WESTERN FORBS: BIOLOGY, ECOLOGY, AND USE IN RESTORATION

ORANGE AGOSERIS

Agoseris aurantiaca (Hook.) Greene
Asteraceae – Aster family

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NOMENCLATURE

Orange agoseris (*Agoseris aurantiaca* [Hook.] Greene) belongs to the Cichorieae tribe of the Asteraceae family (Lee et al. 2003).

NRCS Plant Code. AGAU2 (USDA NRCS 2020).

Subtaxa. The following varieties are currently recognized by the Flora of North America (Baird 2006): *Agoseris aurantiaca* var. *aurantiaca* (Hook.) Greene and *A. a.* var. *purpurea* (A. Gray).

Synonyms. *Agoseris* species are widespread with high levels of morphological and regional variability (Baird 2006). This variability makes identification difficult and many inaccurate descriptions exist in the literature. Hybridization and intermediate forms are also common within the genus. Many synonyms for *Agoseris* species have resulted from the naming of variant populations: *Troximon aurantiacum* (Baird 2006).

Variety aurantiaca: *A. angustissima* (Greene), *A. arachnoidea* Rydberg, *A. carnea* Rydberg, *A. gaspensis* Fernald, *A. gracilens* (A. Gray) Greene, *A. g. var. greenei* (A. Gray) S.F. Blake, *A. greenei* (A. Gray) Rydberg, *A. howellii* Greene, *A. lackschewitzii* (Douglas) M. Henderson & R.K. Moseley, *A. nana* Rydberg, *A. naskapensis* J. Roussea & Raymond, *A. prionophylla* Greene, *A. subalpina* G.N. Jones, *A. vulcanica* Greene (Baird 2006).

Variety purpurea: *Macrorhynchus purpureus* A. Gray, *A. arizonica* (Greene) Greene, *A. attenuata* Rydberg, *A. aurantiaca* subsp. *purpurea* (A. Gray) G.W. Douglas, *A. confinis* Greene, *A. frondifera* Osterhout, *A. glauca* (Pursh) Rafinesque var. *cronquistii* S.L. Welsh, *A. graminifolia* Greene, *A. longirostris* Greene, *A. purpurea* (A. Gray) Greene, *A. purpurea* var. *arizonica* (Greene) G.L. Wittrock, *A. roseata* Rydberg, *A. rostrata* Rydberg (Baird 2006).

Common Names. Orange agoseris, mountain agoseris, mountain dandelion, orange mountain dandelion (Shaw 1995; Baird 2006; Blackwell 2006).

Chromosome Number. Chromosome numbers are: 2n = 18, 34, 36; 2n = 18 for variety *aurantiaca* and 2n = 18, 34, 36 for variety *purpurea* (Löve 1968; Baird 2006). 2n = 17 was reported for plants collected in Arizona (Keil et al. 1988).

Hybridization. Variety *aurantiaca* has formed hybrids with *A. glauca*, *A. grandiflora*, *A. monticola*, and *A. parviflora.* Variety *purpurea* has hybridized with *A. parviflora*, *A. glauca*, and *A. g.* var. *dasycephala*. *A. × montana* Osterhout is the recognized hybrid of *A. a.* var. *purpurea* and *A. g.* var. *dasycephala* that occupies high-elevation sites in the Rocky Mountains of Colorado (Baird 2006).

DISTRIBUTION

Orange agoseris is widespread throughout the Rocky Mountains and Intermountain West (Cronquist 1994; Welsh et al. 2016), occurring in all western states and Canadian territories west of Colorado. It is also found in South Dakota and a disjunct population occurs in Quebec (Baird 2006). Variety *aurantiaca* is the most common variety occurring throughout the range identified for the species. Variety *purpurea* is common in the Colorado Plateau and southern Rocky Mountains and occurs in Nevada, Utah, Wyoming, Colorado, Arizona, and New Mexico (Baird 2006).

