

## Plant Propagation Protocol for *Pedicularis bracteosa*

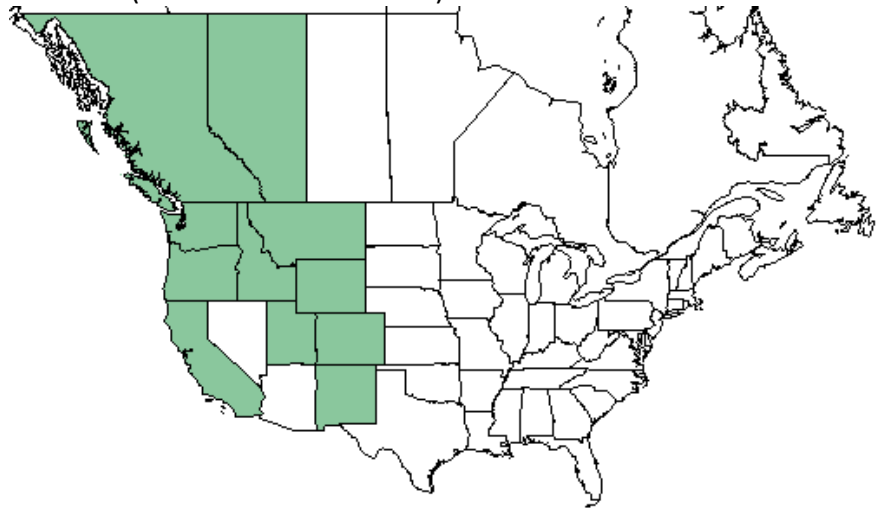
ESRM 412 – Native Plant Production



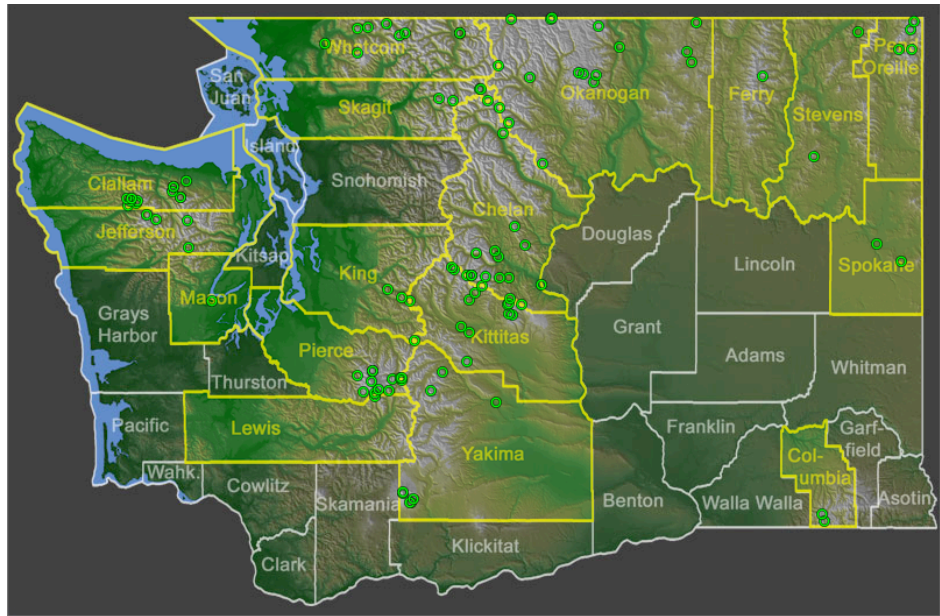
Source: Burke Herbarium 2017 Photo credit: G. D. Carr

