a continuous range existing at a time when cooler, more extensive timberline habitat existed (1,3 in (9). Typical alpine larch stands are often isolated pockets of open, parklike groves, less than 0.05 acre (0.2 ha) (3 in (9). Besides occurring on rocky talus and exposed bedrock, larch in this setting also occurs on colluvial hillslope soils and on deep alluvial soils around the lakes (5) Throughout its distribution, alpine larch commonly grows on slopes covered with granite or quartzite talus (boulders), which have not been previously occupied by vascular plants. The species also grows in cracks in massive bedrock. These undeveloped soils would probably be classified (31 in (3)) as fragmental and as loamy skeletal families within the order Entisols*(Cryorthents).* Such substrates have been referred to as azonal soils, and more specifically as Lithosols in earlier classifications. Throughout the range of alpine larch, pH values were found to be very acidic, ranging from 3.9 to 5.7 in the mineral soil (B horizon). Bitterroot Range sites had an average pH of 4.6. Such strongly acid, shallow, rocky, and cold soils are extremely infertile (2). Alpine larch grows on several types of geologic substrates but has an affinity for acidic rock types, being most abundant on granitic and quartzite substrates and absent or scarce on nearby limestone or dolomite (4,21, in (3). Alpine larch achieves its best growth in high cirque basins and near the base of talus slopes where the soils are kept moist throughout the summer by aerated seep water. It can also tolerate boggy wet-meadow sites having very acidic organic soils. The species is most abundant on cool, north-facing slopes and high basins where it forms the uppermost band of forest. It also covers broad ridgetops and grows locally under relatively moist soil conditions on south-facing slopes. (3)
Climate and elevation range	Alpine larch grows in a very cold, snowy, and generally moist climate. (3) Mean annual precipitation for most alpine larch sites is between 800 and 1900 mm (32 and 75 in), the larger amount being more prevalent near the crest of the Cascades. Most stands in the Montana Bitterroot Range evidently receive 1000 to 1500 mm (40 to 60 in). About 75 percent of this precipitation is snow and sleet.

	In the Bitterroot Range, alpine larch is abundant above 2290 m (7,500 ft) on northern exposures. It extends lowest on north-facing talus slopes, free from other competing conifers. But, even when moist, open, boulder-covered slopes extend down the mountainsides to the 1370 m (4,500 ft) canyon bottoms, alpine larch rarely colonizes them below 1980 m (6,500 ft). In the Anaconda-Pintler Range of southwestern Montana, alpine larch forms a narrow band between elevations of about 2560 and 2800 m (8,400 to 9,200 ft). Northward in the Rockies, the elevation of its timberlines decreases gradually. Stands in northwestern Montana, Alberta, and southeastern British Columbia are generally found between 1980 and 2380 m (6,500 and 7,800 ft) and in the northern Cascades, between 1830 and 2290 m (6,000 and 7,500 ft). (3). "Most alpine larch stands annually experience winds reaching hurricane velocity, 117 km/h (73 mi/h) or more" (5 in 1).
Local habitat and abundance; may include commonly associated species	The inland Pacific Northwest often has a droughty period for a few weeks in late summer. This drought effect is minor in most alpine larch sites; however, dry surface soils may prevent seedling establishment in certain years (3). Alpine larch grows in pure stands and also in association with whitebark pine *(Pinus albicaulis), s*ubalpine fir *(Abies lasiocarpa)*, and Engelmann spruce*(Picea engelmannii)* near their upper limits. Near the crest of the Cascades, alpine larch is often associated with mountain hemlock *(Tsuga mertensiana)* and subalpine fir (3) Four species dominate in the undergrowth of most alpine larch stands throughout the Pacific Northwest: grouse whortleberry *(Vaccinium scoparium)* smooth woodrush *(Luzula hitchcockii);*mountain arnica *(Arnica latifolia); a*nd red mountain heath *(Phyllodoce empetriformis) (2).* But undergrowth beneath larch stands on bogs, recent moraines, alpine tundra, or rockpile sites, is distinctively different. Often shrub-like (krummholz) subalpine fir and whitebark pine form an undergrowth layer beneath the larch on relatively cold or wind-exposed sites. (3). Although the geographic ranges of *Larix lyallii* and *L. occidentalis* overlap considerably, elevational differences of 150 to 300 m usually separate them. Some morphologically intermediate specimens have been collected from Washington and Montana (Parker 1993 in (5). The big tree was 215.1 cm DBH, 31.3 m tall, with a crown diameter of 18.0 m. The tall tree was in a closed-canopy stand of very tall trees west of the upper lake, in the company of many comparably tall trees; it was 38.5 m tall and 101.0 cm DBH. (5). The (oldest) current record seems to be sample BAL091 from a tree collected near Baker Lake, Montana in 1997 by Malcolm Hughes, Connie Woodhouse and Peter Brown. This sample starts in 987 and ends in 1997 for a total history of 1,011 years, verified by crossdating (NCDC 2008 in (5). Other old tree records include: Margaret Colenutt collected a sample with 838 rings