Habitat and Plant Associations. Orange agoseris occupies dry to wet sites ranging from lowland grasslands and shrublands to subalpine meadows and alpine tundra (Baird 2006; Hitchcock and Cronquist 2018). It is often found along roadsides and in other disturbed sites (Baird 2006). In Utah, variety *aurantiaca* occurs in sagebrush (*Artemisia* spp.), mountain brush, pinyon-juniper (*Pinus-Juniperus* spp.), and alpine meadow communities, and variety *purpurea* occurs in mountain brush, quaking aspen (*Populus tremuloides*), quaking aspen-fir (*Abies* spp.), and spruce (*Picea* spp.)-fir communities (Welsh et al. 2016). Orange agoseris is often found in association with big sagebrush (*Artemisia tridentata*), rabbitbrush (*Chrysothamnus* spp., *Ericameria* spp.), perennial grasses, and pinyon-juniper from valleys and lowlands to as high as 10,800 feet (3,300 m) in the mountains of Utah (Jensen 2007). In California, it occurs along streams and in meadows (Fig. 1), shrublands, and moist grassland openings in montane conifer forests (Munz and Keck 1973; Hickman 1993). In the Great Basin, Balckwell (2006) notes orange agoseris occurs in seep areas in rocks, on grassy slopes, and in openings in montane communities.

The following studies describe some of the species and plant communities associated with orange agoseris at sporadic sites throughout its range. Descriptions of plant associations from orange agoeris' southern-most range are lacking. In Alberta, orange agoseris occurs with alpine timothy (*Phleum alpinum*) and tufted hairgrass (*Deschampsia caespitosa*) in alpine meadows at the forest-tundra ecotone (Heusser 1956). Orange agoseris occurs in several subalpine meadows in the Olympic Mountains in Washington. It was most common in mesic Idaho fescue (*Festuca idahoensis*) grasslands occupying dry south- to west-facing slopes from 5,150 to 5,550 feet (1,570-1,690 m) elevations in the northeastern part of the mountain range. These grasslands occupy relatively steep slopes and are snow-free by mid-June. Orange agoseris was next most common in cushion plant communities on moderately steep to steep south- to southwest facing slopes between 5,050 to 5,250 feet (1,540-1,600 m). The cushion plant communities occupy windy sites that are snow-free by early May and experience frequent spring freezing and thawing (Kuramoto and Bliss 1970). In Mount Rainier National Park, Washington, orange agoseris occurs in Sunrise Meadows with poorly developed soils dominated by greenleaf fescue (*F. viridula*) and broadleaf lupine (*Lupinus latifolius*) (Frank and del Moral 1986).

Figure 1. Orange agoseris growing in a meadow in California. Photo: J. Pawek, CalPhotos, 2012.

In the Cascade Range in Oregon, orange agoseris grows in montane meadow openings in conifer forests dominated by lodgepole pine (*Pinus contorta*) and grand fir (*Abies grandis*). Dominant species in the meadows include California brome (*Bromus carinatus*), blue wildrye (*Elymus glaucus*), and wild strawberries (*Fragaria* spp.) (Halpern et al. 2014). On Fairview Mountain in southeastern Lane County, Oregon, orange agoseris occurs along roadsides between 5,000 and 6,000 feet (1,500-1,800 m) elevation, where the growing season is short and mountain hemlock (*Tsuga mertensiana*) and Alaska cedar (*Chamaecyparis nootkatensis*) are common (Baker 1951). In the Wallowa Mountains, orange agoseris occurs with western moonwort (*Botrychium hesperium*) in mesic meadows or forest edges between 5,035 and 5,450 feet (1,535-1,660 m) in steep calcareous canyons of the Lostine River drainage (Zika et al. 2002). Orange agoseris occurs infrequently along roadsides and in dry meadows in the Tenderfoot Creek Experiment Forest in the Little Belt Mountains of Montana (Mincemoyer and Birdsall 2006). In the Wind River Mountains of Wyoming, it grows in tufted hairgrass-flat-top pussytoes (*Antennaria corymbosa*) meadows surrounded by subalpine forests. These meadows are wet after snowmelt and dry as summer progresses (Cole and Monz 2002). In Gunnison County, Colorado, orange agoseris is a common forb in subalpine meadows at about 11,200 feet (3,400 m) elevation in the Virginia Basin (Huntly 1987). On Arizona's Kiabab Plateau at an elevation of 8,400 feet (2,560 m), orange agoseris occurs in meadow vegetation dominated by mountain muhly (*Muhlenbergia montana*), squirreltail (*Elymus elymoides* subsp. *elymoides*), and pine dropseed (*Blepharoneuron tricholepis*) (Merkle 1962).

