Solidago puberula (Downy Goldenrod): Possible Utilization for Native Environment Restoration, Medicinal Uses, and More

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Executive Summary

Solidago puberula is a plant native to the Northeastern United States and is present throughout much of Eastern North America. It is the perfect addition to perennial gardens that require low maintenance and can be grown in many climate conditions. This beautiful plant can be used as a pollinator attractor or as a cut flower to fill arrangements to add a pop of color. *Solidago puberula* has also been subject to many medicinal uses in indigenous cultures and research regarding its essential oil anti-inflammatory properties. Production of this plant is straightforward and is favored by native plant nurseries. Consumers looking for a plant that offers multi-benefits, including soil health, pollinator habitat, and native landscape restoration, will find interest in *Solidago puberula.*

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I. INTRODUCTION

A. Taxonomy

Solidago puberula, commonly known as downy goldenrod, is a part of the *Solidago* genus (goldenrods), which has about 120 species in the Asteraceae, all ranging from 2 cm to 2.5 m tall (Semple and Beck 2021). *Solidago puberula* is a perennial flowering herbaceous plant with two subspecies: *S. p.* ssp. *puberula* and *S. p.* ssp. *pulverulenta*.

B. Geographic Distribution in the Wild

Solidago puberula is native to the eastern part of North America. Figure 1 shows the native range of *Solidago puberula* highlighted in green from the United States Department of Agriculture's (USDA) website (USDA, 2014). The native range covers most of the eastern United States, Quebec, and Ontario.

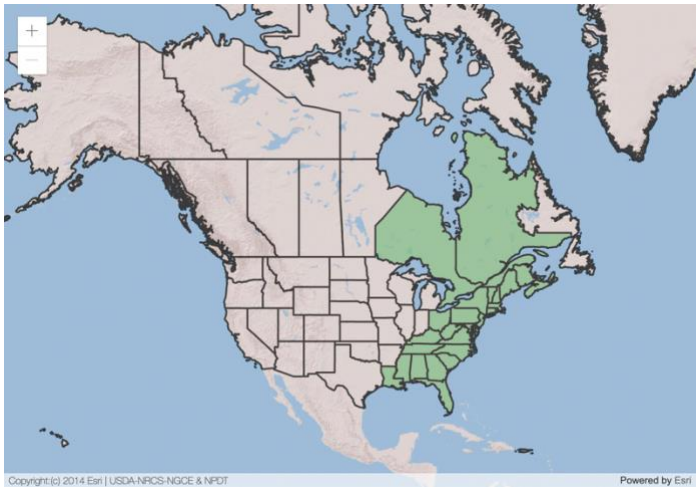

FIGURE 1. The native range of *Solidago puberula* highlighted in green. The native range consists of eastern the United States and Canada. https://plants.sc.egov.usda.gov/home/plantProfile?symbol=SOPU

C. Native Growing Climatic Conditions

Solidago puberula grows natively in Eastern Temperate Forests and Northern Forest ecoregions. The Eastern Temperate Forest ecoregion covers a wide area along Eastern United States and the Southeastern Coastal Plains and eastern hardwood forests. Climatic and environmental conditions of the eastern temperate forest are observed to be temperate, humid, thick and diverse forest cover, and dense human population (Gilliam et al. 2011). Latitudinally climate goes from cool, continental, to subtropical. There are many wetlands, streams, and lake systems. Soils of this region are known to be leached due to relatively high rainfall, making soils naturally low in nutrients and show excess in calcium and nitrogen (Gilliam et al. 2011).

The Northern Forest ecoregion climate and environmental conditions are distinguished by long, cold winters and short, warm summers. Temperature can range from -20.5 °C in the winter to 18 °C in the summer. This ecoregion is heavily forested with conifers, black spruce (*Picea mariana*), white spruce (*Picea glauca*), jack pine (*Pinus banksiana*), balsam fir (*Abies balsamea*), and tamarack (*Larix laricina*). Shallow soils and exposed bedrock are found throughout this region, making ideal growing conditions for shrubs, lichens, and forbs (Pardo et al. 2011). *Solidago puberula* can be characterized as a forb plant, which is an herbaceous, broadleaf plant that is not grass-like.

