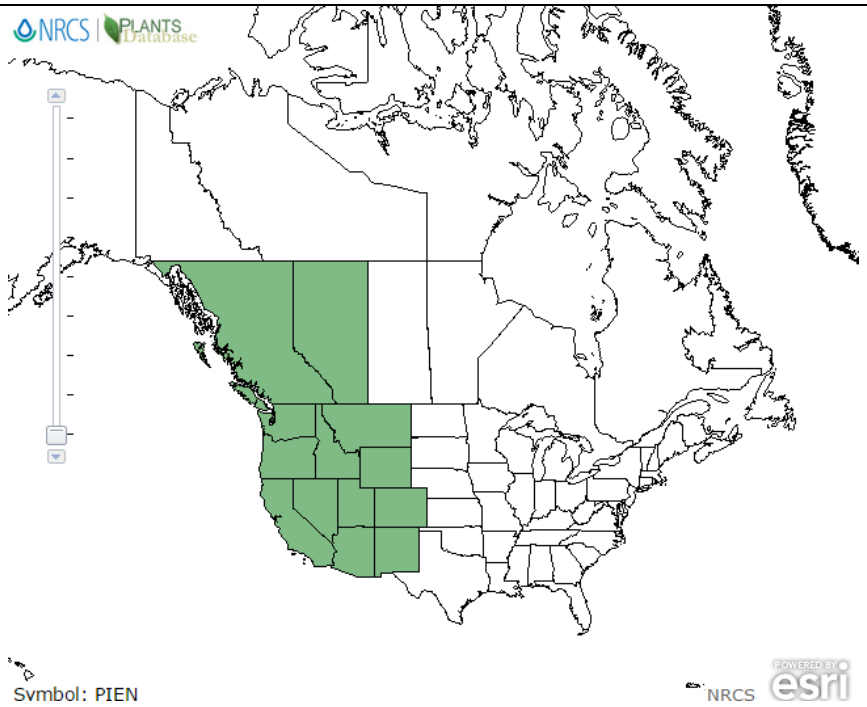
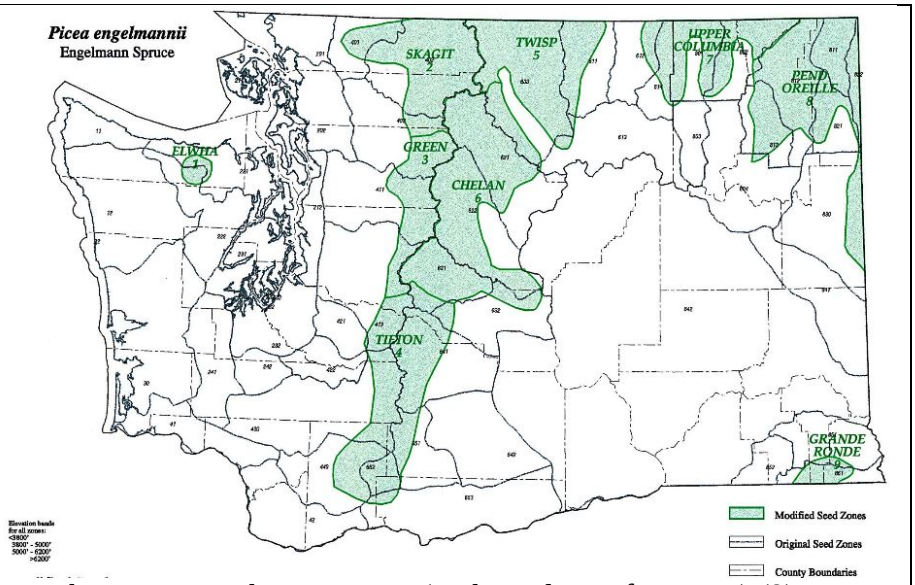
Plant Propagation Protocol for *Picea engelmannii*
ESRM 412 – Native Plant Production
Protocol URL: https://courses.washington.edu/esrm412/protocols/PIEN.pdf

TAXONOMY	
Family Names	
Family Scientific Name	Pinaceae
Family Common Name	Pine Family
Scientific Names	
Scientific Name	*Picea engelmannii* Parry ex Engelm.
Varieties	*Picea engelmannii* Parry ex Engelm. var. *engelmannii* *Picea engelmannii* Parry ex Engelm. var. *mexicana* (Martínez) Silba
Sub-species	N/A
Cultivar	N/A
Common Synonym(s)	N/A
Common Name(s)	Engelmann spruce. Named for George Engelmann who was a physician and a botanist from St. Louis, MO (1809-1884) (5).
Species Code (as per USDA Plants database)	PIEN
GENERAL INFORMATION	
Geographical range	 Distribution in North America (8).

