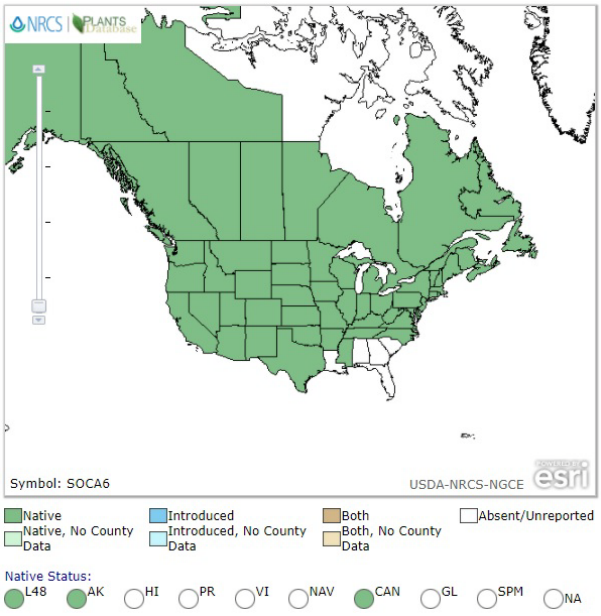
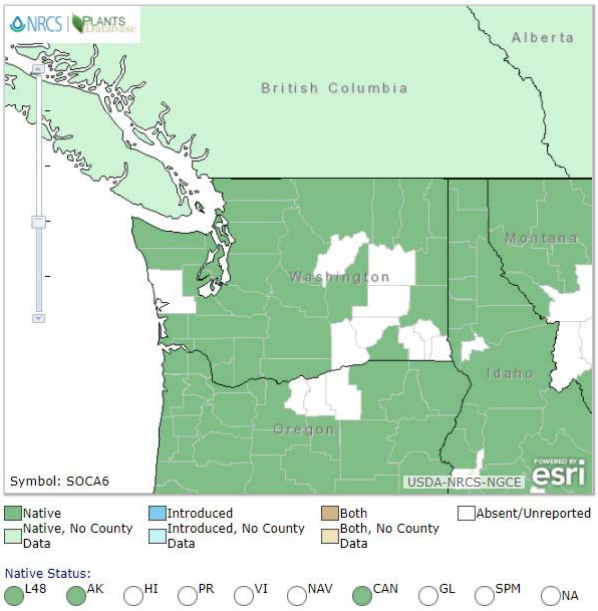
Plant Propagation Protocol for *Solidago canadensis*
ESRM 412 – Native Plant Production
Spring, 2018

North America Distribution



Washington State Distribution



Source: https://plants.usda.gov/core/profile?symbol=SOCA6 (USDA Plant Database)

TAXONOMY	
Plant Family	
Scientific Name	Asteraceae (USDA Plant Database)
Common Name	Aster family (USDA Plant Database)
Species Scientific Name	
Scientific Name	*Solidago canadensis* L. (USDA Plant Database)
Varieties	1. *Solidago canadensis* L. var. *canadensis* 2. *Solidago canadensis* L. var. *gilvocanescens* Rydb. 3. *Solidago canadensis* L. var. *hargeri* Fernald 4. *Solidago canadensis* L. var. *lepida* (DC.) Cronquist 5. *Solidago canadensis* L. var. *salebrosa* (Piper) M.E. Jones (USDA Plant Database)
Sub-species	None
Cultivar	None
Common Synonym(s)	None
Common Name(s)	Canada goldenrod (USDA Plant Database)
Species Code	SOCA6 (USDA Plant Database)
GENERAL INFORMATION	
Geographical range	1. This species is found in almost all US states except Hawaii, Louisiana, Alabama, Georgia, South Carolina and Florida, and all