Elevation. Orange agoseris occurs from 650 to 11,800 feet (200-3,600 m) in elevation. Variety *aurantiaca* occupies this entire range, while variety *purpurea* is absent at lower elevations, occurring at mid- and higher elevations from 5,900 to 11,800 feet (1,800-3,600 m) (Baird 2006). The elevation range for the species in the Great Basin is 6,500 to 11,500 feet (2,000-3,500 m) (Blackwell 2006) and in California it is 4,900 to 11,500 feet (1,500-3,500 m) (Hickman 1993). In Utah, variety *aurantiaca's* elevation range is 4,510 to 11,240 feet (1,375-3,425 m) (Welsh et al. 2016).

Soils. The soils described in orange agoseris habitats throughout its range are highly variable in texture and depth (Fig. 2). Soil moisture requirements are also broad (Gavin and Brubaker 1999), although dry to moist, well-drained soils are generally preferred (Jensen 2007; LBJWC 2021; Plants for a Future 2020). On Arizona's Kiabab Plateau, orange agoseris grows in meadows on shallow limestone sands (Merkle 1962). Both orange agoseris varieties occur in high-altitude meadows in Boulder Park, northern Colorado, which are concentrated on moist, gravelly soils. These high-altitude meadows are well supplied with moisture, but the climate is severe, and frosts occur nearly every week (Reed 1917). In Oregon's Cascade Range, orange agoseris grows in meadow openings of montane conifer forests where soils are deep (>5.6 feet [1.7 m]), very fine sandy loams (Halpern et al. 2014). In the Crested Butte area of west-central Colorado (10,500-11,500 ft [3,200-3,500 m]), orange agoseris averaged 0.5% cover on 60-year-old burn scars on heavy clay-textured soils (Langenheim 1962). On Deer Ridge in Olympic National Park, Washington (5,250-5,580 ft [1,600-1,700 m]), orange agoseris occurs in meadows with weakly developed, sandy soils. Moisture content of these soils ranged from 8.5 to 25.4% between mid-June to early September (del Moral 1983a).

Figure 2. Orange agoseris growing at a rocky site in California. Photo: G.A. Monroe, CalPhotos, 1987.

Orange agoseris grows in nutrient poor soils, but its abundance may be greater and growth better on soils with higher nutrient content or when nutrients are added. Ant (*Formica canadensis*) mound and nonmound vegetation were compared in south-facing meadows near Gothic, Colorado (9,500 ft [2,900 m]) (Culver and Beattie 1983). Density of orange agoseris on mounds (1.1 stems) was about twice that on nonmounds (0.5 stems). Ant mounds were 4 to 5 years old, and all but one was inactive. Phosphorus, potassium, zinc, and iron contents were significantly greater on mounds than nonmounds ($P < 0.05$), but organic matter was significantly less on mounds than nonmounds (Culver and Beattie 1983). On Deer Ridge in Olympic National Park, Washington (5,250-5,580 ft [1,600-1,700 m]), total biomass of agoseris (orange agoseris and pale agoseris [*Agoseris glauca*]) increased significantly ($P < 0.05$) when dominant species were removed (cut at the base up to 4 times/season) and fertilizer was added (0.02 lb/ft^2 [80 g/m^2], 18% N, 24% P, 6% K) (del Moral 1983a). In subalpine meadows near the Rocky Mountain Biological Laboratory in western Colorado, nitrogen deposition rates are low (averaging 0.4 g nitrate, 0.06 g ammonium/yr). Treatments adding low (1 g N/m^2/yr) and high (20 g N/m^2/yr) levels of nitrogen did not improve per flower female reproduction of orange agoseris (Burkle and Irwin 2010).