	 Distribution in Washington state (with seed transfer zones) (9).
Ecological distribution	Facultative Wetland Species in Western Mountains, Valleys and Coast (8).
Climate and elevation range	Found at high elevations in cold, humid environments associated with heavy snowpack and long winters (9). Has a very large latitudinal range (from Mexican border to British Columbia) but range is narrowly limited by temperature and precipitation (9). Found mostly above 1,000 meters, at higher elevations as the range moves south (7). Prefers moist, well drained mineral soils with snow being the primary form of precipitation (4).
Local habitat and abundance	See WA distribution map. In WA mostly commonly found in the Okanagan Highlands but also occurs on the crest and east side of the Cascades. Small, isolated populations are also found in the Blue Mountains and Olympic Peninsula (9). Associated with subalpine spruce/fir forests (4).
Plant strategy type / successional stage	Often a co-climax species along with subalpine fir. Lodgepole pine (*Pinus contorta*) is often an important seral species associated with PIEN in drier environments (4). Has low tolerance to drought, salinity, anaerobic conditions and fire. High tolerance for CaCO3. pH range from 6-8. Need for a minimum of 30 frost free days/year. Shade tolerant (8).

	Seedlings tolerant to deer foraging (7). Has a low seeding vigor and slow seed spread rate (8).
Plant characteristics	Perennial tree (gymnosperm) that grows in a narrow, spire-like form up to 120 feet tall. Needles are 4-sided and dark blue-green. Bark is loose, scaly and reddish-brown (2). Trees are long lived, but with a slow growth rate due to very short spring/summer growing season at high elevations (no taller than 30 feet at 20 years old) (8).
PROPAGATION DETAILS Seed Propagation Method (in Montana) as explained by Evans (3)	
Ecotype	Spruce/Fir forest, West Glacier, Glacier National Park, Flathead County, MT. 1100m elevation.
Propagation Goal	Plants
Propagation Method	Seed
Product Type	Container (plug)
Stock Type	172 ml conetainers
Time to Grow	9 months
Target Specifications	Seedlings with a height of 15cm and a caliper measurement of 8mm. The root system should be a firm plug in the conetainer.
Propagule Collection Instructions	Collect cones in late September to early October when cones turn tan and scales start to reflex. Mature seeds are firm and dark brown to black. Cones can be collected in burlap sacks and spread over a canvas tarp in drying shed prior to seed cleaning.
Propagule Processing/Propagule Characteristics	Classified as non-dormant. Seed germination is equal in light and dark (1). 260,000 seeds per kilogram or 572,000 seeds per pound. Purity: 100% Germination:70% to 80% Seed storage is 5 to 17 years at 0C in sealed containers. Seeds are sensitive to adverse storage conditions. They should be air dried and tumbled to extract the seeds. Seeds must also be "dewinged".
Pre-Planting Propagule Treatments	Stratification is not required. However, pre-chilling seeds and pre-soaking increases germination energy and uniformity of emergence. Seeds were surface sterilized with an 8:1 water/bleach solution. Seeds are placed into a 48 hour running water rinse, followed by 30 to 60

	day cold, moist stratification. Seeds are placed in fine mesh bags buried in moist peat moss in ventilated containers under refrigeration at 3C.
Growing Area Preparation / Annual Practices for Perennial Crops	Greenhouse and outdoor nursery growing facility. Direct seeding covering seeds lightly with medium. Medium consists of 70% 6:1:1 milled sphagnum peat, perlite, and vermiculite and 30% sand with Osmocote controlled release fertilizer. Seeds are sown in late winter (January/February). Greenhouse temperatures are maintained at 21 to 25C during the day and 16 to 18C at night. Seedlings are hand watered and remain in greenhouse until mid-May. Seedlings are then moved to outdoor nursery for the remainder of the growing season. Seedlings in nursery are irrigated with Rainbird automatic irrigation system in early morning until containers are thoroughly leached.
Establishment Phase Details	Medium is kept slightly moist during germination. PIEN is sensitive to excessive irrigation prior to and after germination. Careful attention to irrigation is needed at this stage hence the hand watering. After seedlings are well established, they must dry down slightly between irrigations. This practice will prevent post emergence damping-off disease and other root diseases.
Length of Establishment Phase	3 weeks
Active Growth Phase	Plants were fertilized with 13-13-13 liquid NPK at 100 ppm during the growing season. Seedlings can be inoculated with mycorrhizal fungi at this stage. Plants were fully root tight 23 weeks after germination and averaged 10 cm in height.
Length of Active Growth Phase	23 weeks
Hardening Phase	Plants are fertilized with 10-20-20 liquid NPK at 200 ppm in August and September. Irrigation is gradually reduced in September and October. Plants are leached with clear water once before winterization.
Length of Hardening Phase	4 weeks
Harvesting, Storage and Shipping	Overwinter in outdoor nursery under insulating foam cover and snow.
Length of Storage	5 months
Guidelines for Outplanting / Performance on	Outplanting Date: Spring or Fall.