	Canadian provinces except Nunavut (Pavek, 2012). 2. See the detail map above (USDA Plant Database).
Ecological distribution	They often occurred in prairie, plains, meadows, pastures, savannahs and stream banks (Plant Database, Lady Bird Johnson Wildflower Center at The University of Texas at Austin).
Climate and elevation range	Full sun or part shade environment. Annual precipitation is 16 to 60 inches (Pavek, 2012).
Local habitat and abundance	They are often found growing in moist soil of meadows, thickets, avalanche slopes and in open forest (Luna *et al*., 2008; Davis and Kujawski, 2001) and typically in moist soil with medium texture and moderate levels of organic matter. They are found in waterways and ditches along roadsides and railroads. Also, they may grow in dry and open slopes in upland prairies, and deciduous and evergreen forests. Though they can grow in dry area, they are rarely found on very dry sites and not found on waterlogged sites (Pavek, 2012).
Plant strategy type / successional stage	1. *Solidago canadensis* are weedy because their aggressive rhizomatous growth. This behavior enables them to rapidly colonize disturbed sites and makes them difficult to control. However, they almost never reach problematic density in stable rangeland environments (Werner *et al*. 1980; Whitson *et al*. 2004). 2. It was introduced to Europe in 1645 and to China in 1930. It is now considered an invasive weed and a threat to biodiversity (Pavek, 2011). 3. The $CaCO_3$ tolerance is medium and the light requirement is sun or part shade (Plant Database, Lady Bird Johnson Wildflower Center at The University of Texas at Austin). 4. It is easily influences by pathogens and pests, which may reduce seed production (Pavek, 2012).
Plant characteristics	*Solidago canadensis* is a native, warm-season, long-lived perennial that spreads by rhizomes and forms large, dense patches. Stems are mostly smooth, covered with fine hairs at the top and are 1 to 7 ft tall. Leaves are sharply toothed, lance-shaped, covered with fine hairs, triple-nerved and 2 to 5 inches long. Flower panicles occur at the end of each stem, and when open, are 10 inches wide. Inflorescences occur mostly on one side of long, drooping panicle branches, have 10 to 17 ray flowers, and bloom July through October. Pollination typically occurs by the aid of insects. Seeds are small and dry with sparse hairs and numerous pale bristles at the tip. (Pavek, 2012)
PROPAGATION DETAILS **Propagation by Seed**	
Ecotype	The following propagation details are gathered from different experiments and the ecotypes what they tested seeds came from are showed below: 1. Forest margin in well drained soils, Fish Creek, 3500 feet elevation, Glacier National Park, MT (Luna *et al*., 2008). 2. George Washington Memorial Parkway (Davis and Kujawski, 2001).

	3. Mt. Desert Island, Maine (Van Der Grinten, 2002).
Propagation Goal	Plants
Propagation Method	Seed
Product Type	Container (plug). (Luna *et al*., 2008; Davis and Kujawski, 2001; Van Der Grinten, 2002)
Stock Type	160 ml containers (Luna *et al*., 2008).
Time to Grow	3 Months (Luna *et al*., 2008).
Target Specifications	1. The height of target plant is 10 cm and 8 to 10 true leaves and root system plugs in 160 ml container firmly (Luna *et al*., 2008). 2. The height is 4 to 6 inches after cutbacks and root system plugs in the media firmly and fully (Davis and Kujawski, 2001). 3. Plant plugs, 1" x 1" x 4" cell size. The height is approximately 4 inches. Firm root plug for a greenhouse crop plant. (Van Der Grinten, 2002).
Propagule Collection Instructions	1. Seeds are collected in October when the pappus is fully extended and the achenes turn dark brown. They collected seeds with paper bags and then kept them in a well ventilated drying shed before cleaning. (Luna *et al*., 2008). 2. The seeds start to ripen at 7 days after full bloom stage and fully ripen at 28 days (Shen *et al*., 2004). 3. Hand harvested when seeds develop a grayish cast (Van Der Grinten, 2002).
Propagule Processing/Propagule Characteristics	1. Seed dormancy is classified as nondormant and its longevity is up to 5 years at 3 to 5℃ in sealed containers. Seeds are cleaned with a hammermill and office clipper at NRCS. The seeds per Kg are approximate 4,400,000. The purity is 100% and germination percentage is 50% (Luna *et al*., 2008). 2. Large pieces of chaff can be removed by hand easily. Seeds can produce 2,200 seedlings per gram of seed sown (Davis and Kujawski, 2001). 3. Drying the seed after harvesting is allowed. Materials then run on the Clipper seed cleaning machine with a serial processes. The detail can be found in Van Der Grinten (2002). The harvest weight was 63 pounds and after processing, it was 35 pounds. The seed is so small that hard to clean. The purity is only 12%. Seeds per pound are 2,000,000. (Van Der Grinten, 2002). 4. Seed stripped from plant inflorescences and utilized rub board to hand clean and extract achenes from inflorescence. Hand-screened product with 1/24 box screen. Small inert material removed with the South Dakota seed blower. Seed lot purity is not very good, many stems and other inert materials approximately the same size as achenes in seed lot. It's hard to separate them. Small seed size, up to 1,300,000 seeds per pound. (Wynia, 2002).
Pre-Planting Propagule Treatments	1. According to Shen *et al*. (2004), the optimum temperature for seeds of *Solidago canadensis* to germinate is between 20-30℃. When temperature is below 20℃ or above 30℃, the seed germination