<b>TAXONOMY</b>	
<b><i>Plant Family</i></b>	
Scientific Name	Orobanchaceae (formerly placed in Scrophulariaceae)
Common Name	Broomrape family (formerly in figwort family)
<b><i>Plant Species</i></b>	
Scientific Name	<i>Pedicularis bracteosa</i> Benth.
Varieties and Sub-species	<i>Pedicularis bracteosa</i> var. <i>atrosanguinea</i> <i>Pedicularis bracteosa</i> var. <i>bracteosa</i> <i>Pedicularis bracteosa</i> var. <i>flavida</i> <i>Pedicularis bracteosa</i> var. <i>latifolia</i> <i>Pedicularis bracteosa</i> var. <i>pachyrhiza</i> <i>Pedicularis bracteosa</i> var. <i>siifolia</i> (Burke Herbarium 2017)
Cultivar	None listed
Common Synonym(s)	None listed
Common Name(s)	Bracted lousewort, wood betony, fernleaf
Species Code (as per USDA Plants database)	PEBR
<b>GENERAL INFORMATION</b>	
Geographical range	Widely distributed throughout the mountainous areas of Washington; British Columbia south to California, east to Montana, Colorado and

New Mexico (Burke Herbarium 2017).



Source: USDA Plant Database 2017



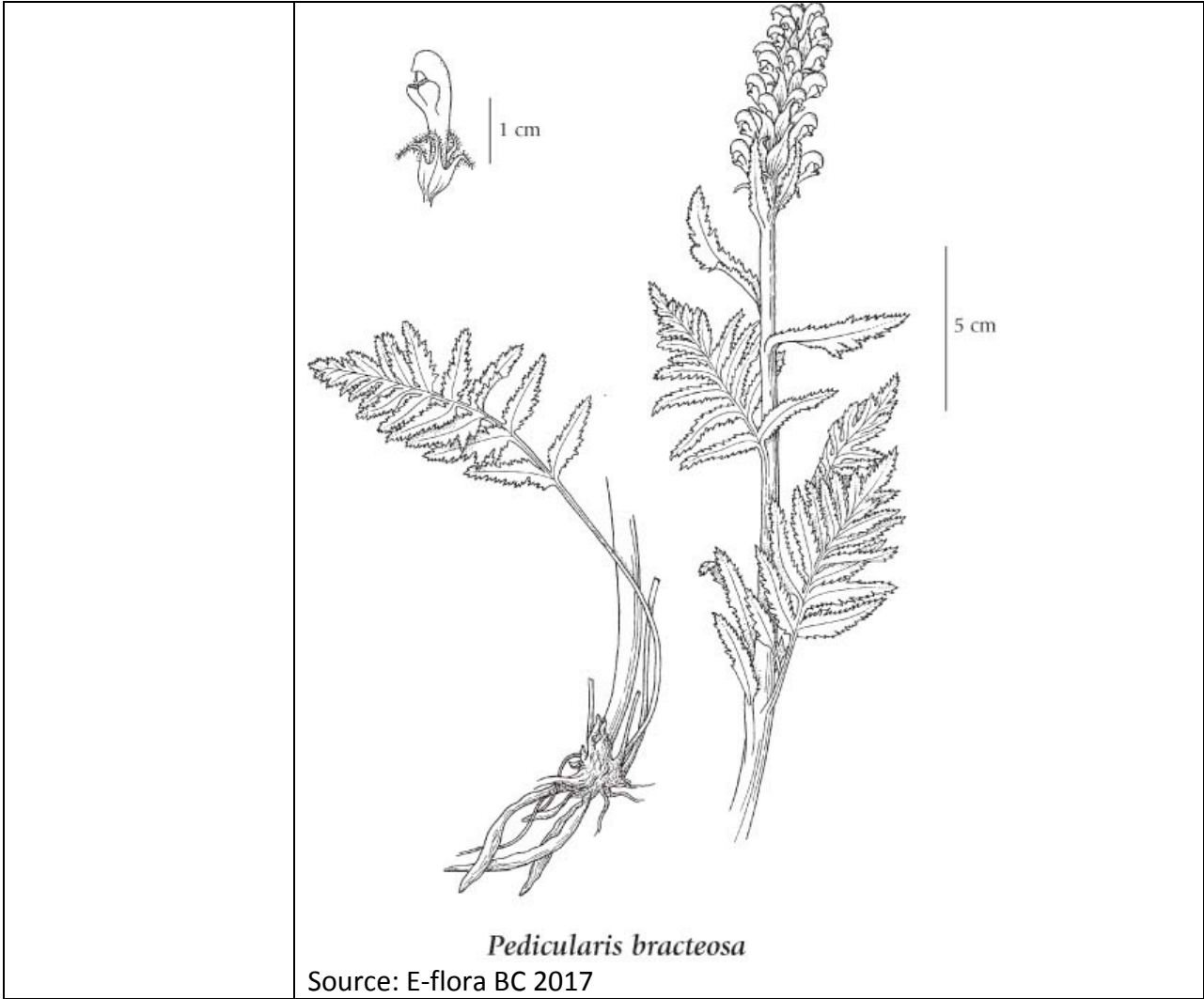
Source: Burke Herbarium 2017

Ecological distribution

Moist, open forest thickets, meadows and clearings in the mountains (Pojar et al 1994).

Shade-intolerant, subalpine, Western North American forb distributed more in the Cordilleran than the Pacific region. Species occurs in continental boreal and cool temperate climates on very moist to wet nitrogen-medium soils. Common in subalpine meadows and open-canopy, high elevation forests on water-receiving sites in the coastal interior ecotone (E-flora BC 2017).

Climate and elevation range	Occurs in montane boreal & cool temperate climates at an average elevation of 1694 meters, with a minimum elevation of 8 meters and a maximum of 2520 meters. (E-flora BC 2017)