DESCRIPTION

Orange agoseris is a perennial scapose herb (Fig. 3) from a simple to branched caudex and strong, deep taproot (USFS 1937; Munz and Keck 1973; Welsh et al. 2016). Herbage is glabrous to villous and exudes a milky juice when damaged (Spellenberg 2001; Welsh et al. 2016). Leaves are entirely basal, erect to decumbent with leaf blades 1.4 to 15 inches (3.5-38 cm) long and 0.1 to 1.2 inches (0.3-3 cm) wide (Baird 2006). Leaf blades are narrow, linear to oblanceolate, and broadest at the middle (Spellenberg 2001). Leaf margins range from entire or with several teeth or lobes occurring in 2 to 4 pairs (Baird 2006). Flowers are produced individually at the ends of upright leafless stalks (Spellenberg 2001).

Figure 3. Orange agoseris plant in flower growing in Blaine County, Idaho. Photo: ©2017 Barry Rice.

Plants in flower can reach 32 inches (80 cm) tall but are often 16 inches (41 cm) tall or less (Hermann 1966). Orange agoseris produces flower heads that are about an inch (2.5 cm) wide (Fig. 4) and are comprised of 15 to 100 ray-like florets (Spellenberg 2001; Baird 2006; Welsh et al. 2016). The florets are ligulate with 5 lobes at the tip and uniformly fertile (Delmatier and Fertig 2014). Inner ligulate florets are shorter than the outer florets (Spellenberg 2001). The corolla is orange, occasionally yellow orange or pink, and dries to purple or burnt orange (Hickman 1993; Hitchcock and Cronquist 2018). The involucre, which encloses the flower head is 0.5 to 1.2 inches (1.2-3 cm) high, 0.4 to 1.6 inches (1-4 cm) wide, and often tomentose (Fig. 5). Outer, often purple-tinged bracts, can be glabrate and are shorter and wider than the inner bracts (Welsh et al. 2016; Hitchcock and Cronquist 2018). Ray-like flowers produce stamens with anthers that are sagittate at the base with rounded tips. Pistils have linear style branches.

Orange agoseris produces cylindric cypselae fruits, but these are often referred to as achenes in the literature. The cypselae have 0.4 to 0.6-inch (0.9-1.5 cm) long pappi of capillary bristles arranged in a two or three series (Baird 2006; Welsh et al. 2016). Cypselae are 10-ribbed, 4 to 9 mm long, with slender beaks. The beaks are often more than half as long as the cypselae bodies (Munz and Keck 1973; Welsh et al. 2016; Hitchcock and Cronquist 2018).

Figure 4. Orange agoseris flower head with lobed ligulate florets the inner of which being shorter than the outer. Photo: ©Al Schneider, swcoloradowildflowers.com.

Figure 5. Tomentose orange agoseris involucre enclosing the flower head. Photo: C. Wagner, CalPhotos, 2014.

Varieties. The Flora of North America suggests that varieties are best distinguished by the involucre bracts and the beaks and ribs of cypselae (Baird 2006).

Variety *aurantiaca* produces leaves that often have entire margins (Baird 2006; Welsh et al. 2016). Flower stems are often shorter than the leaves (Baird 2006). Involucre bracts can be more than 0.8 inch (2 cm) long and are subequal, slender and tapering (Hermann 1966; Welsh et al. 2016). Cypselae have abruptly tapered beak ends and ribs that are often thicker distally (Baird 2006). Variety *aurantiaca* is often much taller than variety *purpurea* (Welsh et al. 2016).

Variety *purpurea* produces leaves with typically dentate margins (Baird 2006; Welsh et al. 2016). Flower stems are often shorter than the leaves (Baird 2006). Involucre bracts are overlapping, broad, with blunt rounded tips (Hermann 1966; Welsh et al. 2016). Cypselae have gradually tapered beak ends and ribs that are weakly and uniformly ridged but not thickened distally (Baird 2006).