Typical Sites	
Other Comments	3L (1 gallon) containers can be produced in 2 years, with trees averaging 20 cm in height and 1.0 cm in caliper (3). Engelmann spruce is protected in Nevada as a Christmas Tree (8). Experiments on Engelmann spruce in growth chambers showed productivity decreased with projected climate change conditions of warmer nights and more precipitation, but less frequent rainfall events (6). While fire tolerance for Engelmann spruce is low, it is subjected to high intensity, stand replacing fires. While in these conditions *Pinus contorta* is often most efficient at reestablishment, studies show that Engelmann spruce can germinate in burned seedbeds with only slightly less success than in a sterile medium (10).
INFORMATION SOURCES	
References	See below
Other Sources Consulted	See below
Protocol Author	Dan Hintz
Date Protocol Created or Updated	05/27/15

References:

(1) Baskin, Carol C.; Baskin, Jerry M. 2002. Propagation protocol for production of container *Picea engelmannii* Parry ex Engelmann plants; University of Kentucky, Lexington, Kentucky. In: Native Plant Network. URL: http://www.nativeplantnetwork.org (accessed 18 May 2015). Moscow (ID): University of Idaho, College of Natural Resources, Forest Research Nursery.

(2) Engelmann Spruce, *Picea engelmannii*. British Columbia Tree Book. Available: https://www.for.gov.bc.ca/hfd/library/documents/TREEBOOK/engelmannspruce.htm [2015, May 18].

(3) Evans, Jeff; Luna, Tara.; Hosokawa, Joy.; Wick, Dale. 2008. Propagation protocol for production of container *Picea engelmannii* (Parry) Engelm. plants (172 ml conetainers); USDI NPS - Glacier National Park, West Glacier, Montana. In: Native Plant Network. URL: http://www.nativeplantnetwork.org (accessed 18 May 2015). Moscow (ID): University of Idaho, College of Natural Resources, Forest Research Nursery.

(4) Feller, M.C. 1997. Influence of ecological conditions on Engelmann spruce (*Picea Engelmannii)* and subalpine fir (*Abies lasiocarpa*) germinant survival and initial seedling growth in south-central British Columbia. *Forest Ecology and Management*, 107: 55-69.

(5) NPIN: Native Plant Database: *Picea engelmannii*. Lady Bird Johnson Wildflower Center the University of Texas at Austin. Available: http://www.wildflower.org/plants/result.php?id_plant=PIEN [2015, May 18].

(6) Orgill, A. Laflin, M., Walker, B. and Gill, R. 2010. Warming Nights and Increased Precipitation Event Size Decrease *Picea engelmannii* Productivity. Brigham Young University: Department of Biology.

(7) *Picea Engelmannii*. Missouri Botanical Garden: Gardening Help. Available: http://www.missouribotanicalgarden.org/PlantFinder/PlantFinderDetails.aspx?kempercode=a419 [2015, May 18].

(8) Plants Database: *Picea engelmannii* Parry ex Engelm. Engelmann Spruce. United States Department of Agriculture Natural Resoruces Conservation Service. Available: http://plants.usda.gov/core/profile?symbol=PIEN [2015, May 18].

(9) Washington Tree Seed Transfer Zones: Engelmann Spruce. Washington State Department of Natural Resources. Available: http://www.dnr.wa.gov/Publications/lm_wfn_seedzone_engl_spruce.pdf [2015, May 18].

(10) Woodard, Paul M. 1983. Germination Success of *PINUS CONTORTA* Dougl. and *PICEA ENGELMANNII* Parry on Burned Seedbeds. *Forest Ecology and Management*, 5:301-306.

Not Pertinent to Protocol:

(11) Antos, J., Parish, R. and Nigh, G. 2010. Effects of neighbors on crown length of *Abies lasiocarpa* and *Picea engelmannii* in two old-growth stands in British Columbia. *Canadian Journal for Research: NRC Research Press*, 40: 638-647.

