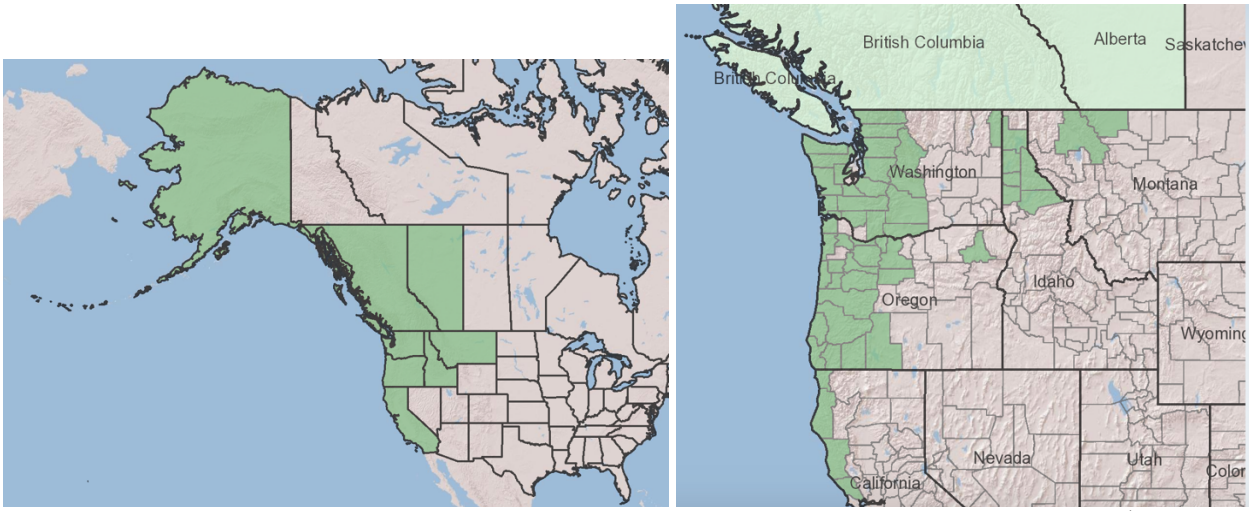
Plant Propagation Protocol for *Tsuga heterophylla*
ESRM 412 – Native Plant Production
URL: https://courses.washington.edu/esrm412/protocols/2021/TSHE.pdf



Country- and county-level range maps, courtesy of USDA PLANTS Database.[1]

TAXONOMY	
Plant Family	
Scientific Name	Pinaceae
Common Name	Pine
Species Scientific Name	
Genus	*Tsuga*
Species	*heterophylla*
Species Authority	(Raf.) Sarg
Varieties	
Sub-species	
Cultivars	
Common Synonym(s)	west coast hemlock, Pacific hemlock, coast hemlock[1]
Common Name(s)	western hemlock
Species Code (as per USDA Plants database)	TSHE; also referred to as TSUHET[3, 4]
GENERAL INFORMATION	
Geographical range	Found on the Pacific Coast from Alaska to northern California, and east through British Columbia to Alberta, northern Idaho, and northwestern Montana.[1, 2, 4] See maps above for visual of range.
Ecological distribution	Tolerates both fairly dry and wet coastal and montane forest sites, and grows on a range of substrates, including decaying wood and mineral soil. It requires high organic content.[2, 4] The species is very shade tolerant but does well in full sun.[1]