D. Species Habitat

Solidago puberula specific growing habitat has not been extensively studied or reported. The genus *Solidago* and *S. puberula's* native growing climatic conditions can be used to provide supplemental information until further research is conducted. *Solidago* grows best in sun to part shade exposure in well-drained to sandy soils, but can tolerate moist clay soils.

Figure 2 shows the USDA's plant hardiness zone map. *Solidago puberula's* native growing range (Figure 1) is overlaid, it would indicate that it can be characterized as a hardy perennial plant with a high to moderate heat tolerance. *Solidago* species thrive in USDA Zones 3 to 8 (Native Plant Trust, 2023).

Solidago puberula is drought and salt tolerant, urban environment tolerant, and resistant to deer and rabbit damage (Native Plant Trust, 2023). It is commonly found in sunny meadows, prairies, woodlands, slopes, and roadsides. *Solidago puberula* is great at attracting pollinators due to its nectar production, especially in moist conditions. Birds are also known to forage the seeds of *Solidago*. This plant would make a fine addition to a native residential perennial garden due to its low maintenance nature and pollinator favored pollen and nectar source. Plant nurseries in the northeastern part of North America could market this crop for sales for residential and commercial use. Native habitat restoration is becoming increasingly popular in urban and rural environments alike due to efforts to combat climate change and human impact on the landscape. It may be necessary to occasionally thin, cut-back, or deadhead after flowering to control self-seeding and spread as this is a perennial species, but otherwise than minor management this would still be considered a low maintenance plant.

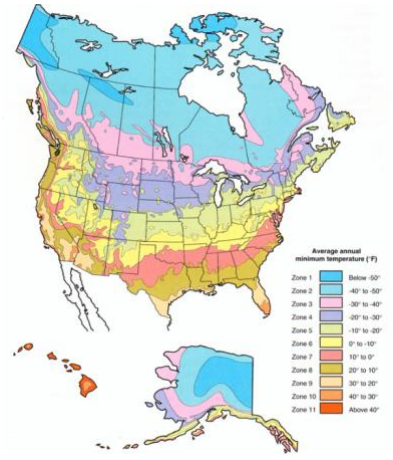

FIGURE 2. USDA plant hardiness zone map.

https://www.wildflowerfarm.com/plant-zone-map.html

E. Tendency to Naturalize and Invasive Threat

Solidago puberula naturalizes quick as it can be spread throughout many different environments and residential landscapes (Native Plant Trust, 2023). However, it is also important to note due to wind-borne seeds and the division of underground rhizomes, intermediate spreading may occur. Extensive research or documentation has not been made concerning the establishment of *Solidago puberula* in the landscape, but information regarding the genus *Solidago* has reported that if not controlled some species may become invasive. A study evaluating herbaceous perennials as weed suppressive groundcovers along the roadside or other low maintained landscapes, found that some species of *Solidago* show a strong performance in suppressing noxious weeds in stressful environments (Hyun Eom et al., 2005). This could be another marketing niche regarding consumers looking for a pollinator friendly, weed suppressive groundcover for marginal land. Another species of *Solidago, S. canadensis*, known as Canadian goldenrod is a well-known invasive species throughout Europe, Asia, and North America (Dudek et al., 2016). Many studies have shown that *S. canadensis* disturbs the natural plant and animal communities, but there is also evidence that it provides a beneficial foraging habitat for multiple families of spiders in Europe (Dudek et al., 2016). There are also several other species of *Solidago* that are considered to be invasive worldwide such as *S. gigantea* (Hall et al., 2022). A study performed to discover management strategies for *S. gigantea* found that short-term mowing treatments in a span of three years is an effective control (Hall et al., 2022). Although, *Solidago* is adept to become an invasive species depending on habitat and circumstance, *S. puberula* is not considered to be one currently.

