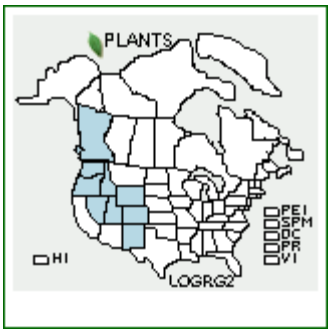
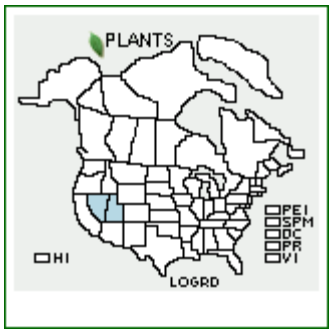


Lomatium grayi var. *grayi*



Lomatium grayi var. *depauperatum*

Plant Propagation Protocol for *Lomatium grayi*
ESRM 412 – Native Plant Production

TAXONOMY	
Family Names	
Family Scientific Name:	Apiaceae
Family Common Name:	Carrot family
Scientific Names	
Genus:	*Lomatium*
Species:	*grayi*
Species Authority:	J.M. Coult. & Rose
Variety:	*Lomatium grayi* (J.M. Coult. & Rose) J.M. Coult. & Rose (5); *Lomatium grayi* (J.M. Coult. & Rose) J.M. Coult. & Rose var. *depauperatum* (M.E. Jones) Mathias (5,6,7).
Sub-species:	
Cultivar:	Common wildland collected seed is available from commercial sources. There are currently no commercial releases of Gray's biscuitroot (3). Commercial growers are producing pooled Source Identified seed representative of Omernik Ecoregion 12 (Snake River Plain) and 80 (Northern Basin and Range).
Authority for Variety/Sub-species:	
Common Synonym(s) (include full scientific names (e.g., *Elymus glaucus* Buckley),	*Lomatium grayi* (J.M. Coult. & Rose) J.M. Coult. & Rose

including variety or subspecies information)	
Common Name(s):	Gray's biscuitroot (1,2); Gray's desert parsley, Milfoil lomatium, Mountain desert parsley, Narrow-leaf lomatium, Pungent desert parsley (3).
Species Code (as per USDA Plants database):	LOGR
GENERAL INFORMATION	
Geographical range (distribution maps for North America and Washington state)	Maps above for distribution in North America and southwest US (5,6); Gray's biscuitroot occurs in Northwest North America, primarily from the Cascade and Sierra Nevada to the Rocky Mountains in Washington, Idaho, Oregon, Wyoming, Nevada, Utah, Colorado and New Mexico. There are two populations in British Columbia, Canada where it is considered a threatened species (2, 3).
Ecological distribution (ecosystems it occurs in, etc):	*Lomatium grayi* is a perennial herb flowering in early spring in the steppe of the intermountain west of North America (4). Widespread E Cascades, dry, open, often rocky places from foothills and lowland to midmontane; central Washington to northern Idaho, south in eastern Oregon and western Idaho to northeast Nevada, irregular to southeast Idaho, Wyoming, and Colorado (8).
Climate and elevation range	This species is adapted to well drained, rocky shallow soils at elevations from sea level to 2750 m (0 to 9,000 ft) (COSEWIC, 2008; Welsh et al., 2003 in (3)). Gray's biscuitroot is generally found in areas receiving 20 to 50 cm (8 to 20 in) mean annual precipitation (3).
Local habitat and abundance; may include commonly associated species	Gray's biscuitroot grows on rocky outcrops, shallow pockets of soil in rocks and in open habitat in sagebrush, mountain shrub, pinyon-juniper, ponderosa pine, and Douglas fir communities (3). Along south-facing slopes along the Snake River Canyon (elev = 160m) found associated with *Agropyron spicatum* and *Opuntia polyacantha*. In sub-alpine meadows in the Blue Mountains (elev. 1800 m) as a co-dominant with *Lupinus sulphureus* and *Eriogonum favum* var. *piperi* surrounded by Pseudostuga menzesii (4). Gray's biscuitroot has been known to be attacked by the larvae of 2 weevils (*Apion oedorhychum* and *Smicronyx* sp.) and one moth (*Greya subalba*) (Ellison and Thompson, 1987 in (3)). These insect pests are known to kill the seed and reduce seed viability. Herbivory by mammals limits species occurrence and spread in Canadian populations (COSEWIC, 2008 in (3)).
Plant strategy type / successional stage (stress-tolerator, competitor, weedy/colonize	Gray's biscuitroot is grazed by deer, sheep, mice, rats, and rabbits (COSEWIC, 2008). Ogle and Brazee (2009) rate it as desirable spring and summer forage for cattle, sheep, horses, elk, deer and antelope. Gray's biscuitroot is one of the first species to green up and flower after snowmelt. This characteristic makes this an important species for early spring pollinators and other insects. Known pollinators include solitary bees and flies (3). This species has been identified as an important plant species in

