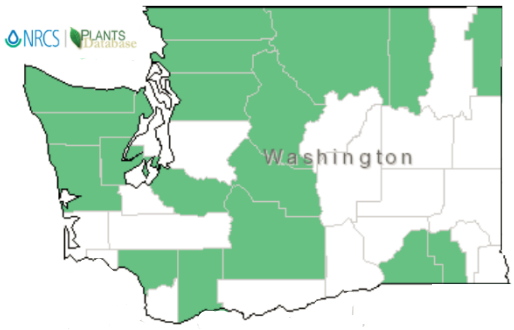
Plant Propagation Protocol for *Sibbaldia procumbens*
ESRM 412 – Native Plant Production
Protocol URL: https://courses.washington.edu/esrm412/protocols/SIPR.pdf

Photo by Craig Althen, hosted by Burke Museum, University of Washington[5]

TAXONOMY	
Plant Family	
Scientific Name	Rosaceae[12]
Common Name	Rose family
Species Scientific Name	
Scientific Name	*Sibbaldia procumbens* L.[12]
Varieties	None recognized in USDA Plants Database.
Sub-species	None recognized in USDA Plants Database.
Cultivar	None.
Common Synonym(s)	*Potentilla sibbaldia* Haller f.[12]
Common Name(s)	Creeping sibbaldia, creeping glow-wort, prostrate sibbaldia[8]
Species Code (as per USDA Plants database)	SIPR[12]
GENERAL INFORMATION	
Geographical range	North American distribution Native to Western United States, Alaska, most of Canada, and Greenland.[12] Listed as endangered in New Hampshire due to isolated populations in the White Mountains,[3,12] but otherwise widespread.[5]

	 Map from USDA Plants Database[12] <u>Washington state distribution</u> Present in more than half of Washington counties, primarily the northern, coastal, and central counties.[12]  Map from USDA Plants Database[12]
Ecological distribution	Found in subalpine and alpine areas, rocky slopes, snow banks, subarctic coastal tundra, high plateaus, and disturbed sites in the mountains such as trail and roadsides.[4,11]
Climate and elevation range	Reported at elevations from 0-4200 m,[4] but typically found at mid to high elevations.[3] Does well in areas where the snow cover lasts until late summer. Grows in both dry and moist habitats.[5] Prefers moist habitats, and can tolerate more than 130 cm of annual precipitation. Species morphology varies with environmental conditions. Plants growing in drier areas have more lateral roots and fewer, smaller leaves.[3]
Local habitat and abundance	Occurs in open, disturbed patches that receive ample sun, but have long durations of snow cover.[3] Grows on slightly acidic soils, such as sandy loam and peat.[1,11]

	Tolerates a range of soil moisture and nutrient levels, but not calcium rich soils.[3] Found on rocky slopes with a 5-40º incline,[3] but most common on slopes with a 22-26º incline and southernly, 100-230º aspect.[13] Usually associated with short species that grow in rocky areas, including mosses, lichens, liverworts, and dwarf perennial herbs such as wild thyme and cudweeds. May grow near sparse populations of fir, spruce, or willow. Also found near sedges, grasses, and short shrubs in the *Vaccinium* and *Erica* genera.[3,13]
Plant strategy type / successional stage	This is a stress tolerant, pioneer species often found in disturbed areas and steep, rocky slopes.[7] The species tolerates both drought and late snow cover. *S. procumbens* can grow on shallow soils less than 5 cm deep,[3] and has even been found on worn concrete roads and gravel parking lots.[11] As a poor competitor, the species does best when the surrounding vegetation is under 5 cm tall. The species is easily shaded out when the surrounding vegetation is more than 10 cm tall. *S. procumbens* benefits from grazing, which increases light availability by reducing the surrounding vegetation. However, heavy grazing is lethal.[3,13]
Plant characteristics	*S. procumbens* is a rhizomatous, perennial forb that primarily spreads through vegetative reproduction.[3] The species is low-growing, usually under 3 inches tall.[1] As shown in the image on the next page, the leaves are green to greenish blue and distinctly trifoliate.[3] The apex of each leaflet is notched three to five times.[9] The flowers are small and yellow, with five petals and five to ten stamens. The species can be distinguished from cinquefoils, which have similar looking flowers, by the fact that cinquefoils have more than ten stamens.[9] Occasionally, *S. procumbens* flowers may be apetalous. The flowers are borne on cymes and pollinated by flies, bees, and ants.[3] The fruit is a small, brown, egg-shaped achene.[4,5] About half of the achenes produced by a wild plant are fertile.[3]