	near Waterton, BC; most or all of this is a crossdated age (Luckman 2006 in (5); A ring-counted age of 791 years for sample COL-6A collected from a stand above Colchuck Lake in the Alpine Lakes Wilderness of WA by C.J. Earle in 1986. This is a pith date, but on a scarred core that may be missing some rings in the early 1300s. The tree was only about 40 cm diameter at the core height, a fine illustration of the rule-of-thumb that exceptionally old trees tend not to be particularly large ones; A crossdated age of 728 years for a specimen from W Alberta collected by B.H. Luckman (Brown 1996). I believe this is from a living tree, collected in the late 1980s or early 1990s. (5)
Plant strategy type / successional stage (stress-tolerator, competitor, weedy/colonizer, seral, late successional)	Alpine larch is an intolerant, native, seral, deciduous, coniferous tree species that will decrease when shaded by more shade-tolerant conifers [2,11, 13 in (9)]. Dominant alpine larch usually live 400 to 500 years, but many trees reach 700 years, and the oldest individuals may live up to 1,000 years [1 in (9)]. Alpine larch generally has one erect bole, with a braided stem. It rarely grows as krummholz because its leaves are deciduous and its buds are woody and protected [2,18 in (9)]. Young alpine larch have very flexible boles, which allow them to occupy snowslide and snow creep sites [3 in (9)]. Small openings in cirques often contain dense, even-aged groves, termed "reproduction glades," of alpine larch seedlings or saplings. This suggests that successful reproduction occurs rarely, and only under ideal conditions. The location of reproduction glades suggests that germination is most successful on a moist mineral soil surface, on northern exposures or in cirques not fully exposed to afternoon sun. Germination probably takes place in July soon after snowmelt. (3)
Plant characteristics (life form (shrub, grass, forb), longevity, key characteristics, etc)	Trees to 25m; trunk to 1.2m diam.; crown sparse, conic. Bark furrowed and flaking into red- to purple-brown scales. Branches horizontal, occasionally pendulous, persistent on trunk when dead; twigs strongly white- to yellow-tomentose for 2--3 years. Buds tomentose, scale margins ciliate. Leaves of short shoots 2--3.5cm ´ 0.6--0.8mm, 0.4--0.6mm thick, keeled abaxially, 2-angled adaxially; resin canals 40--80µm from margins, each surrounded by 6--10 epithelial cells. Seed cones 2.5--4(--5) ´ 1.1--1.9cm, on curved stalks 3--7 ´ 2.5--4mm; scales 45--55, margins erose, abaxial surface tomentose; bracts tipped by awn 4--5mm, exceeding mature scales by ca. 6mm. Pollen 78--93µm diam. Seeds yellow to purple, body 3mm, wing 6mm (6). Large seed crops are infrequent. In Montana they occur about 1 year out of 10, and even modest-sized crops occur in about the same frequency. Appreciable quantities of seed are not produced until trees are at least 80 years old. Dominant trees, several hundred years of age, produce the largest crops. (3). Alpine larch can begin producing cones when they are 100 years old, but generally do not produce seed in quantityuntil they reach 200 years of age [3 in (9)]. Alpine larch roots extend deep into fissures in the rocky substrate. Trees are well anchored by a large taproot and large lateral roots and are very

	windfirm. (3). The height growth of a small alpine larch will average approximately 0.6 inch (1.5 cm) a year during the first 25 years (3 in 1). Lifespan typically 400 – 500 years, but have been found as old as 700 -1,000 years old. Vigorous saplings, 30 to 35 years old can be found 1.2 m (4 ft) tall. The largest recorded L. lyallii is 46 m (152 ft) tall in Montana's Cabinet Range (2 in 1).
PROPAGATION DETAILS	
Ecotype (this is meant primarily for experimentally derived protocols, and is a description of where the seed that was tested came from):	
Propagation Goal (Options: Plants, Cuttings, Seeds, Bulbs, Somatic Embryos, and/or Other Propagules):	Plants (4)
Propagation Method (Options: Seed or Vegetative):	Seed (4); L. lyallii does not reproduce from sprouts (2 in 1), Techniques for reproduction from rooted cuttings have not been reported (1) and it very rarely layers (has occurred in instances of krummholz) (3 in 1).
Product Type (options: Container (plug), Bareroot (field grown), Plug + (container-field grown hybrids, and/or Propagules (seeds, cuttings, poles, etc.))	Container (plug) (4)
Stock Type:	
Time to Grow	