F. Taxonomic Description

According to the University of Maine's Extension, *Solidago puberula* can reach 30-90 cm (Figure 3.1) with 2.5 cm yellow flower heads on dense spikes (Figure 3.2) that open late July to September (D'Appollonio, 2019). The leaves of *S. puberula* are green, simple, and alternate. The stem is a deep purple covered in fine pubescence (Figure 3.3), implying the origin of the common name downy goldenrod. *Solidago* is known to have underground rhizomes which is a mechanism of plant spread. The *Solidago* genus are dicot plants with root systems that are deep, fibrous, and sometimes rhizomatous (Hua et al., 2007). The preferred growing habitat of *Solidago puberula* would be in sandier soils, fields, roadsides, and woodlands (D'Appollonio, 2019).

FIGURE. 3.1

FIGURE 3.2

Figure 3.3

FIGURE 3.4

FIGURE 3. Growth and phenotypic characteristics of *Solidago Puberula* plants: 3.1) the plant in flower; note the small flowers in the inflorescence. 3.2) the dense flower spike at anthesis 3.3) the intense purple-colored stems would make it an attractive landscape or cut flower crop. 3.4) in full bloom, the plant will form a bright yellow wand like shape near the top.
https://extension.umaine.edu/blueberries/weed-images/herbaceous-broadleaf-weeds/yellow-flowers/downy-goldenrod/
https://shop.wildseedproject.net/products/downy-goldenrod-solidago-puberula-seeds?variant=1046015441

G. Medicinal and Indigenous Use

The genus name of *Solidago* is derived from the Latin word "solida," meaning "to make whole" (Chadwick et al., 1984). The Mi'kmaq and Maliseet indigenous peoples of Canada used *S. puberula* for numerous herbal remedies (Piochon et al., 2011). It has been found that species from the *Solidago* genus has been used to treat arthritis, inflammation, and lung conditions (Paun et al, 2016). Dried *Solidago* has also been used to brew tea that has a calming effect. Modern medicine acknowledges that *Solidago* can be used to treat tumors, gout, asthma, warts, and serve as an astringent, carminative, diaphoretic, diuretic, and stimulant (Apati et al., 2003). Some species are still used today in folk medicine in the Appalachian Mountains to treat several ailments. In 2010, the first study to research the chemical composition of the essential oil from *Solidago puberula* found that the main components were terpenes myrcene (53%), farnesene (10.7%), pinene (9.4%), ocimene (6.0%), and phellandrene (5.7%) (Piochon et al., 2011). Myrcene is the most abundant terpene of *Solidago puberula* as it has been found to have anti-inflammatory properties.

H. Edible

Evidence has shown that *Solidago* is edible and safe for humans to consume. The taste of *Solidago* has been described as mildly astringent, spicy, and bitter (Li et al., 2014). It is found that some people experience mild allergies to *Solidago* pollen, but it is often confused with *Ambrosia psilostachya* or ragweed that is the actual cause for many allergies.

I. Historical Analysis

No known scientific evidence has been found on the domestication or breeding history of *Solidago puberula.* Based on preliminary research, domestication most likely started due to Indigenous herbal needs and more recently for pollinator habitat and native restoration efforts.

II. PRODUCTION INFORMATION

A. Seed Distribution and Cultivars on the Market

There are no known cultivars of *Solidago puberula* on the market. Although there is wild seeds and potted plants of *Solidago puberula* on the market. Native plant nurseries are the source for potted *Solidago puberula.* The Wild Seed Project markets the seed of *Solidago puberula* and is the company where the seeds that were provided for this project came from for further investigation. Figure 4 shows the seed distribution chain of *Solidago puberula* through the Wild Seed Project. The Wild Seed Project sources their seeds from native gardens and private lands unaffected by insecticides throughout Maine. *Solidago puberula* can either be propagated by seed or vegetatively. For current demand and purpose, seed propagation is more commonly used. Species of *Solidago* are easily vegetatively propagated by root tips for research, cut-flower, and landscape uses (Li et al. 2014).