	 Photo by Craig Althen, hosted by Burke Museum, University of Washington[5]
PROPAGATION DETAILS	
Cuttings, as described by Miller & Miller[7]	
Ecotype	Cuttings were collected from plants at the Cascade Pass in North Cascades National Park, Washington. The Cascade Pass has stands dominated by *Tsuga mertensiana* trees that are interspersed with subalpine meadows. The Cascade Pass is located at 1,644 m, where the growing season is short and the annual precipitation ranges from 2.4-2.6 m.
Propagation Goal	Plants
Propagation Method	Vegetative
Product Type	Container (plug)
Stock Type	Plastic plant trays. Information on dimensions not provided.
Time to Grow	Minimum of 6 weeks.
Target Specifications	Healthy plants with roots and shoots large enough to survive outplanting.
Propagule Collection Instructions	Cuttings were taken in 1973 from plants growing in the Cascades Pass.
Propagule Processing/Propagule Characteristics	Stem cuttings root easily.
Pre-Planting Propagule Treatments	Cuttings were dipped in Hormodin 3, which contains 0.8% indolebutyric acid, to promote rooting.
Growing Area Preparation / Annual Practices for Perennial Crops	Cuttings were rooted in the Patricia Calvert Greenhouse at the Washington Park Arboretum in Seattle, Washington. Cuttings were struck in flats filled with a 1:1:1 mix of perlite, peat, and sand.
Establishment Phase Details	The flats were kept on a mist bench with bottom heat, which was used to maintain the temperature of the rooting media at 21ºC.
Length of Establishment Phase	Information not provided.

Active Growth Phase	Rooted cuttings were transplanted to plastic plant trays filled with a 3:2:1 mix of loam, sand, and peat and placed in the lath house.
Length of Active Growth Phase	Minimum of six weeks after striking.
Hardening Phase	Some of the rooted cuttings were outplanted at the Cascade Pass six weeks after striking the cuttings. However, most of the plants were not robust enough to be outplanted at this time, and were instead kept in the lath house and unheated greenhouse over the winter.
Length of Hardening Phase	After being placed in the lath house, the plants were gradually hardened as the days got shorter and colder.
Harvesting, Storage and Shipping	Most of the cuttings were transported on September 1974 from the Washington Park Arboretum to the Cascades Pass in wooden boxes tied to frames.
Length of Storage	Rooted cuttings were kept in the lath house and unheated greenhouse from the end of the 1973 growing season to September 1974.
Guidelines for Outplanting / Performance on Typical Sites	From the 59 trays of *S. procumbens* outplanted in 1973-1974, plants from 47 of the trays were surviving in 1977. Most of the plants survived the 1974 autumn drought that occurred right after outplanting. Using a media mix of peat and perlite when outplanting, especially when the field soil is poor, boosts plant survival and growth rates.
Other Comments	As an early successional species, *S. procumbens* is an excellent choice for restoring disturbed areas. The authors recommend outplanting plants that have been propagated in the greenhouse rather than directly sowing seeds in the field due to low rates of seedling establishment in the field.
Division, as described by Miller & Miller[7]	
Ecotype	Plants were dug up from the Cascade Pass. See the protocol above for information on the ecotype of the Cascade Pass.
Propagation Goal	Plants
Propagation Method	Vegetative
Product Type	Container (plug)
Stock Type	30 x 46 cm flats
Time to Grow	11 months
Target Specifications	Healthy plants with roots and shoots large enough to survive outplanting.
Propagule Collection Instructions	Plants were dug up and divided in September 1975 at the Cascades Pass.
Propagule Processing/Propagule Characteristics	*S. procumbens* is easily propagated by division.