Reproduction. Orange agoseris flowers from May to September (Baird 2006; Jensen 2007), and seed typically ripens from May to September (Jensen 2007; PFAF 2021). Plants produce one to three seed heads each year but may produce more flowering stalks if soil moisture is not limited (Fig. 6) (Jensen 2007).

Figure 6. Single orange agoseris plant producing both flowers and seeds (indeterminate growth). Photo: ©Al Schneider, swcoloradowildflowers.com.

Breeding system and pollination. Flowers have both stamens and pistils and are pollinated by insects (PFAF 2021). Pollinators from the following families: Anthomyiidae, Halictidae, Hesperiidae, Lycaenidae, Muscidae, Nymphalidae, Pieridae, Sarcophagidae, Syrphidae, and Tachinidae interacted with orange agoseris flowers in high-elevation meadows (9, 500 feet [2,900 m]) near Crested Butte, Colorado. Flower-pollinator interactions were observed for 3 years (June through August 2005-2007) during good weather from 9 am to 4 pm (Burkle and Irwin 2009). Orange agoseris was an important nectar source for 27 butterfly species in the Crested Butte area of Colorado, which was monitored for four flight seasons (Sharp et al. 1974).

ECOLOGY

A strong taproot and wind-dispersed seed (Fig. 6) suggests orange agoseris is disturbance adapted (Shaw 1995). Plants are considered shade intolerant (PFAF 2021) and early colonizers of disturbed sites (Titus et al. 1998; Brown et al. 2003). The life span of orange agoseris has been described as short (Eldredge et al. 2013) to long lived (Romme et al. 2016).

Disturbance Ecology. Several studies reported orange agoseris appeared in early primary succession of severely disturbed sites (Frank and del Moral 1986; Titus et al. 1998; Brown et al. 2003). It colonized a denuded subalpine meadow on poorly developed soils at Mount Rainier National Park, Washington. Denuded sites resulted from cabin removal which was followed by bulldozing. Orange agoseris cover was 0.1% on bulldozed sites within 10 years, which was just slightly less than its cover in nearby undisturbed meadows (Frank and del Moral 1986). Orange agoseris colonized an abandoned mine site in southern Montana (Brown et al. 2003). The mine, operated for copper, gold, and silver extraction, was abandoned in 1952. By 1972, plant colonization was limited. Following treatments of lime, fertilizer, and a mix of native and nonnative grasses in 1976, orange agoseris appeared on treated but not untreated mine spoils (Brown et al. 2003). Following the 1980 eruption of Mt. St. Helens in Washington, orange agoseris was found soon after the eruption even on sites with thick mud and little vegetation recovery or colonization (del Moral 1983b). In later sampling, 13 to 14 years after the eruption, orange agoseris was infrequently found at sites where vegetation was essentially eliminated. It was common at refugia sites where some vegetation survived (Titus et al. 1998).

Disturbed sites are common habitats for orange agoseris, and its abundance is often greater on harvested, grazed, or burned sites than on undisturbed sites. In a subalpine huckleberry (*Vaccinium* spp.) field at 1,200 feet (4,000 ft) elevation on Mount Adams in southwestern Washington, effects of heavy sheep grazing, cutting and burning, and fire alone were evaluated. Cover of orange agoseris was greater in treated (0.2-0.4%) than untreated (0-0.1%) sites in all 4 years of post-treatment monitoring (Minore et al. 1979). In the Snowy Range of southeastern Wyoming, orange agoseris occurred on 30- to 50-year-old clearcuts (0.01-0.09% average cover) but was absent from mature lodgepole pine (*Pinus contorta*) montane and subalpine forests (subalpine fir [*Abies lasiocarpa*] and Engelmann spruce [*Picea engelmanii*]). The basal area of trees was 35-61 ft^2/acre (8-14 m^2/ha) in harvested and 17,091 to 27,825 ft^2/acre (3,925-6,390 m^2/ha) in mature forests (Selmants and Knight 2003).