Vegetative propagation of the future market of the *Solidago puberula* plant is possible as it is becoming a plant of choice in northeastern United States for native pollinator gardens and the subject of medicinal research. *Solidago puberula* would also make for an excellent filler flower in wildflower inspired floral arrangements as it has a dense flower head and purple colored stems. Essential oils derived from *Solidago puberula* is also an area of interest within the pharmaceutical industry as it has shown to have many beneficial terpenes. Also, weed

suppression abilities, high stress tolerance, pollinator appeal, and low management needs of *Solidago* make this plant a notable choice for marginal land groundcover.

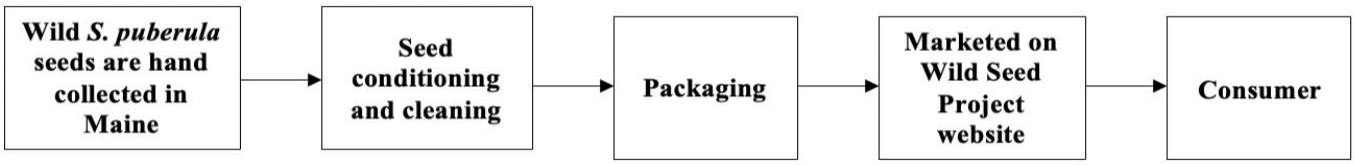

FIGURE 4. Wild Seed Project's *Solidago puberula* seed distribution chain. (Gierke, 2023)

B. Plant Characteristics

Solidago puberula is an herbaceous perennial plant that produces blooms in August to October in its native and established ranges (D'Appollonia, 2019). This plant could be positioned on the market as a perennial plant that flowers late summer to early fall. *Solidago puberula* is a plant with high drought and stress tolerance that does well in sun, part-sun, and part-shade light. This plant also does well in many soil types, including wetlands to sand. It can be inferred from *Solidago puberula's* native range that the USDA would rank *S. puberula* in Hardiness and Heat Zones 3 (-40 to -34.4 C;) to 8 (-12.2 to -6.7 C); refer to figure 5. The adaptable nature of this plant is highly sought out for a low maintenance plant on the market. As mentioned above *Solidago puberula,* would most likely be marketed as an herbaceous perennial plant in nurseries and other plant or seed distributors to be planted for use in pollinator gardens, marginal land groundcover, native landscape restoration, and more. *Solidago puberula* could also be marketed as a cut flower to be used in various types of floral arrangements.

Solidago puberula would make a fine addition for a pop of color when other boarder garden plants begin to fade in the late summer. It is also known to be a preferred pollinator food source known to attract monarch butterflies and bees in the landscape. Overall, *Solidago* is an

easy plant to establish in home gardens and other landscapes, but some species can become aggressive spreaders so it is important to know information about the plant down to the species level. There has been cultivars developed particularly for the garden landscape to lower spreading issues such as the top-rated cultivars ‘Fireworks’ (*Solidago rugosa*) and ‘Golden Fleece’ (*Solidago sphacelate*). ‘Fireworks’ *Solidago* is a little larger than *Solidago puberula*, but shares many of the same plant characteristics such has being stress tolerant and pollinator friendly. ‘Golden Fleece’ *Solidago* looks a lot more similar to *S. puberula.*, it is about the same size and has purple-colored stems and works well in native gardens or naturalistic plantings.