	percentage decreases significantly. The seeds can germinate under relative soil water content of 15-50% but their ability of breaking ground is very weak. So covering with soil of above 0.5cm thickness can effectively inhibit them from germinating. The germination rate of seeds stored at normal temperature is higher than that of seeds buried in soil. 2. Seeds will germinate more efficiently when surface sowing the seed on moist media, covering the trays with plastic to trap moisture and placing the trays on heat mats set to keep the media around 80-86°F (Davis and Kujawski, 2001).
Growing Area Preparation / Annual Practices for Perennial Crops	1. In the propagation protocol prepared by Luna *et al*. (2008), the growing areas are greenhouse and outdoor nursery. They directly sow seeds which are lightly covered with medium. When covering seeds, careful attention is necessary because germination rate will decrease if seeds are buried too deep in containers. Growing medium is mixed with milled spaghnum peat, perlite, and vermiculite The proportion is 6:1:1 and also mix with Osmocote controlled release fertilizer and Micromax fertilizer at the rate of 1 gram of Osmocote and 0.20 gram of Micromax per container. Containers are filled and sown and irrigated thoroughly. Greenhouse temperatures are maintained at 22°C day/ 13°C night during germination and growth. 2. In the propagation protocol prepared by Davis and Kujawski (2001), greenhouse is alternating with day/night temperatures (day: 70-85°F in winter depending on the natural solar; night: 65-68°F). Extended daylight provided from 4:30-10:30 with high intensity lights. Seed was hand sown into 392 plug trays with germination mix and then seedlings transplanted to 72 plug trays or Ropak multipots with Sunshine #1 or #5 potting mix and amended with 18-6-8,180-day Nutricote SR at 0.15 lb. per ft^3, or 20 oz. per 3.8 ft^3 bale of potting media. 3. In the propagation protocol prepared by Van Der Grinten (2002), greenhouse is for seeding and initial growth at 70°F and lathe house for growing and hardening off. Plants grown in Rootrainers (bookplanter, 1" x 1" x 4" cell size) which allows the plug to be removed by the root system. Growing Media are Metro-Mix 360 media.
Establishment Phase Details	1. In this phase, medium must be kept moist during germination. Germination usually complete in 1 to 2 weeks. Seedlings are thinned at the true leaf stage. (Luna *et al*., 2008). 2. The sowing date should be in fall or winter. It takes 6-7 days to emerge. Seed is heavily sown onto germination mix in propagation plug trays and kept evenly moist and given bottom heat until germinated. Seedlings were transplanted from germination to multipots about 4 weeks. (Davis and Kujawski, 2001). 3. Hand sowing 4 to 5 seeds per cell in the greenhouse in February with a light layer of Metro-Mix applied on top after seeding, followed by a

	through and regular watering. Germination is relatively uniform. Seeds will emerge in 1 to 2 weeks. Greenhouse temperature should be 70°F. (Van Der Grinten, 2002).
Length of Establishment Phase	3 weeks (Luna *et al*., 2008).
Active Growth Phase	1. Shoot and root grow rapidly following germination. Plants are fertilized with liquid fertilizer (N:P:K 2:1:2) at 100 ppm until root plugs firmly in the soil. They are rhizomatous and quickly fill containers in 4 to 5 weeks. (Luna *et al*., 2008). 2. Cutback of foliage was performed at about 10 weeks. Fertilized lightly approximately bi-weekly or as needed with soluble fertilizer at approximately 75-100 ppm N. (Davis and Kujawski, 2001). 3. Monitor watering. Fertilization with Miracle-Gro can be applied. Plants can be thinned to 2 plants per cell at this stage. (Van Der Grinten, 2002).
Length of Active Growth Phase	5 weeks (Luna *et al*., 2008).
Hardening Phase	1. Irrigation is gradually reduced in September and October. Plants are leached with clear water and fertilized with liquid fertilizer (N:P:K 1:2:2) once before winterization. (Luna *et al*., 2008). 2. The greenhouse is cooled down or plugs are moved outdoors 2 weeks before outplanting and fertilization is stopped. (Davis and Kujawski, 2001). 3. The Rootrainers are moved from the greenhouse to outside lathe house in early spring prior to being transplanted. (Van Der Grinten, 2002).
Length of Hardening Phase	4 weeks (Luna *et al*., 2008).
Harvesting, Storage and Shipping	1. It takes 3 months to harvest. Generally, the harvest date is in June. Seedlings can overwinter in outdoor nursery under insulating foam cover and snow. (Luna *et al*., 2008). 2. It takes about 14 weeks to harvest. Plugs are not overwintered. Seed can be stored in seed bags in National Plant Materials Center cooler at 40°F and 35% relative humidity. (Davis and Kujawski, 2001). 3. Harvest date is in October. Store dried seed in cooler at 40°F. (Van Der Grinten, 2002).
Length of Storage	5 months (Luna *et al*., 2008).
Guidelines for Outplanting / Performance on Typical Sites	No information.
Other Comments	1. *Solidago canadensis* is invasive species in Europe and China. A lot of researches are conducted there not to find out how to propagate it but how to ease it, such as influences of herbicides, uprooting and allelopathic compounds that affect native plants, etc. (Abhilasha *et al*.,

