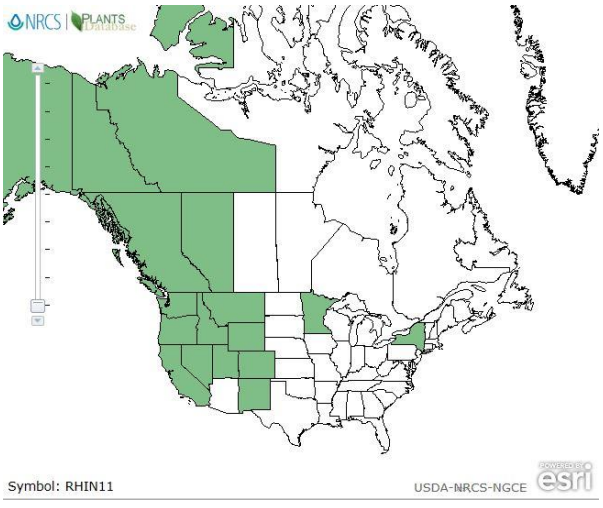
Plant Propagation Protocol for *Rhodiola integrifolia* Raf.
ESRM 412 – Native Plant Production
Protocol URL: https://courses.washington.edu/esrm412/protocols/RHIN11.pdf

Source: Tracy, 2007[15].

Source: Tracy, 2007[15].

Source: Matson, 2005[11].

North American Distribution



Source: USDA, Plants Database, 2017[18].

Washington Distribution

TAXONOMY	
Plant Family	
Scientific Name	Crassulaceae
Common Name	Stonecrop Family
Species Scientific Name	
Scientific Name	*Rhodiola integrifolia* Raf.
Varieties	
Sub-species	*Rhodiola integrifolia* Raf. ssp. *integrifolia* *Rhodiola integrifolia* Raf. ssp. *leedyi* (Rosend. & J.W. Moore) Kartesz *Rhodiola integrifolia* Raf. ssp. *neomexicana* (Britton) Kartesz *Rhodiola integrifolia* Raf. ssp. *procera* (R.T. Clausen) Kartesz
Cultivar	
Common Synonym(s)	*Rhodiola integrifolia* Raf. ssp. *integrifolia* • *Sedum alaskanum* (Rose) Rose ex Hutch. • *Sedum integrifolium* (Raf.) A. Nelson • *Sedum rosea* (L.) Scop. ssp. *integrifolium* (Raf.) Hultén • *Sedum rosea* (L.) Scop. var. *alaskanum* (Rose) A. Berger • *Sedum rosea* (L.) Scop. var. *frigidum* (Rydb.) Hultén • *Sedum rosea* (L.) Scop. var. *integrifolium* (Raf.) A. Berger • *Sedum roseum* (L.) Scop. ssp. *integrifolium* (Raf.) Hultén, orth. var. • *Sedum roseum* (L.) Scop. var. *alaskanum* (Rose) A. Berger, orth. var. • *Sedum roseum* (L.) Scop. var. *frigidum* (Rydb.) Hultén, orth. var. • *Sedum roseum* (L.) Scop. var. *integrifolium* (Raf.) A. Berger, orth. var. • *Tolmachevia integrifolia* (Raf.) Á. Löve & D. Löve *Rhodiola integrifolia* Raf. ssp. *leedyi* (Rosend. & J.W. Moore) Kartesz • *Sedum integrifolium* (Raf.) A. Nelson ssp. *leedyi* (Rosend. & J.W. Moore) R.T. Clausen • *Sedum rosea* (L.) Scop. var. *leedyi* Rosend. & J.W. Moore • *Sedum roseum* (L.) Scop. var. *leedyi* Rosend. & J.W. Moore, orth. var.