Local habitat and abundance	Common and abundant at subalpine and alpine elevations from southern mainland British Columbia south to California (Pojar et al 1994).  Grows on turfey slopes, near alpine brooks or seepages, or among willows and scrub conifers near or above treeline (Porsild 1979).
Plant strategy type / successional stage	No information found. Much work has been done with pollination strategies for the <i>Pedicularis</i> genus (see "Work cited but not used" section for papers on pollination biology), but limited information was available about general plant strategies.
Plant characteristics	<b>General:</b> Perennial herb from a mix of coarse fibrous and tuberous-thickened roots, smooth except long-hairy in the inflorescence; stems single or clustered, erect, 30-100 cm tall, un-branched. <b>Leaves:</b> Basal leaves similar to the stem leaves but longer-stalked, or much smaller or lacking; stem leaves alternate, short-stalked to un-stalked, 7-16 cm long, deeply pinnately cleft into narrowly oblong to lanceolate segments, the main segments 1-7 cm long, jaggedly incised and also finely saw-toothed or merely double-toothed, the leaves reduced and less divided upward. <b>Flowers:</b> Inflorescence a dense, elongate, terminal spike of numerous flowers, above several hairy, leaf-like but undivided bracts; corollas yellow or tinged with red or purple to wholly purple, 13-21 mm long, 2-lipped, the upper lip hood-like, beakless or very short-beaked, about as long as the tube, the lower lip 3-lobed; calyces 7-10 mm long, hairy, 5-lobed, the lobes glandular-hairy to nearly smooth, the upper lobe shortest; stamens 4. <b>Fruits:</b> Capsules, asymmetrical, flattened, curved, smooth, 10-12 mm long; seeds several, 2-5 mm long, net-veined. Source: E-flora 2017.



**PROPAGATION DETAILS: SEEDS**

Five different scientific studies for alpine seed propagation were found that included the genus *Pedicularis* in the study group, but the only one who specifically grew *P. bracteosa* as part of the study was Kaye in 1997.