In grasslands surrounded by ponderosa pine (*Pinus ponderosa*) forests on Arizona's Mogollon Rim (~7,200 ft [2,200 m] elevation), the relative abundance of orange agoseris varied between grazed and ungrazed sites protected from cattle, deer (*Odocoileus* spp.), and elk (*Cervus canadensis*) for 8 to 9 years. Relative abundance of orange agoseris was 0.91 on grazed and 0.14 on protected plots at site one, 0.14 on grazed and 1.1 on protected plots at site two, and 0 on grazed and 2.16 on protected plots at site three. Cattle use resulted in about 70% biomass consumption (Rambo and Faeth 1999).

In a montane meadow in Oregon's Cascade Range, the frequency and cover of orange agoseris were similar at the interior of pile burn and unburned plots 7 years after treatments. Orange agoseris frequency was 3.3% and cover 0.1% at the center of pile burn scars and frequency was 3.3% and cover 0.3% in unburned vegetation adjacent to the burn scar (Halpern et al. 2014). Following the 1988 fires in Yellowstone National Park, orange agoseris was more common on recently burned sites. It was present on 25% of burned plots in 1999 and just 1% of burned plots in 2012 (Romme et al. 2016). In krummholz communities on Sourdough Ridge in Washington's North Cascades National Park, cover and frequency of orange agoseris were greater on 29-year-old burned (1% cover, 4-10% frequency) than unburned sites (0%-trace cover, 0-5% frequency) (Douglas and Ballard 1971).

Wildlife and Livestock Use. Orange agoseris is eaten by a variety of livestock and wildlife species, and high levels of use were reported for domestic sheep and northern pocket gophers (*Thomomys talpoides*). Hermann (1966) indicated that orange agoseris was fair to good livestock forage, and variety *purpurea* was highly palatable to sheep and cattle on the Manti-La Sal National Forest. In feeding observations on twoneedle pinyon-Utah juniper (*Pinus edulis*-*Juniperus osteosperma*) winter range in the Piceance Basin in Colorado, orange agoseris made up to 2% of the diets of tame mule deer (*Odocoileus hemionus*) from October through April (Bartmann 1983).

Small mammal use of orange agoseris was reported in Utah and Colorado. On Utah's Wasatch Plateau, removal of orange agoseris was observed on five northern pocket gopher mounds (Aldous 1951). On the Black Mesa of west-central Colorado, orange agoseris was among the 10 most important forbs in diets of northern pocket gophers trapped in Idaho fescue-dominated grasslands (Carleton 1966). From stomach content analyses of 397 individuals, researchers found that northern pocket gophers fed on leaves, stems, and roots. Based on 2 years of monthly use from June through October, use was greatest in October when stems and leaves made up 6.4% and roots made up 17.7% of diets by volume (Ward and Keith 1962). In the mountains of west-central Colorado where golden-mantled ground squirrels (*Citellus lateralis lateralis*) and least chipmunks (*Neotamias minimus*) are sympatric, orange agoseris was ranked as edible on a scale from highly edible, edible, sometimes edible, and never edible (Carleton 1966).

Agoseris species are eaten by and can be important in the diets of greater sage-grouse (*Centrocercus urophasianus*) (Martin et al. 1951; Pennington et al. 2016). In a review of the use of forbs by greater sage-grouse, *Agoseris* species were among the most important for females in spring and for adults and juveniles in summer in sagebrush habitats in Oregon, Idaho, and Nevada (Pennington et al. 2016).

Orange agoseris was an important nectar source for 27 butterfly species in the Crested Butte area of Colorado, which were monitored for four flight seasons (Sharp et al. 1974).

Ethnobotany. Orange agoseris was and is used as a food and medicine by Indigenous peoples. It is a potherb used to make teas and wines (Shaw 1995). The Karuk tribe of California sucked the juice out of the plant near the crown and chewed it like gum (Schenck and Gifford 1952). Gosiute Indians of Utah and Nevada ate the leaves (Chamberlin 1911). The Ramah Navajo used orange agoseris as a ceremonial medicine. An infusion of leaves or roots was taken internally or used as a lotion to treat arrow or bullet wounds, and wet leaves were rubbed on swollen arms, wrists, and ankles. Orange agoseris was considered a life medicine and provided protection from witches by the Ramah Navajo (Moerman 2003).