Pre-Planting Propagule Treatments	Rootone no. 10, which consists of 0.4% alpha naphtyl acetamide, was applied to stimulate more rooting.
Growing Area Preparation / Annual Practices for Perennial Crops	A growing media similar to the Cornell Peat-Lite Mix B was prepared using a 1:1 mix of peat and perlite, plus 64 g/ft^3 of ground dolomitic limestone, 32 g/ft^3 of superphosphate, and 32 g/ft^3 of fertilizer consisting of 5% nitrogen, 4% phosphorous, and 10% potassium. The stock type used was 30 x 46 cm flats.
Establishment Phase Details	Divisions were planted in flats in the North Cascades National Park's 1.22 x 3.66 m polyethylene cold frame in Marblemount, Washington.
Length of Establishment Phase	Information not provided.
Active Growth Phase	From March-August 1976, plants received a dose of liquid fish-base fertilizer every month. This fertilizer contained 10% nitrogen, 5% phosphorous, and 5% potassium.
Length of Active Growth Phase	6 months
Hardening Phase	Plants were kept in the cold frame over the winter of 1975-1976.
Length of Hardening Phase	Plants were gradually hardened in the cold frame as the days got shorter and colder.
Harvesting, Storage and Shipping	To transport the plants to Cascade Pass, the plants were removed from the flats and placed in plastic bags for ease of carrying. After 11 months in the flats, the plants had formed a dense growth that allowed them to survive this rough method of transport.
Length of Storage	Plants were kept in the cold frame from the end of the 1973 growing season to August 1976.
Guidelines for Outplanting / Performance on Typical Sites	In October 1977, 75-90% of the several species that were outplanted, including *S. procumbens*, were reported to have survived. This was remarkable considering that 1976 and 1977 were years with severe drought. No numbers were specifically reported for the species *S. procumbens*, but high survival rates were noted for all species planted. Plants were not fertilized after outplanting, but doing so could increase growth and survival rates.
Other Comments	Although *S. procumbens* can be germinated from seed, the North Cascades National Park prefers vegetatively propagating this species through cuttings and division.
Seed viability, as described by Chambers[2]	
Ecotype	Seeds were gathered from *S. procumbens* growing in Beartooth Plateau, Montana. This area is characterized by rocky, alpine meadows dominated by grasses and forbs such as *Geum*. Seeds were collected from plants

	growing in undisturbed meadow patches with over 90% vegetation cover and disturbed meadow patches with under 15% vegetation cover.
Propagation Goal	Seeds
Propagation Method	Seeds
Product Type	Propagules (Seeds)
Stock Type	Information not provided.
Time to Grow	Information not provided.
Target Specifications	Seeds with high viability after storage.
Propagule Collection Instructions	Seeds were gathered by hand on September 9, 1983, September 14, 1984, August 22, 1985, and September 10, 1986. Since the timing of seed maturation depends on the weather, the date of seed harvest varied from year to year. Seeds were collected at maturity.
Propagule Processing/Propagule Characteristics	Most of the seeds collected were filled. Despite annual differences in the weather, there was no significant difference in seed viability from year to year. The percentage of viable seeds was consistently between 65% and 80% for each annual harvest. A seed batch lost 16% viability after one year of storage, 22.4% total after two years, and 49.4% total after three years of storage at 1-2ºC and 11% seed moisture.
Pre-Planting Propagule Treatments	After collection, seeds were dried for 14 days, threshed, cleaned, and then stored at 1-2ºC and 70-85% relative humidity. For each year of collection, seed viability was tested after six months of storage using three batches of 100 seeds. First, seeds were placed in distilled water for 18 hours. Then, the seed coats were carefully removed and the seeds were soaked in a 1% aqueous solution of tetrazolium. Next, the seeds were put in the dark at 30ºC for two days. Finally, the seeds were cut in half and viability was counted as the percentage of seeds with fully stained embryos. Tetrazolium stains living tissue red, so a partly stained or unstained embryo indicates that the embryo is damaged or dead. Additionally, the viability of seeds collected on September 9, 1983 was tested after one, two, and three years of storage at 1-2ºC and 11% seed moisture.
Growing Area Preparation / Annual Practices for Perennial Crops	Information not provided.