r, seral, late successional)	sage-grouse habitat because of its early growth habit and the associated insects that provide a critical food source for sage-grouse chicks. Gray's biscuitroot is a host plant for the rare Indra swallowtail butterfly (*Papilio indra*) and is one of two plants used as a host by the Anise Swallowtail (*Papilio zelicaon*) (Thompson 1989 in (3). The female Indra Swallowtail butterfly lays eggs on *Lomatium* sp. and the essential oils of three varieties of *Lomatium grayi; L. grayi.* var. *grayi, L. grayi* var. *depauperatum* and *L. grayi.* var. (undescribed) have been analyzed (9). Among the major components, *L. grayi* var. *grayi* shows myrcene (8.4%), β-phellandrene/limonene (27.2%), γ-terpinene (10.4%), and senkyunolide (24.4%). *L. grayi* var. *depauperatum* shows myrcene (8.1%), p-cymene (4.3%), β-phellandrene/limonene (20.8%), (Z)-β- and (E)-β–ocimene (23.6%), γ-terpinene (4.4%), germacrene D (4.6%), senkyunolide (4.7%), and (Z)-ligustilide (6.7%). *L. grayi* (new varity) shows β-phellandrene/limonene (17.7%), γ-terpinene (16.1%), and senkyunolide (44.0%). These observations contrast significantly with the reported composition of *L. grayi.* Only *L. grayi* var. *depauperatum* and *L. grayi* (new variety) attract the butterfly. *Ethnobotanic:* The tender young stems and roots of Gray's biscuitroot were eaten by the Paiute Indians (Mahar, 1953 in (3)). *Medicinal:* Though not proven in clinical trials, this species may possess antiviral and antibacterial properties based on its relationship to fernleaf biscuitroot (*L. dissectum*) (COSEWIC, 2008 in (3)).
Plant characteristics (life form (shrub, grass, forb), longevity, key characteristics, etc)	The plants live to approximately 7 years of age (COSEWIC, 2008 in (3)), with growth only occurring in the spring when moisture is available. Gray's biscuitroot is a large, perennial, aromatic herb with a branched caudex arising from a deep taproot. Mature plants can reach up to 60 cm (24 in) tall. The leaves are finely divided and parsley like (Thompson, 1984 in (3)). Leaves very finely dissected, generally with several hundred or > 1000 very narrow and often subterete ultimate segments that lie in numerous different planes so that the leaf has "thickness;" leaves often evidently scaberulous (8). Individuals are andromonoeciuos; the umbels flower centripetally, with bisexual , protogynous flowers outermost with an umbel (Harden 1929, Thompson 1984 in (4)). Each plant bears up to 20 naked stems (scapes) which end in an umbel with several hundred male or hermaphroditic flowers (Thompson, 1984 in (3)). The petals and stamens are yellow, but quickly dry to a whitish color after anthesis (Welsh et al., 200 in (3)). This species also has a distinctive pungent odor. Plants leaf out in early spring, flower quickly, set seed, and then enter summer dormancy. Seeds mature in July (3). Umbels can contain male or hermaphroditic flowers (Thompson, 1987 in (3)). Individual plants often do not flower in consecutive years (Thompson and Moody, 1985), and there can be considerable variation in the number of flowers produced from one population to the next (Thompson, 1987 in (3)). Selection for faster growth rates and higher flowering frequency at small sizes and early ages may favor the more staminate-biased sex ratios (10).