Ecotype	<ol style="list-style-type: none"> <li>1. Alsos et al 2012: Arctic tundra in Isfjorden area of Svalbard, Norway.</li> <li>2. Bliss 1958: Arctic tundra near Umiat, Alaska.</li> <li>3. Cooper et al 2004: Arctic tundra on Colesdalen, NW coast, and Adventdalen in Spitsbergen, Svalbard, Norway.</li> <li>4. Kaye 1997: Alpine tundra in Olympic National Park, Clallam Co., Washington: on the south face of Blue Mountain at 1700-1800 m elevation; along the trail to the Elwha River from Hurricane Hill at 1460-1500 m and at 1675-1700 m near the First Divide</li> </ol>
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	<p>area of Mount Angeles.</p> <p>5. Li et al 2007: Alpine and subalpine meadows from the northwestern Yunnan Province in China.</p>
Propagation Goal	Germinated seeds
Propagation Method	Seed
Product Type	Germinated seeds
Stock Type	<p>Native seed from:</p> <ol style="list-style-type: none"> <li>1. Alsos et al 2012: Arctic tundra in Isfjorden area of Svalbard, Norway.</li> <li>2. Bliss 1958: Arctic tundra near Umiat, Alaska.</li> <li>3. Cooper et al 2004: Arctic tundra on Colesdalen, NW coast, and Adventdalen in Spitsbergen, Svalbard, Norway.</li> <li>4. Kaye 1997: Alpine tundra in Olympic National Park, Clallam Co., Washington.</li> <li>5. Li et al 2007: Alpine and subalpine meadows from the northwestern Yunnan Province in China.</li> </ol>
Time to Grow	<ol style="list-style-type: none"> <li>1. Alsos et al 2012: No information listed for how long seeds were germinated.</li> <li>2. Bliss 1958: Seeds were considered to have germinated when the radicle appeared (p. 181). (the author did not list a time frame for germination).</li> <li>3. Cooper et al 2004: Soil samples from the polar heath, bird cliff, proglacial habitat and thermophilic heath were grown over 12 weeks (11 for thermophilic heath) simulating the maximum Svalbard summer period. Samples from intact and disturbed <i>Dryas</i> heath were grown over 14 weeks (p. 117).</li> <li>4. Kaye 1997: The maximum monitoring period was 145 days, but was less than 80 days for most species (Kaye 1997, p. 116).</li> <li>5. Li et al 2007: 100% of the seeds germinated after 10 days of incubation (p. 1260).</li> </ol>
Target Specifications	Germinated seeds.
Propagule Collection Instructions	<ol style="list-style-type: none"> <li>1. Alsos et al 2012: Seeds were collected between August 27<sup>th</sup> and September 19<sup>th</sup>, 2008 in the Isfjorden area of Svalbard. <i>M. rubella</i> seeds were collected on September 10<sup>th</sup>, 2008 in</li> </ol>

	<p>Sassendalen in a “disturbed moss tundra” habitat (Appendix 1). When possible, seeds were shaken out of the plants to ensure only mature seeds were collected (p. 820).</p> <ol style="list-style-type: none"> <li>2. Bliss 1958: Seeds of the alpine species were obtained from plants growing in the alpine tundra of the Snowy Range of the Medicine Bow Mountains, 11,000 feet above sea-level, approximately 40 miles west of Laramie, Wyoming, in 1954 and 1955 (p. 181).</li> <li>3. Cooper et al 2004: Seeds collected in early July to late August in the year 2000 (p.116). The top 2 cm of organic soil was collected together with bryophytes and litter. Soil samples were collected within 10 cm of focus species to maximize chance of capturing dispersed seed (p. 117).</li> <li>4. Kaye 1997: Seeds (or single seeded fruits such as caryopses and achenes) were harvested by hand in August or September of 1987 from single populations within Olympic National Park, Clallam Co., Washington (p. 116).</li> <li>5. Li et al 2007: Seeds of <i>Pedicularis</i> species often mature from August to September in northwestern Yunnan Province. In this experiment, seeds of eight <i>Pedicularis</i> species were collected from August to November 2004 (p. 1259).</li> </ol>
<p>Propagule Processing/ Propagule Characteristics</p>	<ol style="list-style-type: none"> <li>1. Alsos et al 2012: If the plants were wet, seed capsules were collected and left in paper bags to dry. Seeds that were obviously not ripe were not collected (p. 820).</li> <li>2. Bliss 1958: Seeds were placed in glass vials or paper bags, air dried and shipped to Duke University (p. 181).</li> <li>3. Cooper et al 2004: Samples of seed collected in the field were cooled 2-6 °C during transport (p. 117).</li> <li>4. Kaye 1997: Seeds were hand-cleaned, sorted, and stored in paper packets at 7 °C (p. 116).</li> <li>5. Li et al 2007: Seeds were allowed to dry at room temperature for about half a month and were stored in paper bags at 4 °C in a refrigerator until used (p. 1259).</li> </ol>
<p>Pre-Planting</p>	<ol style="list-style-type: none"> <li>1. Alsos et al 2012: If the plants were wet, seed capsules were</li> </ol>