Climate and elevation range	Found from sea level to 1550m in elevation.[4]
Local habitat and abundance	Is the most common forest tree species in Alaska.[2] Often associated with Douglas-fir, silver fir, grand fir, giant arborvitae, and redwood at low elevations, or with noble fir, Alaska cedar, mountain hemlock, and western, white, and lodgepole pines at higher elevations.[1]
Plant strategy type / successional stage	Western hemlock becomes a climax species in ecological succession; its shade tolerance allows it to self-replace and it tends to dominate both the overstory and understory of the forest.[7]
Plant characteristics	A narrow-crowned tree that grows up to 60 meters (nearly 200 feet), western hemlock's branches sweep downward and can appear droopy. Foliage looks feathery, as the short, flat, blunt needles are of many different lengths 5-20 mm long and are produced in flat sprays. Papery female cones are small (about 2 cm long) and numerous, oblong and light brown in color when mature. Bark is rough and can appear scaly; it is gray-red-brown in color and can be thick and furrowed in older trees.[2]
PROPAGATION DETAILS Seed Propagation	
Ecotype	Avalanche, Glacier National Park in Montana, at 1100m elevation.[4]
Propagation Goal	Plants[3,4, 5]
Propagation Method	Seed[3,4, 5]
Product Type	Container (plug)[3, 4, 5]
Stock Type	172mL conetainers[4] or 1, 2, 3, and 4 gallon containers[5]
Time to Grow	0[3; 19 months[4]; 1 year[5]
Target Specifications	Container seedlings with firm root system (but not root-bound); Luna et. al. specifies that plants be 7 cm tall and 7 mm caliper.[4, 5]
Propagule Collection Instructions	If collecting from cones, collect in late September with pruning poles and store in burlap bags in a drying shed. Cones should be harvested when light tan color and before they begin to reflex.[4]
Propagule Processing/Propagule Characteristics	Use a tumbler to extract seeds from cones and remove wings in a fanning mill. Seed longevity to 5 years at 0 degrees C in sealed containers. There are 572,000 seeds per kg; Luna et. al. had a germination rate of 52%.[4]
Pre-Planting Propagule Treatments	Seeds' physiological dormancy must be broken. Rinse for 48 hours with running water; no bleach treatment. Put in cold moist stratification for 0-84 days (Luna et. al. cites 45 days in fine mesh bags in moist peat moss, at a temperature of 3 degrees C)[4]; germination happens at 20 degrees C. [3] Edwards (1972) confirms that stratification assists with faster and more uniform germination, though deems that rather than true dormancy, *T. heterophylla* instead falls under "delayed germination" because it simply takes longer for unstratified seeds to germinate given the same germination conditions.[6]
Growing Area Preparation / Annual Practices for Perennial Crops	Grow seeds in a greenhouse and outdoor nursery. Sow seeds directly on the growth media surface to provide access to light.[4]

	Growing media used by Luna et. al. consisted of 6:1:1 sphagnum peat moss, perlite, and vermiculite. Controlled release fertilizer is used.[4] Steinfeld uses SunGro Grower's Gold Mix #1.[5] Greenhouse conditions are 21-25C during the day and 16-18C at night. Hand-water and keep seedlings in the greenhouse until mid-May, then move to the outdoor nursery. Media should be watered until soaked.[4]
Establishment Phase Details	Germination is complete in 20 days. Liquid NPK fertilizer (7-40-17) is used for a month and seedlings are shaded for protection from direct sun.[4] Irrigate 1-2 times a week through overhead irrigation system, and maintain low density spacing of individual plants to ensure space and light for growth.[5]
Length of Establishment Phase	4 weeks[4, 5]
Active Growth Phase	Rapid growth stage is achieved 4-5 weeks post-germination, with optimum conditions being 18-23C and some liquid NPK fertilizer during this phase. Move plants to outdoor shadehouse in late May.[4] Ensure that moisture levels of the media remain at field capacity, especially during warm summer months.[5]
Length of Active Growth Phase	12-20 weeks[4, 5]
Hardening Phase	Fertilize in early fall; gradually lessen frequency of watering in September and October.[4,5] If winter temperatures reach low teens, bring trees into indoor shelter.
Length of Hardening Phase	4 weeks-3 months[4,5]
Harvesting, Storage and Shipping	The whole process until harvest takes 1.7 years, with a harvest date of September of the second year. Store plants in outdoor shadehouse with insulation.[4]
Length of Storage	5 months[4]
Guidelines for Outplanting / Performance on Typical Sites	Seedlings transplant best to their permanent location when they are 8-20 inches tall (usually 5-8 years old).[1]
Other Comments	1 gallon container stock can be produced in 2 years.[4]
PROPAGATION DETAILS Vegetative Reproduction: Cuttings	
Ecotype	Some cuttings collected from managed forests between Clallam Bay, WA and Tillamook, OR in the Coast Range, 0-300m elevation;[8] some from throughout the coast of British Columbia.[10]
Propagation Goal	Cuttings, with the ultimate goal of plants[8, 10]
Propagation Method	Vegetative[8, 9, 10]
Product Type	Container (plug)[8, 9, 10]
Stock Type	11.4 liter pots[8]
Time to Grow	