PROPAGATION DETAILS	
Ecotype (this is meant primarily for experimentally derived protocols, and is a description of where the seed that was tested came from):	Intermountain West (2). Rocky Mountain Research Station, Weiser River Road, Idaho; 2130 ft. elevation (1)
Propagation Goal (Options: Plants, Cuttings, Seeds, Bulbs, Somatic Embryos, and/or Other Propagules):	Seeds (1). The seeds are approximately 12 mm (0.5 in) long with broad lateral wings. The lateral wings are approximately 2 mm (0.08 in) wide and comprise up (3).
Propagation Method (Options: Seed or Vegetative):	Seed (1)
Product Type (options: Container (plug), Bareroot (field grown), Plug + (container-field grown hybrids, and/or Propagules (seeds, cuttings, poles, etc.))	Propagules (seeds, cuttings, poles, etc.) (1)
Stock Type:	
Time to Grow (from seeding until plants are ready to be outplanted):	3 Years (2).
Target Specifications (size or characteristics	Field produced seed with >95% purity (2).

of target plants to be produced):	
Propagule Collection (how, when, etc):	Small lot, 2.6 pounds, hand collected into paper bags (1). Seed matures in July into August. Wildland seed disarticulates readily and is easily hand collected. Very clean collections can be made by shaking ripened inflorescences over a bag or tarp (2,3).
Propagule Processing/Propagule Characteristics (including seed density (# per pound), seed longevity, etc):	METHOD OF CLEANING: Stems were rubbed by hand to remove seed. Seed was then air-screened, to scalp off non-seed material, using a Clipper Eclipse, Model 324, with a top screen, 24 and then 23 round, a 22 round middle screen, and a 6 round, bottom screen, low air. Lot was again air-screened using an office Clipper, with a top screen, 24 round and a bottom screen, 6 round, medium speed, medium air. Number of Seeds per Pound: 39,444, Purity: 85%, X-Ray100 Seeds: 65% Filled (1). Minor screening to remove sticks provides excellent purity. Additional cleaning can be done with an air-screen cleaner.. There are approximately 86,000 seeds/kg (39,000 seeds/lb) (Barner 2008) (2).
Pre-Planting Propagule Treatments (cleaning, dormancy treatments, etc):	Seed of Gray's biscuitroot requires a 3-month moist chilling to relieve dormancy (Shock 2011). Fall-dormant seeding is required for field germination (2). Ellison (4) germinated in moistened sand at 5°C under constant light, embryo facing downward 2.5 cm apart in metal trays enclosed in plastic bags with trays rotated and moisted every 1-2 weeks for 2-3 months before transplanting into pots. Mean germination time was 46-51 days. Germination success was 92.8% for seeds with herbivores excluded from developing umbels, and 70.0 % with herbivory present (4). Scholten et al. (2009 in (3)) observed that greatest embryo elongation in the closely releated fernleaf biscuitroot (*L. dissectum*) occurred at temperatures of 3.4 to 5.5° C (38 to 42° F) with the best germination percentages occurring at 3.4 C (38° F) with approximately 16 weeks of cold/moist stratification (3).
Growing Area Preparation / Annual Practices for Perennial Crops (growing media, type and size of containers, etc):	Seed production fields should be seeded at 25 to 30 PLS/ft. Rows planted on 75 cm (30 in) centers allow for between row cultivation and weed control. When using weed barrier fabric, plant seeds into 8 cm (3 in) holes at 30 to 45 cm (12 to 18 in) spacing (2).
Establishment Phase (from seeding to germination):	Ellison (4) grew seedlings in 4x20.5cm and 2.5 x 13 cm pots with a "greenhouse mix" (55% peat, 45% pumice, N:P:K 11:12:14 (total) containing added micronutients, pH=7.1-7.2) for 45 days in both a growth-chamber and greenhouse, watered every two days. Larger seeds produced significantly larger plants under most controlled environmental conditions after 45 days, including competition with *Bromus tectorum* and/or herbivory