Establishment Phase Details	Information not provided.
Length of Establishment Phase	Information not provided.
Active Growth Phase	Information not provided.
Length of Active Growth Phase	Information not provided.
Hardening Phase	Information not provided.
Length of Hardening Phase	Information not provided.
Harvesting, Storage and Shipping	Information not provided.
Length of Storage	Information not provided.
Guidelines for Outplanting / Performance on Typical Sites	Information not provided.
Other Comments	The rapid decline in seed viability over a few years of storage in this study suggests that seeds should be stored at subfreezing temperatures if the duration of storage is more than two years.
Seed germination and seedling survival with erosion control blankets, as described by Scianna and Lapp[10]	
Ecotype	Information not provided.
Propagation Goal	Germinants
Propagation Method	Seed
Product Type	No product
Stock Type	Petri dishes
Time to Grow	The germination trial was conducted for 143 days.
Target Specifications	High germination percentages and low germinant mortality rates.
Propagule Collection Instructions	Information not provided.
Propagule Processing/Propagule Characteristics	Information not provided.
Pre-Planting Propagule Treatments	Seeds were stratified, but not sterilized. No further details provided.
Growing Area Preparation / Annual Practices for Perennial Crops	This study was conducted at the Bridger Plant Materials Center in Bridger, Montana. Seeds were started on moistened germination pads in petri dishes. The petri dishes were kept in a growth chamber that alternated between 30ºC during an 8-hour day and 20ºC during a 16-hour night. During the day, the growth chamber was lit with 20-watt, florescent, cool white lightbulbs to create an average light intensity of 25.6 μmol. Seeds were placed in three treatment groups. For the first treatment group, the petri dishes were simply placed in the growth chamber. For the second group, petri dishes in the growth chamber were covered with an erosion control blanket made of a netting stuffed with straw and coconut fiber. For the third group, petri dishes were placed inside a box that blocked all light.

	Five replications of 25 seeds were used per treatment group.
Establishment Phase Details	After 66 days, 19.2% of the seeds in the control treatment with no covering germinated, 5.6% of the seeds in the treatment group covered by an erosion control blanket germinated, and 0% of the seeds in the treatment group covered by a box germinated. After 66 days, the erosion control blanket and box covering the petri dishes in the second and third treatment groups were removed. The seeds and seedlings were then grown in the petri dish for the following 77 days. After a total of 143 days, 28.0% of the seeds in the control treatment with no covering germinated, 7.2% of the seeds in the treatment group covered by an erosion control blanket germinated, and 17.6% of the seeds in the treatment group covered by a box germinated.
Length of Establishment Phase	The germination trial was conducted for 143 days.
Active Growth Phase	After 66 days, 12.5% of the germinants in the treatment group with no covering died and 57.1% of the germinants in the treatment group covered by the erosion control blanket died. Seedling death was primarily attributed to pathogens.
Length of Active Growth Phase	Information not provided.
Hardening Phase	Information not provided.
Length of Hardening Phase	Information not provided.
Harvesting, Storage and Shipping	Information not provided.
Length of Storage	Information not provided.
Guidelines for Outplanting / Performance on Typical Sites	Information not provided.
Other Comments	Seed germination was significantly lower when the petri dishes were placed under the erosion control blanket. However, the net benefit of using erosion control blankets in the field may exceed the reduced germination rates by decreasing seed predation while increasing soil moisture and retention. The seeds appear to be photodormant. Seeds placed in the dark box did not germinate before the box was removed. Likewise, planting seeds too deep could inhibit germination. To reduce seedling mortality rates, seeds should be sterilized with a fungicide.

Effect of mycorrhizae on seedlings, as described Kytöviita, Vestberg, and Tuomi[6]	
Ecotype	*S. procumbens* seeds were collected from the subarctic meadows of Kilpisjärvi in northern Finland. Other common plant species in these meadows include *Antennaria dioica, Solidago virgaurea,* and *Campanula rotundifolia*. Mycorrhizae are also common in the meadow soil. The mycorrhizal fungi used to inoculate *S. procumbens* were from strains collected relatively close to the region of seed collection. *Glomus hoi* is from the seed collection location. *Glomus claroideum* is from agricultural land in Muddusjärvi, Finland. The unknown species of *Glomus* is from a glacier in northern Norway.
Propagation Goal	Seedlings
Propagation Method	Seed
Product Type	Container (plug)
Stock Type	Plastic pots with a cross-sectional area of 700 cm^2
Time to Grow	Seedlings were grown for 53 days before harvesting for biomass and mycorrhizal colonization measurements.
Target Specifications	Successfully inoculated seedlings with most of their root area colonized by mycorrhizal fungi. The biomass of inoculated seedlings should be greater than the biomass of control seedlings that were not inoculated.
Propagule Collection Instructions	No information provided on the timing and method of seed collection. Collection likely occurred in late summer. The species typically flowers between June and August. Seed takes 1-2 months to mature.[3]
Propagule Processing/Propagule Characteristics	Seventy-five seeds were planted per pot to obtain about 30 germinants per pot. Thus, around half of the seeds were expected to be viable.
Pre-Planting Propagule Treatments	Seeds received 6 weeks of cold, moist stratification at 4-8ºC. Seeds were secured in nylon bags and then covered with sand. After stratification, *S. procumbens* seeds were partitioned into foil packets, with 75 seeds per packet. The foil packets were then put in 6ºC storage for 10 days.
Growing Area Preparation / Annual Practices for Perennial Crops	Plastic pots with a cross-sectional area of 700 cm^2 were used. There were eight pots to a tray. Each pot in a tray was used for a different treatment, and there were 13-16 pots per treatment. The pots held 350 cm^3 of media consisting of 9 parts of sterile stand to 1 part of perlite.