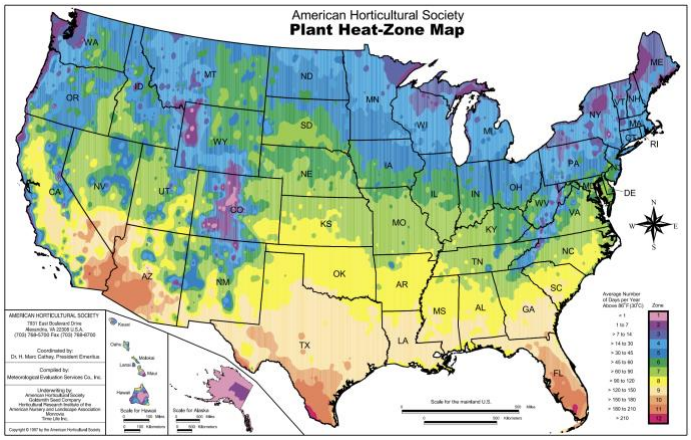

FIGURE 5.1
https://ahsgardening.org/about-us/news-press/cool_timeline/heat-zone-map-developed/

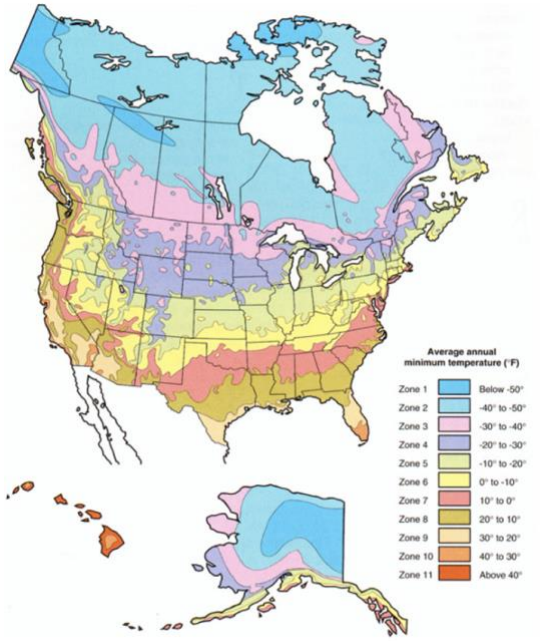

FIGURE 5.2
https://www.wildflowerfarm.com/plant-zone-map.html

FIGURE 5. *Solidago puberula* can grow in a wide range of temperatures, making this plant tolerant to both the cold and heat. (Zones 3 to 8)
5.1) USDA Hardiness Zones. 5.2) USDA Hardiness Zone Map

C. Potential Production Environment

Solidago puberula is not a common crop that has been extensively sold on the horticultural market or in nurseries, but as a general guideline for production systems we can assume it would be similar to other species within the genus. Researchers of *Solidago* have noted that sown seeds need about a two-month period of cold stratification to break dormancy (Pliszko & Kostrakiewicz-Gieralt, 2018). This is usually naturally accomplished as it is a reoccurring wild perennial in the landscape of states that experience cold winters. *Solidago puberula* seeds were acquired from the Wild Seed Project which has the goal of restoring native plants back into the landscape, particularly for the northeast region of the United States. These seeds were direct sown into a 288 cell using the soilless medium Jolly Gardener Germination Mix during week 11. One seed was pressed on top of the medium and covered with a dusted layer of media and then placed into an organic germination house at the University of Minnesota. The seeds are extremely small, about 1-4 mm with numerous pappus hairs (Figure 6). This is great for reseeding in the natural landscape by wind distribution, but can pose a problem in production systems. A suggestion regarding this difficulty would be to sow multiple seeds in a larger cell and thin back once they emerge or wait until they show their first true leaves to be transplanted into a larger container to divide if they are not too crowded. Before sowing the seeds, the information regarding cold stratification was unknown, but there still has been evidence of emergence after 14 days of sowing. *Solidago* generally will germinate within 14-21 days when they are kept at 21 degrees Celsius. Full emergence or the estimated germination rate of 90% has yet to be achieved. According to the Wild Seed Project's seed packet, *Solidago puberula* can safely be transplanted into the garden after the threat of frost when the seedlings reach about 30-45 centimeters.