	Rhodiola integrifolia Raf. ssp. *neomexicana* (Britton) Kartesz • *Rhodiola neomexicana* Britton • *Sedum integrifolium* (Raf.) A. Nelson ssp. *neomexicanum* (Britton) R.T. Clausen *Rhodiola integrifolia* Raf. ssp. *procera* (R.T. Clausen) Kartesz • *Sedum integrifolium* (Raf.) A. Nelson ssp. *procerum* R.T. Clausen
Common Name(s)	Ledge stonecrop[18], king's crown[3, 9, 13], kingscrown[16], roseroot[9, 13], western roseroot[7], pacific roseroot[16], midsummer-men[9]
Species Code (as per USDA Plants database)	RHIN11
GENERAL INFORMATION	
Geographical range	Canada: AB, BC, NT, and YT. USA: CA, CO, ID, MN, MT, NM, NV, NY, OR, UT, WA (Okanogan, Pend Oreille, Pierce, Whatcom, and Yakima), and WY[6, 18]. *R. integrifolia* ssp. *leedyi* is also found in South Dakota [20]. See Distribution Maps above.
Ecological distribution	Found in subalpine, alpine, and arctic ecosystems, on rocky cliffs, talus, ridges, scree slopes, gravelly moist soils as well as in wet meadows, generally where it is moist in early summer[3, 9, 10, 16].
Climate and elevation range	All elevations in the north and mostly high elevations in the south[13]. In USDA Plant Hardiness Zones 2b to 9b and prefers full sun[2, 10, 17].
Local habitat and abundance	Although it has a relatively wide geographical range, *R. integrifolia* tends to be uncommon[16]. One study showed that its distribution in a subalpine ecotone to be restricted and is found in relatively low density, being most abundant in gravelly soils with north-facing aspects and little slope[4]. *Rhodiola integrifolia* Raf. ssp. *leedyi* (Rosend. & J.W. Moore) Kartesz is a federally-listed threatened species[12, 20] wherever found[20]. It is only found in seven locations in three states: four populations are in Minnesota, two are in upstate New York , and one in South Dakota[20].
Plant strategy type / successional stage	Stress-tolerater of the wind, cold, and poor soil conditions in subalpine, alpine, and arctic ecosystems[3, 9, 10, 16, 17].
Plant characteristics	This is an erect, hairless, succulent, perennial forb 5-20 cm tall. Its branched rhizomes produce clustered annual stems which are covered with many persistent leaves[13,

	[16]. Rhizomes are thick, fleshy, and scaly, and fragrant when cut[12, 13]. Leaves are flat, oval to oblong, irregularly serrate to entire margin, green to rosy pink, covered with white waxy powder, 0.5-4 cm long, being smaller and scale-like at the bottom of the stem and larger further up[9, 13, 16]. Usually dioecious but can occasionally have perfect flowers[13]. Flowers are terminal, usually dark purple, sometimes pink or yellow, in open cymes[9, 13, 16]. Flowers are 4 or 5-parted, petals are fleshy, oblong, obtuse to acute, 1-4 mm [9, 13]; sepals 1-2 mm and the number of stamens are equal or more than number of petals[9]. Fruits are red or purple follicles, mostly erect with divergent tips[13]. It can reproduce sexually by seeds or asexually by rhizomes[12, 14]. Phylogenetic studies have shown that *R. integrifolia* is an allopolyploid species derived from the hybridization of two other North American *Rhodiola* lineages: *R. rhodantha* and *R. rosea*[7, 8]. This would account for the morphological similarity between *R. integrifolia* and *R. rosea*, although *R. integrifolia* is more closely related to *R. rhodantha* genetically[7, 8].
PROPAGATION DETAILS: Olfelt *et al.* 1998[12]	
Ecotype	Three of the four known populations of *R. integrifolia* ssp. *leedyi* in Minnesota (MN1, 44°06.1'N, 92°08.0'W; MN2, 43°52.9'N, 92°24.2'W; MN3, 43°43.9'N, 92°24.2'W) and a single known population in New York (42°30.2'N, 76°54.9'W), as well as 11 western *R. integrifolia* populations in Colorado and New Mexico [exact subspecies and population locations not specified]. [The plants in this study were not outplanted and were kept in the greenhouse for reproduction and development study].
Propagation Goal	Plants
Propagation Method	Seed
Product Type	Container (plug)
Stock Type	164-cm^3 "Super Cell Cone-tainers"
Time to Grow	
Target Specifications	Mature plants that flower and produce seeds.
Propagule Collection Instructions	Seeds were collected from mature follicles of plants separated by at least 1m.
Propagule Processing/Propagule Characteristics	
Pre-Planting Propagule Treatments	Seeds were removed from follicles in the laboratory and stored at 4°C over desiccant until germination

