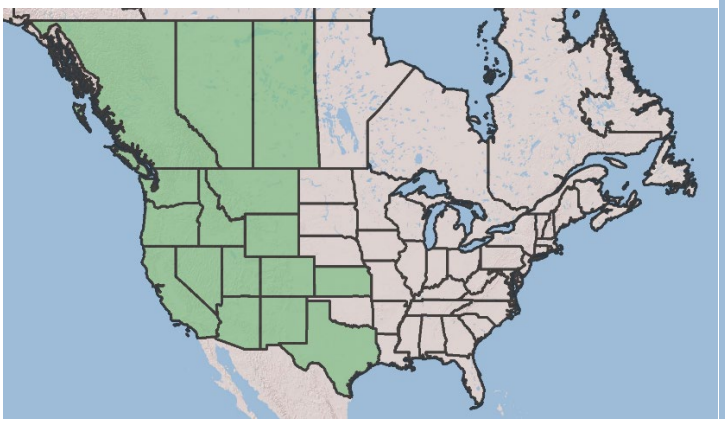
Plant Propagation Protocol for *Salix exigua*
ESRM 412 – Native Plant Production
URL: https://courses.washington.edu/esrm412/protocols/2021/SAEX.pdf

Credit: Richard Old[6]

North America Distribution



Pacific Northwest Distribution

Source: USDA PLANTS Database[9]

TAXONOMY	
Plant Family	
Scientific Name	Salicaceae
Common Name	Willow family
Species Scientific Name	
Scientific Name	*Salix exigua* Nutt.
Varieties	No varieties in USDA PLANTS Database
Sub-species	No sub-species in USDA PLANTS Database
Cultivar	Greenbank, Silver Sands[10], Silvar[1]
Common Synonym(s)	*Salix argophylla* Nutt. *Salix columbiana* (Dorn) Argus *Salix exigua* Nutt. Var. *angustissima* (Andersson) Reveal & Broome *Salix exigua* Nutt. var. *columbiana* Dorn *Salix exigua* Nutt. var. *hindsiana* (Benth.) Dorn *Salix exigua* Nutt. var. *luteosericea* (Rydb.) C. K. Schneid *Salix exigua* Nutt. var. *virens* Rowlee *Salix fluviatilis* Nutt. var. *argophylla* (Nutt.) Sarg. *Salix hindsiana* Benth. *Salix hindsiana* Benth. var. *leucodendroides* (Rowlee) C.R. Ball *Salix hindsiana* Benth. var. *parishiana* (Rowlee) C.R. Ball *Salix hindsiana* Benth. var. *tenuifolia* (Andersson) Andersson *Salix interior* Rowlee var. *angustissima* (Andersson) Dayton *Salix interior* Rowlee var. *luteosericea* (Rydb.) C.K. Schneid. *Salix linearifolia* Rydb. *Salix longifolia* Muhl. var. *argophylla* (Nutt.) Andersson *Salix longifolia* Muhl. var. *exigua* (Nutt.) Bebb *Salix longifolia* Muhl. var. *opaca* Andersson *Salix luteosericea* Rydb. *Salix malacophylla* Nutt. ex C.R. Ball *Salix macrostachya* Nutt. var. *leucodendroides* Rowlee *Salix nevadensis* S. Watson *Salix parishiana* Rowlee *Salix sessilifolia* Nutt. var. *hindsiana* (Benth.) Andersson *Salix sessilifolia* Nutt. ssp. *hindsiana* (Benth.) Andersson *Salix sessilifolia* Nutt. var. *leucodendroides* (Rowlee) C.K. Schneid. *Salix stenophylla* Rydb. *Salix thurberi* Rowlee[9]
Common Name(s)	Coyote willow, narrowleaf willow, sandbar willow[9], gray willow, dusky willow, pussywillow[8]
Species Code (as per USDA Plants database)	SAEX[9]