Horticulture. Although orange agoseris is not readily available as a horticultural species, it does have potential for use in low-maintenance landscaping along roadsides, at rest areas and campgrounds. It produces attractive orange flowers and spreads by wind-dispersed seeds.

REVEGETATION USE

Orange agoseris has many traits that make it a good species for restoring native habitats. It is a colonizer of early successional and disturbed habitats. It is attractive to pollinators (Eldredge et al. 2013). The species has broad moisture tolerance (Gavin and Brubaker 1999) and a wide-ranging elevation tolerance (Baird 2006) suggesting it may be adaptable to changing climates or transitional sites.

DEVELOPING A SEED SUPPLY

For restoration to be successful, the right seed needs to be planted in the right place at the right time. Coordinated planning and cooperation is required among partners to first select appropriate species and seed sources and then properly collect, grow, certify, clean, store, and distribute seed for restoration (PCA 2015).

Developing a seed supply begins with seed collection from native stands. Collection sites are determined by current or projected revegetation requirements and goals. Production of nursery stock requires less seed than large-scale seeding operations, which may require establishment of agricultural seed production fields. Regardless of the size and complexity of any revegetation effort, seed certification is essential for tracking seed origin from collection through use (UCIA 2015).

Seed Sourcing. Because empirical seed zones are not currently available for orange agoseris, generalized provisional seed zones developed by Bower et al. (2014), may be used to select and deploy seed sources. These provisional seed zones identify areas of climatic similarity with comparable winter minimum temperature and aridity (annual heat:moisture index). In Figure 7, Omernik Level III Ecoregions (Omernik 1987) overlay the provisional seeds zones to identify climatically similar but ecologically different areas. For site-specific disturbance regimes and restoration objectives, seed collection locations within a seed zone and ecoregion may be further limited by elevation, soil type, or other factors.

The Western Wildland Environmental Threat Assessment Center's (USFS WWETAC 2017) Threat and Resource Mapping (TRM) Seed Zone application provides links to interactive mapping features useful for seed collection and deployment planning. The Climate Smart Restoration Tool (Richardson et al. 2020) can also guide revegetation planning, seed collection, and seed deployment, particularly when addressing climate change considerations.