According to a leader in floriculture solutions, Danziger, classifies *Solidago* as a quantitative long day plant that requires a minimum of 12 to 13 hours of daylight 3 to 5 weeks after planting. It has also been noted that *Solidago* has shown success by propagating unrooted cuttings from a mother plant (Danziger, 2021). Danziger also mentioned that pinching low on the central stem about 3 to 5 weeks after planting is preformed to increase growth habitat and flowering potential. After pinching is carried out plants should undergo a long day treatment at a light intensity of 120 lux. Also, after pinching, gibberellic acid should be applied to stimulate further plant development (Gupta & Chakrabarty, 2013). Common pests of *Solidago* encountered in large production systems are the white fly, aphids, leaf miner, and caterpillar. Common diseases include: powdery mildew, rhizoctonia, and agrobacterium (Danziger, 2021).

FIGURE 6.1

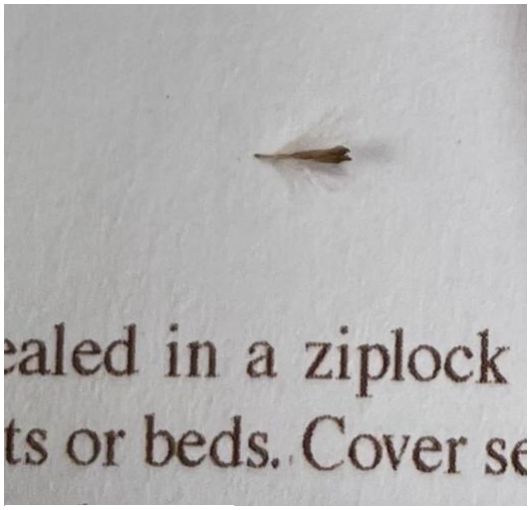

FIGURE 6.2

FIGURE 6. *Solidago puberula* seeds from the Wild Seed Project. 6.1) These seeds are difficult to work with on a small scale due to their small size and ability to stick to each other and clothing. 6.2) Single *Solidago puberula seed* (1-4mm) Notice the pappus hairs surrounding the seed.

D. Market Niche

Solidago puberula has great potential for a position on the market. Native crop species have been a hot item concerning environmental restoration and providing a beneficial insect and pollinator habitat and nectar source. *Solidago puberula's* low maintenance nature and ability to thrive in many different environments make it a great option for a beginner gardener and landscape designer alike to incorporate in pollinator and rock gardens as well as for roadside management and commercial lot landscapes (Figure 7).

E. Marketing Pitch

Consumers that are looking for hardy perennial crops to be planted on their marginal land do not have to look any further as *Solidago* is great at suppressing noxious weeds and providing groundcover to minimize erosion, runoff, and sequester carbon. *Solidago puberula* would also make for a great cut flower in floral arrangements due to its wildflower nature, canary yellow dense floral spike, and purple stem. There is also an interest in the medicinal capacities of the essential oils derived from *Solidago puberula* in aid of inflammatory disorders. *Solidago puberula* can be grown by seed in many environments easily, and is available as a potted plant at a few select native plant nurseries throughout the northeastern United States. Get yours today to help out the pollinators!

FIGURE 7. Beautiful picture of *Solidago puberula* making a colorful statement on a rocky landscape.
https://www.inaturalist.org/taxa/126658-Solidago-puberula

III. Production Information Guide

Stage 1: Moist Stratification

For spring planting in a greenhouse environment *Solidago puberula* seeds require a cold period to break dormancy. To moist stratify seeds, place them in a moistened paper towel in a ragdoll fashion. Insert ragdoll into a sealable plastic bag leaving a small hole unsealed or a few puncture holes to allow airflow. Seeds can also be sprinkled and lightly covered by moist, clean builder's sand or sawdust in a resealable container. Again, puncture lid with a few holes for airflow. Place ragdoll or container into a cooler or protected environment that is below 4°C for a minimum of 60 days. Check seeds periodically and lightly mist medium when drying occurs.

Direct Sowing

If planning to direct seed outdoors in native environment conditions sow outdoors in November through February (allowing 60+ days below 4°C) by sprinkling seeds in desired location or in pots and lightly cover. This will mimic natural growing conditions and allow seeds to overwinter and break dormancy in the spring.

