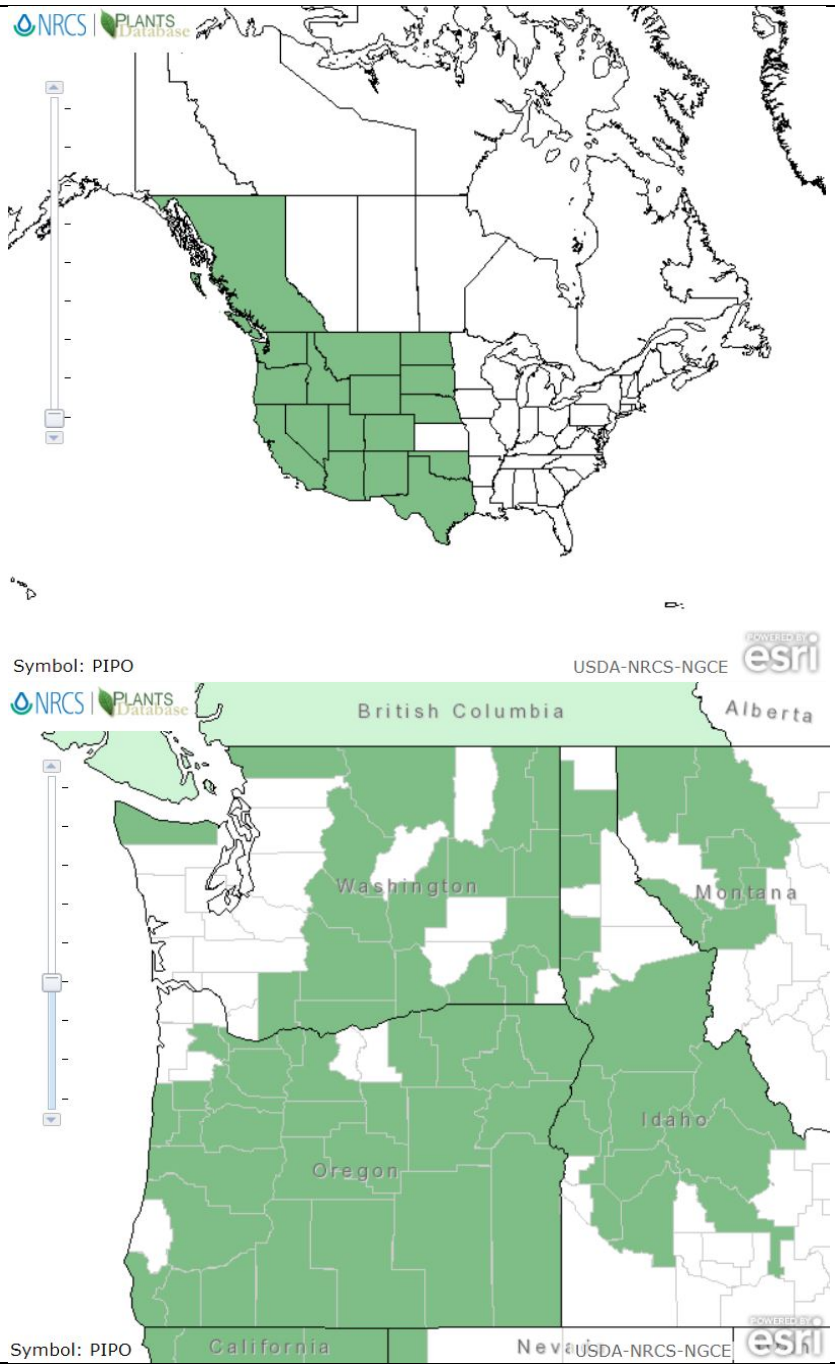
Plant Propagation Protocol for *Pinus ponderosa*
ESRM 412 – Native Plant Production