	2008; Guo *et al*., 2009; Yang *et al*., 2007). 2. *Solidago canadensis* readily establishes on road shoulders and old burns and is vigorously rhizomatous. It is an excellent forb for erosion control (Luna *et al*., 2008).
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Other Sources Consulted	None
Protocol Author	Arthur Hsin-Wu Hsu
Date Protocol Created or Updated	05/07/18

Appendix. Propagation protocol prepared by Mercedes Mijares in 2006.

Plant Data Sheet

Solidago Canadensis
var. Gilvocanescens

Var. Canadensis

Species: Canada Goldenrod - Solidago Canadensis var. Gilvocanescens. Height: 2-5 feet(40-150 cm). Width: 3 feet (91 cm). (4)

Range: It is found in AR, AZ, CA, CO, CT, IA, ID, IL, IN, KS, KY, MA, ME, MI, MN, MO, MS, MT, ND, NE, NH, NJ, NM, NV, NY, OH, OR, PA, RI, SD, TN, TX, UT, VA, VT, WA, WI, WV, WY. But the variety Gilvocanescens is only found in 17 states. (4)

Climate, elevation: Hardy to USDA Zone 3 (average minimum annual temperature -40ºF). (3)

Local occurrence: This species is native to 39 states, but in Washington state, is can be found in these Counties: Whatcom, Okanogan, Ferry, Stevens, Pend Orelle, Spokane, Whitman, Walla Walla, Grant, Chelan, Snohomish, King, Pierce, Thurston, Mason, Jefferson, Clallam, Yakima, Pacific, Lewis, Wahkiakum, Cowlitz, Clark, and Klickitat. (4)

Habitat preferences: Abandoned farmlands, infrequently grazed pastures, waste areas, and tallgrass prairies, also along roadsides and fence lines, in dry open fields, and in open woods or damp meadows that dry out every year. This is a perennial plant. (3)
Plant strategy type/successional stage: It is consider an invasive plant by Cornell University and Western Society of Weed Science in cooperation with Cooperative Extension Services, University of Wyoming. Fairly shade intolerant although it occurs in sparsely wooded areas and is sometimes dominant or codominant in disturbed forest understories. One of the first species to invade following disturbances or fire, it is eventually replaced by shrubs. Has an allelopathic effect on Sugar Maple (*Acer saccharum*) seedlings and reduces germination of herbaceous species, including itself. (3,4)
Associated species: It is in the family of Asters (Asteraceae). (4)
May be collected as: Reproduces by seed and vegetatively by rhizomes. Therefore, it can be collected as seed or division. (3)
Collection restrictions or guidelines: If collected by division, it can only be collected after its first year of growth. Allow seed heads to dry on plants; remove and collect seeds (1, 3)

Seed germination (needs dormancy breaking?): It needs stratification. (3)

Seed life (can be stored, short shelf-life, long shelf-life): N/A

Recommended seed storage conditions: N/A
Propagation recommendations: By seed in late winter to spring, but division is the most successful method (spring). (2, 3)
Soil or medium requirements: Tolerates wide range of soil fertility and texture conditions, but typically found in fairly moist soils. Not found on waterlogged sites and only rarely on very dry sites. It prefers dry areas. It requires full sun.(2, 3)
Installation form: Cultivars and species available by mail order from specialty suppliers or at local nurseries. Do not plant in busy areas, since bees love this plant. .(2, 3)
Recommended planting density: Spacing: 24-36 in. (60-90 cm) (1)
Care requirements after installed: Do not use fertilizer after installation. Average Water Needs; Water regularly; do not overwater (1, 2)

Normal rate of growth or spread; lifespan: It is an aggressive creeping plant. (2)

Sources cited

1. Dave's Garden. Cited May 20, 2006. Available at http://davesgarden.com/pf/go/1154/index.html
2. Rainy Side Gardens in the Pacific North West. Plant Gallery and growing guide. Native plants (internet). Cited May 20, 2006. Available at http://www.rainyside.com/features/plant_gallery/nativeplants/Solidago canadensis.html
3. Rook, J.S. Earl. Solidago Canadensis. Canada goldenrod. September 27, 2002. Cited May 20, 2006. Available at http://www.rook.org/earl/bwca/nature/herbs/solidagocan.html
4. USDA plants. Plant Data base. Cited May 20, 2006. Available at http://plants.usda.gov/java/profile?symbol=SOCA6&photoID=soca6_003_avp.tif

Data compiled by: Mercedes Mijares.