Target Specifications	
Propagule Collection Instructions	Collect from trees aged 28-62 years, from the previous year's last growth cycle and from the top or middle third of crown for optimal rooting.[8, 10] Best practice is to take from the outer section of the main branches where the most vigorous shoots are.[10] Cuttings should be long enough to have at least 2 cm in the soil and ideally should have 4 cm sticking out of the soil.[9] Thus, a length of 6-10 cm is a good range, with 2.5-3.5 cm of the leaves at the bottom of the cutting removed.[10] Cuttings can be taken mid-October to mid-February with generally equal results, though cuttings set in January produced the best crops.[9,10] The best cuttings are those which are semi-lignified and without large buds (look for a whitish stem, rather than green or brown).[9]
Propagule Processing/Propagule Characteristics	
Pre-Planting Propagule Treatments	Of the 10 cm long cuttings, the bottom 2 cm had needles removed and were treated with a dip into water then 10% "Dip 'n Grow" rooting chemical.[8] However, liquid rooting hormone is often preferable over powder, and another optimal rooting solution is 10,000 ppm of IBA (Stim-Root).[9] Not all shoots universally respond to the auxin treatment, but there are no adverse effects to the treatment. A 24 hour basal dip in 100 ppm IBA solution works well for Brix and Barker (1975).[10] Storage in plastic bags with wet paper towels up to 12 weeks in 4C had no significant effect on rooting. Though no comparison with a control was possible because no mold developed on the control plants, no harmful effects of a chlorine bleach were observed, so it could potentially be a good tool if mold or fungus were to develop during storage. Brix and Barker use a basal dip of 10% Benlate talc powder or a 24 hour soak in 150 ppm Benlate solution to increase rooting and prevent fungus.[10]
Growing Area Preparation / Annual Practices for Perennial Crops	Cuttings were rooted in the mist bench (80% relative humidity) in a greenhouse for two growing seasons before planting and were grown in 11.4-liter containers. A ratio of steam-sterilized 1:1:1 sand:peat:perlite was used with temperatures kept at 10-13C November-April and 15-20C May-October.[8,10] Light was supplemented to be 16 hour daylight conditions.[8] Rooting can also be done in Styroblocks with bottom heat and mist. Media should be well-draining to allow for the numerous wet-dry cycles throughout the growing season. Root at a soil temperature of 16-18C.[9]
Establishment Phase Details	Weekly spraying of fertilizer and fungicide.[8]

Length of Establishment Phase	Rooting after 5-6 months.[8] Brix and Barker found that rooting began mid-March for cuttings that had been collected and set in December, with the fastest rooting occurring from mid-April to mid-June.[10]
Active Growth Phase	After rooting, shoot growth is slow, but the second year can see growth of 5-10 cm height. In the third growth season, you can get 25 cm height growth.[10]
Length of Active Growth Phase	
Hardening Phase	
Length of Hardening Phase	
Harvesting, Storage and Shipping	Lift stock in late fall and cold-store for planting the following spring.[9]
Length of Storage	
Guidelines for Outplanting / Performance on Typical Sites	Seed cones can be seen a year after rooting, but pollen cones can take 4 years.[10]
Other Comments	It is more ideal that the stock plant from which cuttings are taken be young, since plagiotropism is decreased and growth and rooting is more optimal with young than with more mature stock material. Ensuring young stock material can be done by hedging, serial propagation, and tissue culture. However, this can achieve variable results for container cuttings of this species. Approximately 90% rooting success was shown.[9] Plagiotropism is an occasional issue but is often overcome and is less severe a problem than it is with Douglas-fir cuttings.[10]
INFORMATION SOURCES	
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