TAXONOMY	
Plant Family	
Scientific Name	PINACEAE
Common Name	Pine Family
Species Scientific Name	
Scientific Name	*Pinus ponderosa* Lawson & C. Lawson
Varieties[7]	*Pinus ponderosa* Lawson & C. Lawson var. *arizonica* (Englem.) Shaw *Pinus ponderosa* Lawson & C. Lawson var. *pacifica* J.R. Haller & Vivrette, nom. illeg. *Pinus ponderosa* Lawson & C. Lawson var. *brachyptera* (Engelm.) Lemmon *Pinus ponderosa* Lawson & C. Lawson var. *ponderosa* C. Lawson *Pinus ponderosa* Lawson & C. Lawson var. *scopulorum* Engelm. *Pinus ponderosa* Lawson & C. Lawson var. *washoensis* (H. Mason & Stockw.) J.R. Haller & Vivrette
Sub-species[7]	*Pinus ponderosa* Lawson & C. Lawson ssp. *arizonica* (Engelm.) A.E. Murray *Pinus ponderosa* Lawson & C. Lawson ssp. *coulteri* (D. Don) A.E. Murray *Pinus ponderosa* Lawson & C. Lawson ssp. *jeffreyi* (Balf.) Engelm. *Pinus ponderosa* Lawson & C. Lawson ssp. *benthamiana* (Hartw.) Silba *Pinus ponderosa* Lawson & C. Lawson ssp. *critchfieldiana* Callaham, nom. illeg. *Pinus ponderosa* Lawson & C. Lawson ssp. *brachyptera* (Engelm.) Callaham, nom. illeg. *Pinus ponderosa* Lawson & C. Lawson ssp. *brachyptera* (Engelm.) Silba *Pinus ponderosa* Lawson & C. Lawson ssp. *readiana* Callaham *Pinus ponderosa* C. Lawson ssp. *scopulorum* (Engelm.) A.E. Murray *Pinus ponderosa* C. Lawson ssp. *washoensis* (H. Mason & Stockw.) A.E. Murray
Cultivar	
Common Synonym(s)	
Common Name(s)	ponderosa pine, big heavy, black jack, bull pine, ponderosa white pine, Sierra brown bark pine, silver pine, western pitch pine, western red pine, western yellow pine, yellow pine, Yosemite pine[8].
Species Code (as per USDA Plants database)	PIPO
GENERAL INFORMATION	
Geographical range[3]	

	
Ecological distribution	Wide-ranging conifer that appears throughout western U.S., southern Canada, and northern Mexico but is also prevalent in the Black Hills of South Dakota and Wyoming, along the Front Range of the Rocky Mountains in Colorado and along the Mogollon Rim in Arizona, forming the southern limit of the Colorado Plateau[2]. Yet it is primarily found in the Inland Northwestern U.S. and northern California[2]. Grows in a wide variety of ecosystems and biophysical settings, but mostly occurs in the Arid West, Great Plains, Northcentral and Northeast, and Western Mountains, Valleys and Coast[3].

Climate and elevation range	Average annual-precipitation for *P. ponderosa* is from 12 to 40 inches or more[4]. It grows well in hot, dry climates and can bear very cold winters[4]. Found in elevations ranging from sea level to 3,281 m (10,000 ft.) but is dependent on the latitude[2].
Local habitat and abundance	*P. ponderosa* occupies the greatest geographical of any coniferous species other than *Pseudotsuga menziesii* (Mirbel) Franco var. *glauca* (Beissn.) Franco[2]. In Washington State it occurs primarily East of the Cascade mountains and is a central species of most forest types in eastern Washington[5]. Its distribution forms the lower treeline along the Columbia Basin[5]. In drier climates *P. ponderosa* grows alongside quaking aspen (Populus tremuloides Michx.), Douglas-fir, western larch, lodgepole pine (Pinus contorta Dougl. ex Loud), and grand fir (Abies grandis (Dougl. ex D. Don) Lindl.) or white fir (Abies concolor (Gord. & Glend.) Lindl. ex Hildebr.)[2]. In more temperate climates, *P. ponderosa* grows on south facing aspects with other seral species like Douglas-fir, western larch, lodgepole pine, western white pine, grand fir/white fir, and western redcedar (Thuja plicata Donn ex D. Don)[2]. It commonly grows alongside shrubs and grasses such as ceanothus, sagebrush, oak, snowberry, bluestem, fescue, and polargrass[8].
Plant strategy type / successional stage	At lower elevations of coniferous forests *P. ponderosa* is a climax species but is considered a midsuccessional species where more competitive conifers can grow at higher elevations[8].
Plant characteristics	*P. ponderosa* is an evergreen tree that spreads from seed reaching mature heights of 55 to 90 feet and diameter breast high of 15 to 35 inches[4] (age at maturity ranges from 70 to 250 years but can live up to 300 to 600 years[8]). Drought tolerant but high water, inundated soils, or a high-water table can drown it out as it uses a taproot[4]. It is found on a wide variety of soil depths and compositions but prefers sandy loams[4]. Needles are 3 to 5 inches long commonly with 3 and sometimes 2 or 4 needles per fascicle which remain on the stem 3 to 4 years with a major needle drop in September and October[4]. Cones are 3 to 6 inches long, pineapple-shaped, and take over 2 years to mature[4]. The bark is dark brown to nearly black when young and becomes cinnamon brown to orange-yellow around 90 years of maturity[4].
PROPAGATION DETAILS	
Ecotype	Idaho