<p>Propagule Treatments</p>	<p>collected and left in paper bags at 5-8 °C in 35 % relative humidity (RH) to dry. Seeds that were obviously not ripe were not collected. Seeds of species which did not seem 100 % ripe were left in paper bags at 5-8 °C until September 19<sup>th</sup> to permit ripening, after which they were assumed to be ripe (p. 820).</p> <ol style="list-style-type: none"> <li>2. Bliss 1958: Seeds were placed in glass vials or paper bags, air dried and shipped to Duke University, where they were stored at 5°F for 6 to 7 months. After removal from storage, the seeds were cleaned, sorted and the unfilled and shrunken ones removed (p. 181).</li> <li>3. Cooper et al 2004: Samples of seed collected in the field were cooled 2-6 °C during transport and stored in paper bags at 0.5 °C for 5 to 7 weeks (p. 117).</li> <li>4. Kaye 1997: Seeds were hand-cleaned, sorted, and stored in paper packets at 7 °C. Several treatments to break dormancy were applied: after-ripening in dry paper packets at 7 °C for 9 months; darkness; scarification (abrasion) of the seed coat; and/or moist cold stratification of 10 month old seed for 6, 12, and 18 weeks at 5 °C. Only a subset of treatments was applied to each species (see Table 1 on p. 117). For <i>P. bracteosa</i>, only darkness and stratification were tested, but no germination numbers were reported. Darkness was applied by wrapping two layers of aluminum foil around the plastic box containing the petri plates. The dark-box was placed for a minimum of 18 weeks on the same shelf in the same germinator as the other seeds (p. 116).</li> <li>5. Li et al 2007: Seeds were allowed to dry at room temperature for about half a month and were stored in paper bags at 4 °C in a refrigerator until used. Germination experiments were conducted in December 2004 (p. 1259). Based on statistical analysis, scarifying seed coat with sandpaper resulted in significantly improved germination in all tested <i>Pedicularis</i> species (except <i>P. lutescens</i> ). Scarification was the most effective germination promoting method, showing a significantly positive effect in six of eight species when compared with other treatments (p. 1260).</li> </ol>
<p>Growing Area Preparation / Annual Practices</p>	<ol style="list-style-type: none"> <li>1. Alsos et al 2012: 3 to 50 seeds of each species were placed on a 9 cm diameter petri dish with 10% agar solution (p. 821).</li> </ol>

for Perennial Crops	<ol style="list-style-type: none"> <li>2. Bliss 1958: Seeds were placed in sterilized petri dishes between layers of moist filter paper and incubated at 72°F (p. 181).</li> <li>3. Cooper et al 2004: Soil samples from the polar heath, bird cliff, proglacial habitat and thermophilic heath were spread thinly on filter paper in plastic petri dishes. Samples from intact and disturbed <i>Dryas</i> heath were placed on commercial sterilized soil in aluminum foil boxes. Unidentified seedlings were transplanted to a mixture of peat and perlite and grown at 15 °C until identification was possible (p. 117).</li> <li>4. Kaye 1997: Depending on seed availability and treatment, 45–300 seeds were put on moist cellulose pads in 10 cm petri plates, stacked in a 40 x 25 x15 cm clear plastic box, and placed in a 20 °C constant-temperature germinator equipped with cool-white fluorescent lights on an 8 hour photoperiod (p. 116).</li> <li>5. Li et al 2007: All germination tests were carried out on three layers of filter paper saturated with distilled water in transparent glass petri dishes (p. 1259).</li> </ol>
Establishment Phase Details	<ol style="list-style-type: none"> <li>1. Alsos et al 2012: The light temperature was 4,000 K (Osram 35 W, 840 HE) and the brightness was 3,300 lm (manufacturer’s information). The proton flux was approximately 40 umol per square meter per second measured with a quantum flux sensor at the level of the seeds. If the germination percentage obtained was low, but the seeds still seemed viable, a new germination test was attempted following an additional period of stratification (p. 821).</li> <li>2. Bliss 1958: Seeds were placed in sterilized Petri dishes between layers of moist filter paper and incubated at 72°F, one sample in the light and the other in the dark. Distilled water was added when necessary to keep the filter paper moist. The dishes were removed twice a week for seed counting, at which time the continuous dark period was broken for approximately 1 hour. The number of seeds tested varied according to the quantity of seed available. Seeds were considered to have germinated when the radicle appeared (p. 181).</li> <li>3. Cooper et al 2004: Soil samples from the polar heath, bird cliff, proglacial habitat and thermophilic heath were spread thinly on filter paper in plastic petri dishes and germinated at 18 °C in a greenhouse, using a 24-hr photo-period (150 umol) over 12 weeks (11 for thermophilic heath) simulating the maximum</li> </ol>