	on the seed source plant (4). Presumably in field growth, above ground growth is slow as young plants invest significant resources to produce a substantial taproot (2). Plants grow in early spring into summer and go dormant in mid-summer, giving the appearance of mortality. During the first year of establishment, most plants will only produce a few leaves (2). Gray's biscuitroot has exhibited more vigorous, rapid growing seedlings than fernleaf biscuitroot and nineleaf biscuitroot (*L. triternatum*) (3).
Length of Establishment Phase:	1 yr (2).
Active Growth Phase (from germination until plants are no longer actively growing):	Most plants will not produce flowers or fruit during the first 2 to 3 years of growth. Good weed control can be achieved through the use of weed barrier fabric and hand roguing. Because Gray's biscuitroot enters dormancy in early summer, foliar herbicide applications of glyphosate to surrounding weeds are possible after senescence. Highest seed yields have been achieved with the use of supplemental irrigation. Shock and others (2010) showed a significant positive response to irrigation with 10 and 20 cm (4 and 8 in) additional water at Ontario, Oregon. Ontario has a mean annual precipitation of 24 cm (9.5 in), bringing the total received water to approximately 46 cm (18 in) for optimum seed production (2).
Length of Active Growth Phase:	7 yrs (2).
Hardening Phase (from end of active growth phase to end of growing season; primarily related to the development of cold-hardiness and preparation for winter):	
Length of Hardening Phase:	
Harvesting, Storage and Shipping (of seedlings):	Storage: Cold Storage, 33-38 Degrees Fahrenheit (1). Seed can be harvested in production fields via a vacuum type harvester or flail vac. Seed is cleaned using an air screen cleaner. Purities approximating 100% are achievable with minimal effort. Peak seed yields of over 1590 kg/ha (1,400 lb/ac) resulted from 20 cm (8 in) of supplemental irrigation (Shock and others 2010 in (2,3)).
Length of Storage (of seedlings, between	

nursery and outplanting):	
Guidelines for Outplanting / Performance on Typical Sites (eg, percent survival, height or diameter growth, elapsed time before flowering):	Seed can be broadcast or drilled to 3 to 6 mm (1/8 to 1/4 in) depth into a well prepared, weed-free seed bed. This species should be seeded in late fall as a dormant planting to allow natural stratification. A single species seeding rate of approximately 23 lbs/ac provides 25 to 30 seeds/ft (2,3). Large Scale Seed Production Shock et al. (2010a in (3)) showed a significant positive response to irrigation with 10 and 20 cm (4 and 8 in) additional water at Ontario, Oregon. Ontario has a mean annual precipitation of 24 cm (9.5 in) (U.S. Climate Data, 2010 in (3)), bringing the total received water to approximately 46 cm (18 in) for optimum seed production. Peak seed yields of over 1590 kg/ha (1,400 lb/ac) resulted from 20 cm (8 in) of supplemental irrigation. Rows planted on 75 cm (30 in) centers allow for between row cultivation and weed control. When using weed barrier fabric, plant seeds into 8 cm (3 in) holes at 30 to 45 cm (12 to 18 in) spacing (3).
Other Comments (including collection restrictions or guidelines, if available):	Two separate studies at Ontario, Oregon produced seed in third and fourth growing season (Shock et al., 2010a and b). Additional techniques are being investigated regarding the feasibility of growing Gray's biscuitroot densely in rooting beds prior to field establishment. This method would allow a grower to sacrifice a much smaller area in the first 1 to 2 years of plant development while the plants are not producing seed. Trials indicate that taproots transplanted in autumn establish well (Jensen and Anderson, 2010 in (3)).
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Other Sources Consulted (but that contained no pertinent information) (full citations):	
Protocol Author (First and last name):	Richard L. Ellison
Date Protocol Created or Updated (MM/DD/YY):	05/21/12