Propagation Goal	Plants
Propagation Method	Seed
Product Type	Container (plug)
Stock Type	66 ml (4 cu. in) Ray Leach "Cone-tainers"[9]
Time to Grow	8 months[9]
Target Specifications	Height = 15 cm Root-collar diameter = 2.8 to 3.5 mm Firm root plug[9]
Propagule Collection Instructions	Cones are green to yellow green when immature but turn brown to yellow brown once they are ripe, which occurs between August and September (seed dispersal occurs between August and September)[1]. Cones should be collected when ripe but before the seeds are shed[6] and can be collected with ladders, hydraulic lifts, or by climbing trees[9]. Cones mature in 2 years, 3 to 6 in (8 to 15 cm) long and grow individually or in clusters. The winged seeds are 0.11 to 0.15 in (3 to 4 mm) in body length and 0.6 in (15 mm) in wing length[9]. Trees produce cones at 6 to 16 years of maturity and can produce seeds for up to 350 years. In the Pacific Northwest, good seed crops occur every 4 to 5 years[9].
Propagule Processing/Propagule Characteristics	After harvest cones must be dried quickly to prevent internal heating (seed death), mold development, and rapid deterioration of the seeds[9]. Once initially dried, cones can be temporarily stored in burlap bags, if adequate air circulation is provided around the sacks. Cones can be opened without the use of a kiln by spreading them on a tarp in a warm, well ventilated greenhouse or drying shed for 4 to 12 days. Cones from Pacific ponderosa are opened by placing them in a kiln for 2 hours at 49øC (120øF) and cones from Rocky Mountain ponderosa are opened by placing in a kiln for 2 hours at 74øC (165øF)[9]. Rocky Mountain ponderosa pine produce 10,000 to 15,000 seeds/lb (22,000 to 34,000 seeds/kg)[9]. On average, *P. ponderosa* produces 12,000 cleaned seeds /lb[1].
Pre-Planting Propagule Treatments	Seeds are removed from cones by shaking or tumbling[6]. Bleach seeds prior to stratification by placing them into fine mesh bags and soaking them in a 40% bleach solution (2 parts laundry bleach [5.25% sodium hypochlorite] to 3 parts tap water), mildly agitating them for 10 minutes to ensure they are completely sterilized[9]. After this sterilization process, rinse thoroughly and soak them for 48 hours in running tap water to imbibe them[9].