	treatment. Seeds were submerged for 1 day in 400 ppm gibberellic acid solution and placed on sterilized filter paper in a petri dish moistened with 1.25 mL 0.0014% (w/v) Benlate fungicide in water. The dishes were sealed with Parafilm and kept at 4°C for 24 days and fresh Benlate solution was added as needed to dishes with fungal growth.
Growing Area Preparation / Annual Practices for Perennial Crops	Growing medium: 5-mm layer of fine vermiculite over a steamed sand/peat/compost/soil/vermiculate/perlite (12:12:2:6:1:1) mixture. Containers were maintained in a greenhouse. Fluorescent light supplemented ambient light with ~11 mol photons/m^2/s in a 16 h light/8 h dark cycle from January to April, when fluorescent lights were removed. Average daily low and high temperature ranged from 11°C and 21°C in January to 17°C and 33°C in July. The temperature extremes were 7°C in January and 40°C in July.
Establishment Phase Details	Seeds were sown in pairs in the containers and were misted twice daily.
Length of Establishment Phase	Several days to 2 weeks
Active Growth Phase	Containers were misted twice daily until seedlings were well rooted and then once daily until the plant stems elongated. If a container had two surviving seedlings after 1 months, one seedling was transplanted to a new Cone-tainer. Seedlings were fertilized weekly with 400 ppm 20N:20P>20K beginning 1 month from sowing and treated with Benlate as needed. Aphids were removed from seedlings with jeweler's tweezers and after 1 month, insect pests were controlled by introducing ladybugs (*Hippodamia convergens*) into the greenhouse. *R. integrifolia* ssp. *leedyi* roots grew rapidly in the first 3 to 4 months after sowing and then showed little elongation as they reached the limit of their Cone-tainers.
Length of Active Growth Phase	
Hardening Phase	Containers were misted as needed for the mature plants. Plants flowered in 135-180 days after germination under greenhouse conditions. A marked increase in plant mortality between 6 and 9 months was attributed root rot (*Fusarium* infection)

	due to elevated temperature, poor air circulation, and poor drainage in the grow medium.
Length of Hardening Phase	
Harvesting, Storage and Shipping	
Length of Storage	
Guidelines for Outplanting / Performance on Typical Sites	Although plants have the potential to flower in one growing season, in the field, they would probably not flower until their second growing season due to the later last frost and earlier first frost compared to the greenhouse conditions.
Other Comments	*R. integrifolia* ssp. *leedyi* is listed as a threatened plant species under the Endangered Species Act[20]; therefore, it is illegal to collect or maliciously harm them on Federal land[19].
PROPAGATION DETAILS: Evans 2008[5]	
Ecotype	Alpine fellfield, cliff face, Scenic Point, Two Medicine, Glacier National Park, Glacier Co., MT., 2300 m [This propagation protocol was listed under the synonym, *Sedum integrifolium* (L.) Scop.]
Propagation Goal	Plants
Propagation Method	Vegetative
Product Type	Container (plug)
Stock Type	490 ml containers
Time to Grow	5 months
Target Specifications	Stock Type: Container cutting Height: 4 cm Root System: Firm plug in container
Propagule Collection Instructions	Vegetative Propagation Method: Pre-Rooting Type of Cutting: Herbaceous stem cuttings taken in late August. Cuttings are 2 to 4 cm in length.
Propagule Processing/Propagule Characteristics	Cuttings are treated with rooting medium immediately after collection.
Pre-Planting Propagule Treatments	Succulent stem cuttings can be taken any time of year. Cuttings are treated with 1000 ppm Hormex rooting powder and struck in moist sand. Intermittent mist is not necessary. Cuttings generate roots along the stem in 2 weeks. Rooting %: 100%
Growing Area Preparation / Annual Practices for Perennial Crops	Greenhouse and outdoor nursery
Establishment Phase Details	After cuttings are well-rooted in 2 to 4 weeks, they can be moved to the outdoor nursery.
Length of Establishment Phase	4 weeks