GENERAL INFORMATION	
Geographical range	maps above for distribution in North America and Washington state.
Ecological distribution	Sandy or gravelly soils in stream, river, wetland, shoreline sites, and other wet areas[8,10] Can grow in various dry shrub sites as well if roots can reach moist soil[1].
Climate and elevation range	Below 2700 m elevation[8]. Can grow in a wide range of temperatures, but winters with late frost can hamper success[1].
Local habitat and abundance	Grows among other common wetland plants such as *Salix, Betula,* and *Populus* species[4].
Plant strategy type / successional stage	Pioneer successional stage takes over in alluvial deposits. Has high tolerance to disturbances, droughts, and low nutrients[1].
Plant characteristics	Deciduous shrub with multiple branches, 3-23' high[3,8]. Long, thin leaves[8]. Silky white hairs on leaves, at least when young[3]. Spreads clonally; aggressive[9]. Catkin inflorescence with yellow flower bracts appear in the spring[8]. Dioecious. The fruit consists of many capsules, each holding many small seeds among woolly white hairs[3].
PROPAGATION DETAILS	
Propagation from Seed to Plants in Container (plug) as Detailed by Dreesen[5]*	
Ecotype	N/A
Propagation Goal	Plants
Propagation Method	Seed
Product Type	Container (plug)
Stock Type	One Gallon Tree Pot, 4"x4"x14"
Time to Grow	1-2 years
Target Specifications	Consolidated root mass sufficient to prevent root ball disintegration during out-planting.
Propagule Collection Instructions	Collecting seed from stock plants is easier than wild collections since timing of catkin development determines seed viability. Harvest catkins when cotton emerges from partially opened capsules. Viability may be higher if the capsules are more fully opened, but winds will disperse much viable seed. Place female catkins in paper sacks to capture seed as capsules open during drying. Seed dispersal usually takes a few days in a room with dry air and normal working temperatures. If the number of catkins collected forms a layer one or two catkins thick in the sack, the seed will disperse easily on its own. If a thick layer of catkins is placed in the sack, frequent turning and mixing of the sack will be required for uniform drying and seed release. Catkins may be collected in plastic bags but need to be transferred to paper sacks or drying racks as soon as possible to prevent moisture buildup leading to decomposition.
Propagule Processing/Propagule Characteristics	Seed can be cleaned using an air stream and soil screens. Dreesen uses a compressed air source and a set of soil screens in a series of sizes, from top to bottom: 250 æm, 500 æm, 125 æm. The dry catkins containing partially open capsules are placed between the 250 æm and 500 æm screens. A jet of compressed air is blown through the top screen in a

	swirling fashion; the seed is dislodged and remains on the 125 æm screen with the cotton and empty catkins remaining in the 500 æm screen.
Pre-Planting Propagule Treatments	No stratification.
Growing Area Preparation / Annual Practices for Perennial Crops	Greenhouse 70-72 F (21-22 C[2]) day, 55 F (13 C) night during winter, maximum summer temperature 85 F (29 C) with evaporative pad cooling. Mini-plug Irrigation: Dreesen uses a watering bench with mini-sprinklers to automatically water plug trays once a day in early morning. Cover the watering bench with a copper-coated fabric (Texel Tex-Rr Forestry fabric) to reduce roots leaving the plug cells.
Establishment Phase Details	Sow cleaned seeds immediately. Surface sow seeds; needs light for germination. Dreesen states that New Mexico Plant Materials Center germinates seed in "mini-plug" trays containing 512 cells each 14 mm x 14 mm x 29 mm. Mini-plugs are used due to space restrictions on their automated watering bench; using larger plugs if possible is beneficial. Dreesen uses a standard sphagnum peat moss and a fairly course perlite mix (Sunshine #1). *Salix* seed is very small (about 1 mm in length and 0.3 to 0.5 mm in width), which makes precise seed dispersal difficult. Adding diluent (e.g. grit, perlite) of similar size may help to achieve more precise sowing. If seeding at a very large scale, an automated seeder would probably be effective. Seeds are non-dormant[2]. Keep plug medium surface moist. Germination of willow seed is often apparent after one or two days, when swelling and separation of the cotyledons occurs. Thinning of seedlings is usually performed at the time of mini-plug transplanting or after transplanting into the next container size. Seedlings should be of sufficient size to make clipping feasible.
Length of Establishment Phase	Dreesen did not provide this.
Active Growth Phase	Note: Dreesen states that the plant will be transplanted into an intermediate container and then into a final container. Different practices will be applied to establish, guide through rapid growth, and harden plants in these new containers; these are all part of the broader active growth phase. Intermediate Container Type and Volume: Dreesen uses Ray Leach Super Cell - 10 cubic in. (164 ml) volume, 1.5 in. (3.8 cm) diameter, and 8.25 in. (21 cm) depth.