	The manipulated variables were the presence of an adult *S. procumbens* plant and the type of *Glomus* used for inoculation. Half of the eight pots in a tray already contained a year-old *S. procumbens* plant. Three out of the four adult plants in the tray had been inoculated with mycorrhizal fungi, whereas the last had not. One plant had been inoculated with *Glomus hoi*, another with *Glomus claroideum*, and the third with the unknown species of *Glomus*. The adult plants were inoculated at 22 weeks old. Inoculation was achieved by adding spores to the media. Spores were also added to the media of three out of the remaining four pots in the tray without an adult *S. procumbens*. One pot was inoculated with *Glomus hoi*, the second with *Glomus claroideum*, and the third with the unknown species of *Glomus*. Inoculation was achieved by spreading a 20-mL solution of 2,000 spores on the media surface of each pot.
Establishment Phase Details	The seeds were sown in the greenhouse in March. Each pot received 75 seeds from one foil packet. Before sowing, 40 mL of water was added to the seeds from each foil packet. Seeds were covered with 2-3 mm of sterile sand.
Length of Establishment Phase	Germination began 4 days after planting seeds.
Active Growth Phase	Six times per day, the pots were misted with deionized water. After substantial germination, all but 5-6 seedlings per pot were removed. The selected seedlings were similar in age and well-distributed in the pot.
Length of Active Growth Phase	Seedlings were harvested at 53 days old.
Hardening Phase	Information not provided.
Length of Hardening Phase	Information not provided.
Harvesting, Storage and Shipping	To measure root and shoot biomass, the seedlings were harvested at 53 days old. The media was soaked before harvesting to reduce root loss. Seedlings were cut in two at the root crown and put in a drying oven set at 80ºC for two days. Shoot and root biomass was obtained to the nearest 10^{-5} gram. Another set of measurements was taken to quantify mycorrhizal colonization on seedling roots. Trypan blue was applied to the roots of one seedling per pot to stain the mycorrhizae. Then, the percentage of root area colonized by mycorrhizae was estimated by counting grid squares.
Length of Storage	Information not provided.

Guidelines for Outplanting / Performance on Typical Sites	When the media was not inoculated with mycorrhizae, the biomass of seedlings was similar with and without an adult *S. procumbens* in the pot. This suggests that outplanting *S. procumbens* seedlings near adult *S. procumbens* plants will not hinder their growth. When an adult *S. procumbens* plant was not present, seedlings had higher biomass when grown in inoculated versus non-inoculated media. However, when an adult *S. procumbens* plant was present, seedling biomass was similar when grown in inoculated and non-inoculated media. Thus, seedlings benefit from inoculant added to the media, but not from mycorrhizae growing on adult *S. procumbens* roots. This suggests that adding inoculant to the soil when outplanting might improve seedling growth and survival.
Other Comments	Inoculating media right before planting *S. procumbens* seeds can dramatically improve seedling growth. When an adult *S. procumbens* plant was not present, seedling biomass was two times greater when the media was inoculated with the unknown species of *Glomus*, five times greater when inoculated with *Glomus hoi*, and six times greater when inoculated with *Glomus claroideum*, as compared to the non-inoculated media. *Glomus hoi* or *Glomus claroideum* would be an excellent choice for inoculating *S. procumbens*.
INFORMATION SOURCES	
References	See below.
Other Sources Consulted	See below.
Protocol Author	Kyra Kaiser
Date Protocol Created or Updated	05/15/18

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