Stage 2: Spring sowing for greenhouse environment

For spring planting, start seeds in early February. Due to the small seed size and pappus hairs, hand sowing is recommended. Seeds should be sown into 2.5 cm x 2.5 cm x 9-10 cm root trainer cells to facilitate healthy root growth (Figure 8) (van der Grinten, 2001). Use a pre-moistened germination mix to fill cells (can mix a 1:1 ratio of vermiculite for enhanced water retention). Sprinkle 4 to 5 seeds per cell and cover with a light layer of germination mix or vermiculite. Place cells into a mist house or greenhouse on a capillary mat with frequent watering, temperature should be about 21°C and emergence should occur within 1 to 3 weeks.

Stage 3: Establishment phase

Once seedlings emerge, they should be moved out of the mist house promptly and placed into a greenhouse on a capillary mat for a few days until evidence of further growth. Thin back a couple seedlings per cell if crowding is suspected. Monitor water as root trainers need to be watered regularly. Fertilize with a water soluble mix of 24-8-16 NPK if desired (van der Grinten, 2001). Temperature of greenhouse should be about 21°C.

Stage 4: Pinching and long day treatment

After 3 to 5 weeks, or when plants are established, they should be pinched low on the central stem to increase growth habitat and flowering. After pinching is preformed plants should undergo a long day treatment. *Solidago* is classified as a facultative long day plant, so growth and flowering will be promoted if exposed to a minimum of 12 to 13 hours of daylight 3 to 5 weeks after planting. The light intensity should be about 120 lux. Also, after pinching to further growth potential, gibberellic acid can be applied at a rate of 1000 mg/L (ppm) (Flinn Scientific, 2023).

Stage 5: Hardening phase

When plants near 30 to 45 cm, around 8 weeks after they are planted, they are ready to be hardened off. The root trainers can be moved under an outside lath house during the day when it is a sunny to mild day in the early spring about 1 to 2 weeks before the projected frost date. Plants should be brought back inside during the night to avoid the threat of frost. *Solidago puberula* can be safely transplanted outside when there is no longer a threat of frost in your area.

Stage 6: Harvest

This plant will last all season long blooming in August, September, and October. The cypselae, a dry single-seeded fruit formed from a double ovary that only develops one seed, can be harvested after it has finished flowering (Marzinek et al., 2008). Once harvested for seed, allow the plants to completely dry and then send to be cleaned and conditioned. Due to how small the seeds are they are hard to clean by machines, so hand cleaning and conditioning is used such as by the Wild Seed Project mentioned above (Figure 4). Dried seed should be stored in a cool, dark place. *Solidago puberula* can also be cut for a filler flower in floral arrangements. Once cut, stems should be processed promptly by cutting ends at a 45° angle with a clean Swiss army knife or flower shears (avoid typical scissors) and remove any foliage that would be under the waterline. Place in bucket of lukewarm water with a flower food additive. Allow flower to rest and acclimate before placing in a cooler. Place flowers in a high humidity cooler that is set at 0 to 2°C to increase shelf-life. Cut flowers will last in cooler for about 2 weeks before they begin to deteriorate. For transport, a refrigerated van is suggested.

Other:

Solidago puberula can tolerate both the cold and heat from growing Zones 3 to 8 referring to the USDA Hardiness Zone Map (Figure 5.2). These Zones cover much of the United States and parts of Canada, so this plant could technically be produced in many parts of North America. Nurseries in the northeastern United States already offer this plant for sale. Wild Ridge Plants, a native plant nursery in New Jersey sell this plant in 7.62cm (3in) pots for $12.00 a piece. According to their website, this plant is currently present in much of the Eastern United

States from Maine, and even parts of Canada, all the way to Florida and Louisiana (Figure 9). If direct sowing under conditions that do not produce 60+ days of a cold period of 4°C or less, moist stratification needs to be accomplished before sowing outdoors. If needed, an integrated pest management (IPM) system may need to be developed to combat pest issues in a large production program. Also, seed propagation seems to be the most popular regarding this plant, but vegetative propagation could be explored to enhance the efficiency of the growing process for commercial use and distribution. Experiments including different stratification techniques could also be investigated to offer information to growers concerning which stratification process should be used to produce the highest germination rate.