	Growing Media: Mix of 2 parts Sunshine #1 or #2 with 1 part perlite. 6 lb (2.7 kg) of controlled release fertilizer (CRF) incorporated per cubic yard (0.765 m3) of mix (Dreesen uses Osmocote Plus 15-9-12 (3-4 month release)). For plants started in the greenhouse during spring, 5-6 month release CRF is used, but for summer grown material 3-4 month release CRF is incorporated. Transplanting from Mini-plugs into Intermediate Container: Dibble filled Super Cells to create a hole for the mini-plug seedling. Remove mini-plug seedling root with a flat powder spatula with a blade about 6 mm wide and 30 mm long attached to a handle. Plunge blade along the side of root ball and lever seedling plug out of the cell. Drop plug into the dibbled hole and press the media around the root ball with fingers. Top watering firms and fills any voids around the plug. If excessive numbers of seed have germinated, excess seedlings can be cut off during the plug transplanting process or later after the seedlings are well rooted. Intermediate Container Establishment: The Super Cell seedlings in the greenhouse are watered with soluble fertilizer at every other watering. The fertilizer solution is Peters Peat Lite Special 20-10-20 at a rate of 200 mg/l nitrogen. Thinning of seedlings down to one per container can occur during this phase, usually when the seedlings are 2 to 4 cm tall. Intermediate Container Rapid Growth: Fertigation continues as described above. Intermediate Container Hardening: Super Cell seedlings should be ready to move outside in early May after the last freeze but before excessively hot outdoor temperatures. In the outdoor nursery, larger seedlings may require watering every day, smaller seedlings usually every other day. Final Container Type and Volume: One gallon tree pot, 4"x4"x14" (10 cm x 10 cm x 36 cm), 173 in3 (2.83 l) volume. Growing Media: Commercial nursery canning mix of aged screened softwood bark, pumice, and sphagnum peat moss. Planting Technique: Transplant into treepots in the late summer of the first year or late spring of the second year. Fill treepots with media and dibble with a Super Cell planting dibble. Top-dress with controlled release fertilizer (CRF) at planting or soon thereafter. Use a 5 to 6 month delivery CRF for pots transplanted in late spring, and a 3 to 4 month delivery CRF at a rate of about 15 g per pot transplanted later in the summer. Dreesen supported treepots in cages 36 in. x 36 in. x 8 in. tall (91 cm x 91 cm x 20 cm) constructed of 4 in. x 4 in. (10 cm x 10 cm)

	wire mesh fencing; each cage holds 81 pots. Final Container Establishment: Watering frequency: usually three times/week for riparian species. Plants are typically grown without shade. Final Container Rapid Growth: Watering frequency can be as often as every day for very large riparian plants with substantial leaf areas.
Length of Active Growth Phase	Dreesen did not provide this.
Hardening Phase	The watering frequency is reduced in late September to early October to promote hardening.
Length of Hardening Phase	Dreesen did not provide this.
Harvesting, Storage and Shipping	Dreesen did not provide this.
Length of Storage	Dreesen did not provide this.
Guidelines for Outplanting / Performance on Typical Sites	Dreesen did not provide this.
Other Comments	Dreesen did not provide this.
Propagation from Cutting to Container (plug) as Detailed by Luna and Evans[7]	
Ecotype	
Propagation Goal	Plants
Propagation Method	Vegetative
Product Type	Container (plug)
Stock Type	3 L containers
Time to Grow	1 year
Target Specifications	Stock Type: Container cutting Height: 15 cm Caliper: 6 mm Root System: firm plug in 3L (1 gallon) containers.
Propagule Collection Instructions	Method: Pre-Rooting Type: Hardwood or softwood tip cuttings Collect hardwood tip cuttings before bud break in late winter[12]. Collect softwood cuttings any time after flowering.
Propagule Processing/Propagule Characteristics	Keep cuttings moist and refrigerated until pre-planting treatment. Rooting %:100%
Pre-Planting Propagule Treatments	Cuttings are 20 cm in length and 7 mm in caliper. Cut cuttings into 20 to 30 cm lengths. Recut base and remove 1/3 of leaves or buds. Place cuttings in a 2-minute fungicide bath to remove surface pathogens. Treat cuttings with 1000 ppm liquid Indole-3-butyric acid (IBA)[11]. Place in mist bed with at least 2 nodes below the surface of the rooting medium. Keep cuttings in mist bed with bottom heat for 2 to 4 weeks.
Growing Area	Set automatic mistbed to mist at 6 second intervals every 6 minutes. Too