Active Growth Phase	Growing medium used is 6:1:1 milled sphagnum peat, perlite, and vermiculite with Osmocote controlled release fertilizer (13N:13P2O5:13K2O; 8 to 9-month release rate at 21°C) and Micromax fertilizer (12%S, 0.1%B, 0.5%Cu, 12%Fe, 2.5%Mn, 0.05%Mo, 1%Zn) at 1 gram of Osmocote and 0.25 grams of Micromax per container. Cuttings are irrigated after potting.
Length of Active Growth Phase	12 weeks
Hardening Phase	Plants are fertilized with 10-20-20 liquid NPK at 200 ppm during August and September. Plants are given one final irrigation prior to winterization.
Length of Hardening Phase	4 weeks
Harvesting, Storage and Shipping	Total Time to Harvest: 5 months from cuttings Harvest Date: August Storage Conditions: Overwinter under insulating foam cover and snow.
Length of Storage	5 months
Guidelines for Outplanting / Performance on Typical Sites	
Other Comments	Seed Propagation: Hand collect mature follicles when they begin to tan and split open at the top. Seeds are brown at maturity. Seeds are collected in late August at high elevations. Seeds are cleaned using a hammermill, blower, and screens. Seed longevity unknown. Seed dormancy is classified as nondormant for many temperate *Sedum* species. Seeds/Kg unknown
PROPAGATION DETAILS: Butler and Frieswyk 2001 [1]	
Ecotype	Colorado, Sprague Lake (98-012s), Moraine Park (98-072s), Long's Peak Parking Lot (98-129s) [This propagation protocol is for the genus *Sedum* and not specific for *Rhodiola integrifoila*]
Propagation Method	Seed
Product Type	Propagules (seeds, cuttings, poles, *etc*.)
Stock Type	
Time to Grow	
Target Specifications	
Propagule Collection Instructions	Seed cleaning technique: Seed heads crushed and tiny seeds fall out. Use of screens helpful to separate seeds from miscellaneous plant material.
Propagule Processing/Propagule Characteristics	

Pre-Planting Propagule Treatments	Seed cleaning technique: Seed heads crushed and tiny seeds fall out. Use of screens helpful to separate seeds from miscellaneous plant material.
Growing Area Preparation / Annual Practices for Perennial Crops	Propagation Environment: Greenhouse, 65-70° F day/55°F night. Propagated under tent with misters set 8 am-8 pm, with 10 sec/15 min watering intervals. One week after germination, seedlings were moved to mister area without tent. Germination media: Fafard Germinating Mix (superfine). Growing media: Fafard Growing Mix 2.
Establishment Phase Details	Sowing/planting technique: Surface sown. Best to use small pots, with a few seeds per pot. Germination uniform and rapid, but these plants grow slowly.
Length of Establishment Phase	Time to germination: 7 days.
Active Growth Phase	
Length of Active Growth Phase	Time to potting: 1-1/2 months (unnecessary if planted in small pots to begin with).
Hardening Phase	
Length of Hardening Phase	
Harvesting, Storage and Shipping	Seed storage condition: Seed stored in the greenhouse.
Length of Storage	
Guidelines for Outplanting / Performance on Typical Sites	
Other Comments	
INFORMATION SOURCES	
References	See below
Other Sources Consulted	See below
Protocol Author	Anne-Gigi Chan
Date Protocol Created or Updated	05/14/17

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