Crop Schedule:

Stage 1: 60+ days	**Stage 2: 1-3 weeks**	**Stage 3: 1-3 weeks**
Moist Stratification • 60+ days at ≤4°C by moist stratification.	Sowing • 2.5cm x 2.5cm x 9-10cm root trainer cells • Germination mix or vermiculite mix. • 4 to 5 seeds per cell • For spring planting, start in early February. • Frequent watering • Greenhouse temperature @ 21°C.	Establishment • Thin if necessary. • Capillary mat • Frequent watering • Fertilize if desired. (24-8-16) • Greenhouse Temperature @ 21°C

Stage 4: 5-7 weeks	**Stage 5: 1-2 weeks**	**Stage 6: 1-3 weeks**
Pinching and long-day treatment • After plants are established should be pinched. • Exposed to at least 12 to 13 hours of daylight @ 120 lux. • Gibberellic acid @ 1000 ppm application.	Hardening Phase • Plants 30 to 45 cm • Harden off under outside lath house. • Ready to be transplanted outside when there is no frost risk.	Harvest for seed • October • Dry whole plant • Harvest, clean, and condition seeds. • Store in a cool, dark place. Harvest for cut flower • August, September, October, or whenever in flower. • Process and store in a high humidity cooler @ 0 to 2°C until use or decline (will last about 2.5 weeks).

FIGURE 8. These are the size of the root trainer cells that is recommended for duration of greenhouse growth (about 2.5cm x 2.5cm x 9-10cm). https://www.horticulturesource.com/fresh/product/10-x-20-premium-x-deep-72-

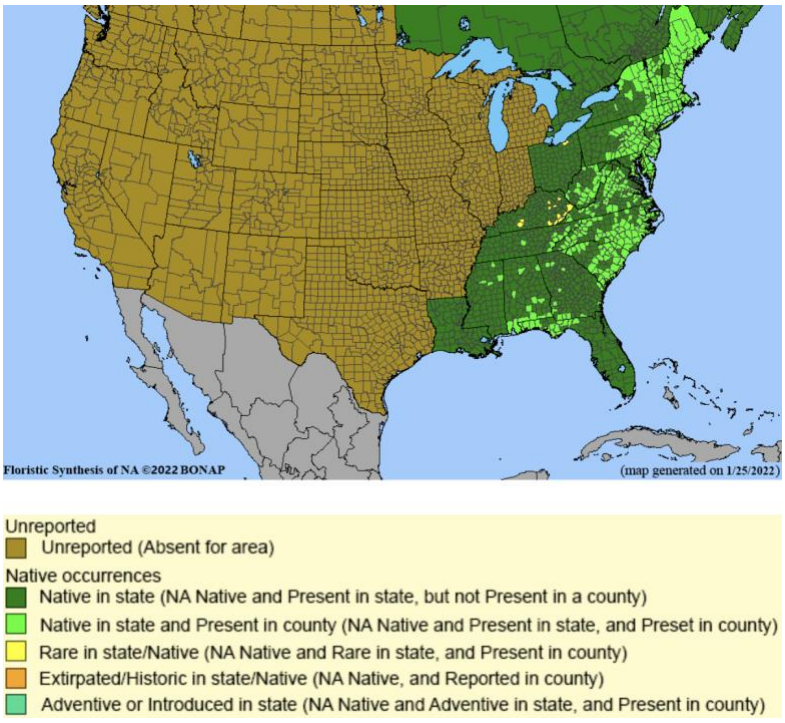

FIGURE 9. This is a map showing the known current locations *Solidago puberula* can be found according to the key to the left. https://wildridgeplants.com/shop/solidago-puberula-downy-goldenrod/

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