Preparation / Annual Practices for Perennial Crops	frequent misting will result in leaf and stem rot. Increase or decrease misting frequency according to daily outdoor temperature and wind. Bottom heat is set to 21C with heating cables buried 12 cm beneath rooting medium. Rooting medium is 50% perlite and 50% sand. Cover mistbed with shadecloth during rooting. After cuttings are potted, move them to an outdoor shadehouse for 4 weeks. After, move to full sun exposure in the outdoor nursery and irrigate with automatic irrigation system in early morning until containers are thoroughly leached. .
Establishment Phase Details	Time to Transplant: 2 to 4 weeks If cuttings prerooted, lift them out of mistbed after adequate root systems have formed.
Length of Establishment Phase	4 weeks
Active Growth Phase	After cuttings are lifted from the mistbed, pot into 3L containers. Growing medium is 70% 6:1:1 milled sphagnum peat, perlite, and vermiculite and 30% sand with Osmocote controlled release fertilizer (13N:13P2O5:13K2O; 8 to 9 month release rate at 21C) and Micromax fertilizer (12%S, 0.1%B, 0.5%Cu, 12%Fe, 2.5%Mn, 0.05%Mo, 1%Zn) at the rate of 5 grams of Osmocote and 2 grams of Micromax per conetainer. Irrigate cuttings after potting and place in the shadehouse for 4 weeks. After establishment in the shadehouse, move plants to full sun exposure in the outdoor nursery.
Length of Active Growth Phase	6 weeks
Hardening Phase	Gradually reduced irrigation in September and October. Given plants one final irrigation prior to winterization.
Length of Hardening Phase	4 weeks
Harvesting, Storage and Shipping	Harvest date: June Storage Conditions: Overwinter in outdoor nursery under insulating foam and snow.
Length of Storage	5 months
Guidelines for Outplanting / Performance on Typical Sites	Luna and Evans did not provide this.
Other Comments	Luna and Evans did not provide this.
Propagation from Cutting to Bareroot (field grown) as Detailed by Zeidler and Justin[12]	
Ecotype	N/A
Propagation Goal	Plants
Propagation Method	Vegetative
Product Type	Bareroot (field grown)

Stock Type	1+0 (grow one year in a seedbed)
Time to Grow	1 year
Target Specifications	Height: 12 in. Caliper: 3/16 in. Root System: Root system must balance top growth.
Propagule Collection Instructions	Collect hardwood cuttings in late winter before budbreak. Collect cuttings from stooling beds that are hedged to maintain straight juvenile wood and for ease of handling and sticking in field beds. May also grow from wild collections. Collect softwood cuttings any time after flowering[7].
Propagule Processing/Propagule Characteristics	Cut to 8 to 10 inch lengths. Hardwood cuttings can be wrapped, bundled and stored in the cooler until they are stuck into field beds. Rooting %:100%[7]
Pre-Planting Propagule Treatments	Zeidler and Justin did not provide this. Place cuttings in a 2 minute fungicide bath to remove surface pathogens. Treat cuttings with 1000 ppm liquid Indole-3-butyric acid (IBA)[11].
Growing Area Preparation / Annual Practices for Perennial Crops	Soils: Trimmer's field soils are Taylorsville Sandy clay loam with Cca horizon shallower than 12", Taylorsville sand clay loam variant with Cca deeper than 12",Taylorsville Clay loam variant with Cca horizon shallower than 12" and Taylorsville Clay loam variant with Cca horizon deeper than 12". Field Bed Preparation: Mark out and form beds as needed and apply 0-45-0 (N:P:K) fertilizer in April. Apply 2 to 3 inches of compost to cutting beds prior to sowing. Apply sulfur in May. Cultivate fields for weeds as needed throughout the growing season. Irrigation: Trimmer uses overhead irrigation with two inch aluminum pipe that can be moved from field to field each year.
Establishment Phase Details	Stick cuttings in prepared field beds during early spring to a depth of 6 inches. Firm soil around stems after sticking to remove air pockets and irrigate after planting. Irrigate beds as surface begins to dry. Rooting occurs when field soils warm in later spring.
Length of Establishment Phase	1 month after rooting in the Spring
Active Growth Phase	Fertilization: Trimmer applies Morgro 21-0-0 (N:P:K) with a Gandy spreader (setting 18, speed 2 mph, rpm 1100 to 1200) the second week of each month during the growing season (April to August) at the rate of 120 lbs/acre. Trimmer irrigates for at least 45 minutes following all fertilizer applications. This insures that foliage will not burn and moves fertilizer into the root zone. Fertilizer is not applied when foliage is wet. All sulfur and 0-45-0 (N:P:K) applications must be mechanically incorporated since these amendments are not mobile in the soil. Root Pruning Procedures: Root prune cuttings after they are well established in June. Test an area to see if cuttings can handle root pruning. If excessive wilting occurs, do not prune.