(12) Torre, A., Wang, T., Jaquish, B. and Aitken, S. 2014. Adaptation and exogenous selection in a *Picea glauca* X *Picea engelmannii* hybrid zone: implications for forest management under climate change. *New Phytologist*, 201: 687-699.

Previous Protocol for *Picea engelmannii* (2006)

Images: USDA Forest Service - Rocky Mountain Region Archives, USDA Forest Service, www.forestryimages.org

Species (common name, Latin name)- Engelmann spruce, *Picea engelmannii*

Range
Engelmann spruce has a large range that stretches from British Columbia, Canada through the western US to New Mexico and Arizona.

Climate, elevation
This species is primarily found at high elevations in areas associated with heavy snowfall. It is very sensitive to high temperatures particularly as a seeding where soil surface temperatures above 45 degrees Centigrade can begin to cause seedling mortality. Prefers cool, humid environments.

Local occurrence
In the Pacific Northwest Engelmann spruce is primarily found as a minor component of the high elevation forests along the east slope of the Cascades.

Habitat preferences

Engelmann spruce prefers cool, humid environments characterized by long winters and short, cool summers. It can grow in a wide range of well drained soils provided that there is access to adequate moisture.

Plant strategy type/successional stage (stress-tolerator, competitor, weedy/colonizer, seral, late successional)
Generally a long lasting seral species, Engelmann spruce can be found as co-climax components of Subalpine fir/Engelmann spruce stands. Pure stands of Engelmann spruce can also be found, particularly in cold environments. It is also relatively shade tolerant compared to the tree species it is associated with, except true firs and hemlocks.

Associated species
In the Rocky Mountains Engelmann spruce is primarily found associated with Subalpine fir or in pure stands near treeline. It can also be a minor component in other forest types. In the PNW it can be found growing, primarily in frost pockets, in association with western white pine *(Pinus monticola),* Douglas-fir, western larch *(Larix occidentalis),* grand fir *(Abies grandis),* and lodgepole pine *(Pinus contorta);* Pacific silver fir *(Abies amabilis),* mountain hemlock *(Tsuga mertensiana),* alpine larch *(Larix lyallii),* and whitebark pine *(Pinus albicaulis).*

May be collected as:
Seed

Collection restrictions or guidelines
Seeds can be collected once cones mature. Typically seeds are released when cones begin opening in September, though some seed will remain in cones through the winter. Cones can be collected before seeds are fully mature as seeds will continue to ripen. Seeds can be separated by first drying the cones then tumbling or shaking. Seed wings can be removed by placing in a cotton bag and rubbing by hand.

Seed germination
Seeds should be soaked in water for 24 hours then chilled for 6 to 8 weeks at 2 degrees C.

Seed life
Engelmann spruce seeds can be stored for 10 to 20 years.

Recommended seed storage conditions
Seeds of Engelmann spruce can safely be stored in cones under field conditions for up to 5 months. For longer storage, seeds should be cleaned and dried to 4-8 % moisture content. Seeds can then be placed in airtight containers and stored between -10 and 3 degrees C.

Propagation recommendations
Seeds or seedlings

Soil or medium requirements Engelmann spruce seeds will establish on a variety of substrates. Germination is slightly higher on mineral soil or a mix of humus and mineral soil. The main medium requirement is adequate moisture.

Installation form
Seeds or seedlings are commonly used in propagation. Studies in Colorado have shown that seeds sown in the field have up to a 28% survival rate. Seedlings improve the success rate but are more costly.

Recommended planting density
Between 300 and 700 seedlings should be planted per acre.

Care requirements after installed
Once established, seedlings are sensitive to high temperatures and drought. If possible seedlings should be grown in partial shade and given at least 1 inch of precipitation spread over each month during the dry season.

Normal rate of growth or spread; lifespan
Engelmann spruce has adopted a slow growth strategy in response to the harsh environments where it is found. Trees may be only 4 to 5 ft tall after 20 years. However, the species is relatively long lived and individuals 500 to 600 years old are not rare. The tree can spread by layering of the lower branches, particularly at high elevations where conditions promote a prostrate growth form.

Sources cited

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http://www.na.fs.fed.us/Spfo/pubs/silvics_manual/Volume_1/picea/engelmannii.htm

Bonner, Franklin T. *Woody Plant Seed Manual*. USDA Forest Service.
http://www.nsl.fs.fed.us/wpsm/Picea.pdf

Kartesz, John. Biota of North America Program (BONAP). USDA Natural Resources Conservation Service PLANTS Database.
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Data compiled by Phillip Chi, 4/28/2006