	<p>Svalbard summer period. Samples from intact and disturbed <i>Dryas</i> heath were placed on commercial sterilized soil in aluminum foil boxes and germinated at 22 °C in a greenhouse over 14 weeks. These samples were stirred in weeks 3 and 11, and gibberillic acid (1 ppm) was added in week 12. All samples were moistened every second day, and seedlings counted weekly. Unidentified seedlings were transplanted to a mixture of peat and perlite and grown at 15 °C until identification was possible (p. 117).</p> <p>4. Kaye 1997: Petri plates were left in the germinator until all seeds had germinated or no new germination occurred for at least four days. The maximum monitoring period was 145 days, but was less than 80 days for most species (p. 116).</p> <p>5. Li et al 2007: All germination tests were carried out on three layers of filter paper saturated with distilled water in transparent glass petri dishes. To guarantee constant moisture in the dishes, they were connected to an extra dish filled with distilled water by a filter paper band. Two light regimes (16 h light/8 h dark and complete darkness) and three artificial treatments were used in our experiments. For the treatment in darkness, the dishes were put into a paper box wrapped with aluminum foil. For artificial treatments, seeds were either scarified by rubbing against 120-grit sandpaper until the seed coat was penetrated or was soaked in gibberellic acid (GA<sub>3</sub>; 100 and 500 mg L<sup>-1</sup>, respectively) for 2 h. All tests were carried out in a growth chamber (Yi-Heng Technology Co., Ltd., model MGC-300A, series Blue Pard; Shang- hai, China) with a cycle of 16 h light (44.4 mmol m<sup>-2</sup> s<sup>-1</sup>, 400–700 nm) at 25 °C and 8 h dark at 18 °C. This temperature and light regime was chosen based on the temperature and light found to produce optimal germination in other studies of high-elevation species. Each treatment consisted of three replications of 20 seeds (p. 1259-1260).</p>
<p>Length of Establishment Phase</p>	<p>1. Alsos et al 2012: No information listed for how long seeds were germinated.</p> <p>2. Bliss 1958: Seeds were considered to have germinated when the radicle appeared (p. 181). (the author does not list a time frame for germination).</p> <p>3. Cooper et al 2004: Soil samples from the polar heath, bird cliff,</p>

	<p>proglacial habitat and thermophilic heath were grown over 12 weeks (11 for thermophilic heath) simulating the maximum Svalbard summer period. Samples from intact and disturbed <i>Dryas</i> heath were grown over 14 weeks (p. 117).</p> <p>4. Kaye 1997: The maximum monitoring period was 145 days, but was less than 80 days for most species (Kaye 1997, p. 116).</p> <p>5. Li et al 2007: 100% of the seeds germinated after 10 days of incubation (p. 1260).</p>
Active Growth Phase	No information found.
Length of Active Growth Phase	No information found.
Hardening Phase	
Length of Hardening Phase	No information found.
Harvesting, Storage and Shipping	No information found.
Length of Storage	No information found.
Guidelines for Outplanting / Performance on Typical Sites	No information found.
Other Comments	Some greenhouse trials failed to meet the germination requirements of some species that successfully germinated in the field, such as <i>Pedicularis hirsute</i> , possibly due to its hemiparasitic association with <i>S. polaris</i> (Cooper et al 2004).
<b>INFORMATION SOURCES</b>	
References	See below
Other Sources Consulted	See below
Protocol Author	Sage Stowell
Date Protocol Created or Updated	May 24 <sup>th</sup> , 2017

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