	Irrigate heavily for 2 to 3 days prior to pruning to saturate the root zone. Set pruning blade to slightly wrench seedlings as they are pruned. Check pruning depth frequently and adjust as needed. Irrigate for a minimum of 2 hours following root pruning to settle soil back around roots. This step is critical to eliminate post root pruning mortality. Irrigate field heavily for 2 to 3 days to further settle the soil. Top Pruning: Trimmer prunes with a sickle bar mower attached to a 656 international tractor. Don't operate above 1200 rpm speed. Frequently check and adjust the cut during the process to ensure the desired height is reached. Keep field workers behind the cutting head.
Length of Active Growth Phase	4 months
Hardening Phase	Hardening begins during the third week of August or when dormancy is induced. No fertilizer is applied after August 28th. Irrigation frequency and duration is shortened and applied only when needed.
Length of Hardening Phase	2 months
Harvesting, Storage and Shipping	Lifting window is during mid-November when cuttings are completely dormant. Hand lift cuttings after the beds have been undercut at a depth of 12 inches with a lifter. "Heel in" Fall-lifted stock in sandy soils after they have been graded and bundled in bundles of 25. Lift them in spring before they break dormancy, then store in a cooler on stacked pallets. Keep lifted stock in cooler at 36-42 degrees F and 92-98% relative humidity with good air circulation.
Length of Storage	Zeidler and Justin did not provide this.
Guidelines for Outplanting / Performance on Typical Sites	Zeidler and Justin did not provide this. "Propagation studies in Ontario have achieved 90% rooting success in bareroot plantings of [*Salix exigua*]"[1].
Other Comments	Zeidler and Justin did not provide this.
INFORMATION SOURCES	
References	See below.
Other Sources Consulted	See below.
Protocol Author	Miguel Orr
Date Protocol Created or Updated	5/3/2021

*Each 'Propagation Details' section draws heavily from the work of writers of other protocols, as indicated at the top of each section. Information in each of these sections is edited slightly for cohesion. Information provided by others is indicated by a citation.

References:

[1]Anderson, Michelle. *Salix exigua*. 2006. Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory U.S. Department of Agriculture. 3 May 2021. <https://www.fs.fed.us/database/feis/plants/shrub/salexi/all.html>.

[2]Baskin, Jerry M. and Carol C. Baskin. *Propagation protocol for production of Container (plug) Salix exigua Nutt.* 2002. University of Kentucky Lexington, Kentucky. 3 May 2021.

[3]Calscape. *Sandbar Willow*. n.d. 3 May 2021. <https://calscape.org/Salix-exigua-()>.

[4]Dixon, Mark D. and Monica G. Turner. "Simulated Recruitment of Riparian Trees and Shrubs Under Natural and Regulated Flow Regimes On The Wisconsin River, USA." *River Research & Applications* (2006): 1058-1083. 3 May 2021. <https://onlinelibrary.wiley.com/doi/epdf/10.1002/rra.948>.

[5]Dreesen, Dave. *Propagation protocol for production of Container (plug) Salix exigua Nutt. plants One Gallon Tree Pot, 4"x4"x14"*. 2003. USDA NRCS - Los Lunas Plant Materials Center Los Lunas, New Mexico. 3 May 2021. <http://NativePlantNetwork.org>.

[6]Giblin, David and Don Knoke. *Salix exigua*. n.d. 3 May 2021. <https://biology.burke.washington.edu/herbarium/imagecollection/taxon.php?Taxon=Salix%20exigua>.

[7]Luna, Tara and Jeff Evans. *Propagation protocol for production of Container (plug) Salix exigua Nutt. plants 3 L containers*. 2008. USDI NPS - Glacier National Park West Glacier, Montana. 3 May 2021.

[8]Stevens, Michelle, et al. "Coyote Willow Plant Guide." n.d. *USDA PLANTS Database.* 3 May 2021. <https://plants.sc.egov.usda.gov/DocumentLibrary/plantguide/pdf/cs_saex.pdf >.

[9]USDA NRCS National Plant Data Team. *Salix exigua Nutt.* n.d. 3 May 2021. <https://plants.sc.egov.usda.gov/home/plantProfile?symbol=SAEX>.

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[11]Wilkinson, Kim M. et al. *Tropical Nursery Manual: A Guide to Starting and Operating a Nursery for Native and Traditional Plants* . United States Forest Service , 2014.

[12]Zeidler, Scott and John Justin. *Propagation protocol for production of Bareroot (field grown) Salix exigua Nutt. plants 1+0*. 2003. Utah Division of Forestry, Fire and State Land - Lone Peak Nurse Draper, Utah. 3 May 2021. <http://NativePlantNetwork.org >.

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