	Place mesh bags into plastic bags and cold stratify them for 60 days at 1 to 2øC (33 to 36øF). After stratification, soak seeds in running tap water for 24 hours[9]. Prior to freezer storage seeds are dried to 7% seed moisture content[9]. Stored seeds require cold stratification for 1-2 months but can be stored for roughly 15 years[1].
Growing Area Preparation / Annual Practices for Perennial Crops	Fill 66 ml (4 cu. in) Ray Leach "Cone-tainers" with a 1:1 Sphagnum peat moss and vermiculite medium with a pH of 4.2[9]. In a fully controlled greenhouse, grow seedlings with 300-watt incandescent lamps at an intensity of 500 lux with 15 min on/off cycles[9]. Irrigate with an overhead traveling boom system that has nozzles every 40 cm and inject fertilizers with a 1:100 injector into irrigation water[9]. Sow seeds in late March and immediately cover with a 6 mm deep layer of Forestry sand or white grit and irrigate once layer is applied until the medium is saturated, acidifying to a pH around 6.0[9]. To reduce damping-off disease, allow air to circulate around the root collar, keep humidity relatively low, and utilize underbench air circulation and heating while maintaining day-time greenhouse temperatures at 75 to 80øF (24 to 27øC) and night-time temperatures at 65øF (18øC)[9].
Establishment Phase Details	Seedlings are thinned to 1 seedling per container when seedcoats begin shedding off germinating seedlings[9]. Maintain same photoperiod lighting[9]. Fertilize seedlings with Peters Professional Conifer Starter (7N:40P2O5:17K2O; The Scotts Company, Marysville, Ohio) and CAN-17 (liquid ammonium calcium nitrate [17N]) with micros (Fe, B, MgSO4) twice per week[9]. To keep irrigation water around pH 6.0, use phosphoric acid and when blocks weigh 80% to 85% of saturated weight, irrigate seedlings[9]. At the end of week 6 salt build-up must be removed so leach the planting medium with irrigation water[9]. Continue to maintain day-time greenhouse temperatures at 75 to 80øF (24 to 27øC) and night-time temperatures at 65øF (18øC)[9].
Length of Establishment Phase	6 to 8 weeks[9]
Active Growth Phase	Maintain same photoperiod lighting[9]. Fertilize seedlings with Peters Professional Conifer Starter (7N:40P2O5:17K2O; The Scotts Company, Marysville, Ohio) and calcium nitrate (15.5:0:0:10) with micros (Fe, B, MgSO4) twice per week[9].

	Irrigate containers when blocks weigh 80% to 85% of saturated weight but begin to steadily decrease the weight to 70% saturated weight by the time growers wish to initiate buds[9]. Once the seedlings reach a height of 4.3 in (11 cm), leach the medium with an abundant amount of irrigation water, allowing the medium to dry until it is moist[9].
Length of Active Growth Phase	5 weeks[9]
Hardening Phase	During bud initiation, micronutrients (Fe, B, MgSO4) are supplied every irrigation, but N is only supplied every other irrigation using CAN-17 at 40 ppm N. Discontinue the use of photoperiodic lighting from previous stages[9]. 3 to 4 weeks after initiation, buds will appear and Peters Professional Conifer Finisher (4N:25P2O5:35K2O; The Scotts Company, Marysville, Ohio) along with CAN-17 and micros (Fe, B, MgSO4) should be applied to crop[9]. Phosphoric acid is used to keep irrigation water pH around 6.0. Temperatures can be ambient but should be maintained under 80øF (27øC) during the day with a minimum temperature of 28øF (-2øC)[9]. From mid-September until pack-out day (the seedlings will be ready to be packed during January), maintain day temperatures as cool as possible and the minimum temperature the crop can undergo is 28øF (-2øC)[9].
Length of Hardening Phase	18 to 22 weeks[9]
Harvesting, Storage and Shipping	Extract seedlings from storage in late November through the end of December, making sure they are well-watered before removal and that the foliage is dry before packing[9]. Seedlings are stored at 33 to 34øF (0.5øC) and placed in plastic bags that are within water repelling containers like waxed boxes or plastic tubs[9]. Seedlings should be monitored for storage mold however the likelihood of storage molds can be minimized by shipping seedlings with minor mold occurrence first, packing disease-free stock, inspecting the crop for on-set of mold, storing them for the shortest possible duration, and keeping temperatures below freezing[9].
Length of Storage	4 to 5 months[9]
Guidelines for Outplanting /	Younger seedling survival is primarily reduced due to moisture stress, but older seedlings can deal with limited amounts of moisture[8]. For the first three to six years, competition from other vegetation should be controlled

Performance on Typical Sites	that is until the trees become well established[8]. Outplanted trees should be 15 to 30 cm in height and spaced 1 to 3 m[8] with an aspect that allows for at least 6 hours of sun per day. Trees will flower between May and June after initial establishment[10].
Other Comments	Ray Leach "Cone-tainers" should be submerged in hot water (75 to 85øC [167 to 185øF]) for 15 to 30 seconds between crops to remove pathogens[9].
INFORMATION SOURCES	
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Protocol Author	Nicholas Zurlini
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