(from seeding until plants are ready to be outplanted):	
Target Specifications (size or characteristics of target plants to be produced):	
Propagule Collection (how, when, etc):	Collect in September (2 in 1). Large or modest seed crops are infrequent (3 in 1) occurring only 1 year out of 10 in Montana (9). L. lyallii does not produce appreciable quantities of seed until it is about 80 years old and dominant (2 in 1).
Propagule Processing/Propagule Characteristics (including seed density (# per pound), seed longevity, etc):	Seed remains viable for up to 3 years (4 in 1). Seeds are nondormant. Store cold and sow in a cold frame in late winter. Germination occurs at 18C (4).
Pre-Planting Propagule Treatments (cleaning, dormancy treatments, etc):	Germination of alpine larch seed has been poor in several tests but is improved by soaking the seeds for 24 hours in 3 percent hydrogen peroxide solution *(8,21,24,30 in (3)).* Such treatment may inhibit root development, however *(25 in* (3)). Germination occurs at 15°C (1 in 1).Seeds germinate in July soon after snowmelt", and need full light and low temperatures (3 in 1). Daytime high temperatures and surface drought are lethal (2 in 1). "One month cold stratification helps germination" (4 in 1).
Growing Area Preparation / Annual Practices for Perennial Crops (growing media, type and size of containers, etc):	Sow seeds late in winter in a cold frame of outdoor seedbed, and give seedlings light shade for the first year (4 in 1). Germination appears most successful on a moist mineral soil surface on northern aspects. Grows on undeveloped, poor, soils; granite or quartzite talus which has not been occupied by vegetation previously. Ph = 3.5 to 5.7. Mycorrhizal development was found on all trees...*Cenococum graniforme* has been identified as an ectotrophic mycorrhiza of subalpine larch" (2 in 1).
Establishment Phase (from seeding to germination):	Plant in early summer (4 in 1)Needs full light and low temperatures (2 in 1).Interestingly, height and diameter growth (NOT germination) increased when on southern slopes (3 in 1)Naturally, reproduction occurs rarely, and only under ideal conditions. Cannot be fully exposed to afternoon sun (2 in 1).

Length of Establishment Phase:	
Active Growth Phase (from germination until plants are no longer actively growing):	This species is very difficult to cultivate even in the relatively cool climates at lower elevations in the Pacific Northwest or in England. Seedlings have been raised at Kew Gardens*(12)*, but they have not grown well, leading to the conclusion that a colder climate than that of Britain is required for alpine larch. Apparently, daytime high temperatures and surface drought are lethal. The species seems to require full light, but low temperatures. Bud dormancy is thought to influence the lack of adaptation to lower elevations (17 in 3). Give effective weed excluding mulch and some winter protection at least one year after planting – if you cannot care for them through the winter, plant out in the summer of the following year (^{4} in 1).
Length of Active Growth Phase:	The growing season for alpine larch lasts approximately 90 days. Bud development is triggered by rising mean air temperature to about 39 degrees Fahrenheit (4 deg C) and can be normally expected to begin the end of May. Shoot growth occurs mostly in July and progresses rapidly. The height growth of a small alpine larch will average approximately 0.6 inch (1.5 cm) a year during the first 25 years [3 in (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):	Leaf fall and dormancy are controlled by photoperiod. Late summer drought, however, has been shown to induce early yellowing [3 in (9)].
Length of Hardening Phase:	
Harvesting, Storage and Shipping (of seedlings):	Cleaned seed number between 105,000 and 163,000 per pound (231-359 500/kg) (9).
Length of Storage (of seedlings, between nursery and outplanting):	
Guidelines for	For the first 20 to 25 years, growth is typically very slow. This strategy

Outplanting / Performance on Typical Sites (eg, percent survival, height or diameter growth, elapsed time before flowering):	allows for extensive establishment of the root system and decreases the probably of top-kill from windthrow or heavy snowpack [2 in (9)]. Alpine larch apparently become deeply rooted; thus, soil moisture near the surface seems to have no influence on their growth [3 in (9)]. Seedlings 16 to 25 years old and only 8 to 16 inches (20-40 cm) tall had taproots penetrating 16 to 24 inches (20-40 cm) and laterals 8 to 24 inches (20-60 cm) beneath the surface [25 in (9)]. Alpine larch seedlings and saplings up to 3 or 4 feet (1.00-1.25 m) tall exhibit evergreen basal limbs. This foliage lasts for two summers and helps establish alpine larch on severe sites [3 in (9)].
Other Comments (including collection restrictions or guidelines, if available):	Disease or insects cause little damage to this tree (9). A heavy seed crop in one area of the Washington Cascades was largely consumed by larvae of an unidentified fly (Diptera) *(2 in (3))*. It is suspected that the larch case bearer (Coleophora laricella) will eventually spread from lower western larch stands to alpine larch stands (3 in (9). Brown heart rot caused by Quinine fungus (Fomes officinales) is often found in alpine larch, but not often enough to be considered prevalent. Needle blight (Sarcotrochila alpina) and cast fungi (Hypodermella laricis) severely infected many stands of alpine larch in British Columbia. The most common fungus infecting alpine larch is an unidentified canker, similar to the European larch canker (Dasyscypha willkommii). This fungus creates noticeable swellings in young and mature twigs. These fungi weaken but usually do not kill the tree.
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