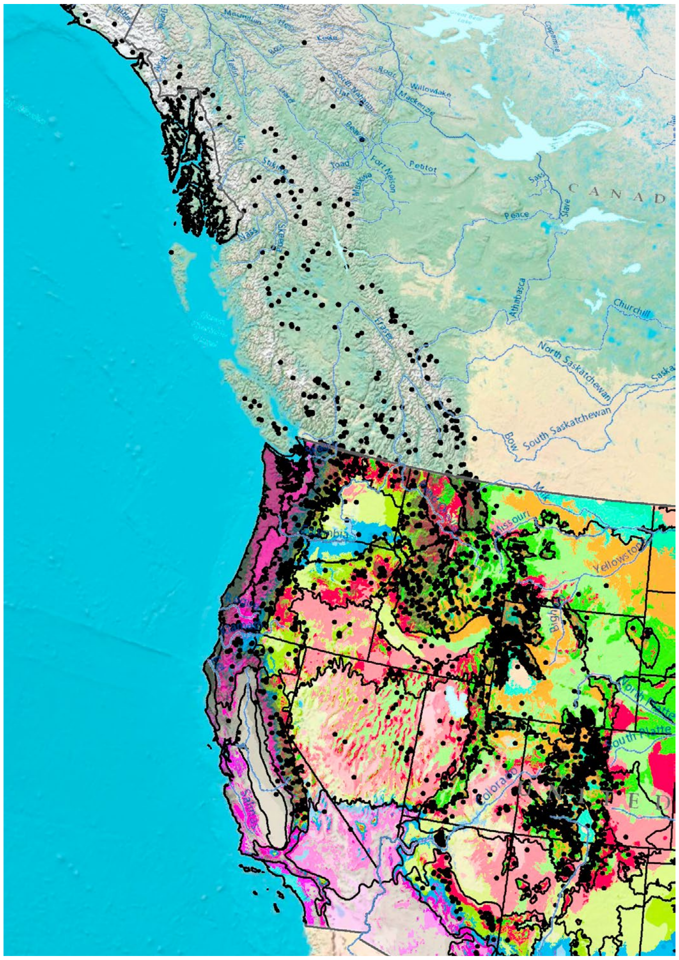

Figure 7. Distribution of orange agoseris (black circles) based on geo-referenced herbarium specimens and observational data from 1876-2018 (CPNWH 2017; SEINet 2017; USDI USGS 2017). Generalized provisional seed zones (colored regions) (Bower et al. 2014) are overlain by Omernik Level III Ecoregions (black outlines) (Omernik 1987; USDI EPA 2018). Interactive maps, legends, and a mobile app are available (USFS WWETAC 2017; www.fs.fed.us/wwetac/threat-map/TRMSeedZoneMapper2.php?). Map prepared by M. Fisk, USDI USGS.

Releases. As of 2021, there were no orange agoseris germplasm releases.

Wildland Seed Collection. Orange agoseris plants are commonly found at low densities, so wildland seed is typically collected by hand (Jensen 2007).

Wildland seed certification. Wildland seed collected for either direct sale or to be used as stock seed for establishment of cultivated seed production fields or for nursery propagation should be Source Identified. This is accomplished by following procedures established by the Association of Official Seed Certifying Agencies (AOSCA) Pre-Variety Germplasm Program that verifies species and tracks seed origin (Young et al. 2003; UCIA 2015). Wildland seed collectors should become acquainted with state certification agency procedures, regulations, and deadlines in the states where they collect.

If wildland-collected seed is to be sold for direct use in ecological restoration projects, collectors must apply for Source Identified certification prior to making collections. Pre-collection applications and site inspections are handled by the AOSCA member state agency where seed collections will be made (see listings at AOSCA.org).

If wildland seed collected by a grower is to be used as stock seed for planting cultivated seed fields or for nursery propagation (See Agricultural Seed Field Certification section), detailed information regarding collection site and collecting procedures, including photos and herbarium specimens must be provided when applying for agricultural seed field certification. Germplasm accessions acquired within established protocols of recognized public agencies, however, are normally eligible to enter the certification process as stock seed without routine certification agency site inspections. For contract grow-outs, this information must be provided to the grower to enable certification. Stock seed purchased by growers should be certified.

Collection timing. On individual plants, seed ripens indeterminately, but across a population, seed ripens quite synchronously (Fig. 8). The first seed heads ripen as a group as do subsequent seed heads across a population. Ripening continues as moisture permits (Jensen 2007).

Seed is wind-dispersed, making the timing of collections critical. Seeds are mature when the pappus begins to spread open (Fig. 9) (Jensen 2007). The Bureau of Land Management's Seeds of Success collection crews made 11 harvests, one from Nevada, two from Oregon, and eight from Utah from 2008 to 2010. Of the ten harvests made in 2010, the earliest was made on June 14 in Wasatch County, Utah, at an elevation of 5,485 feet (1,672 m). The latest was made on August 8 from Wasco County, Oregon, at an elevation of 4,470 feet (1,362 m). Multiple harvests were often made at the same site. The widest difference in collection dates at a single site was 16 days (June 21-July 6) (SOS BLM 2017). Jensen reported that orange agoseris seeds were typically mature and ready for harvest in May and June at elevations between 5,200 and 6,100 feet (1,600-1,900 m) in the Great Basin (Jensen 2007).

Figure 8. Orange agoseris flowering and just starting to produce seed. Photo: S. Matson, CalPhotos, 2017.

Figure 9. Mature orange agoseris seed heads dispersing seed. Photo: J. Pawek, CalPhotos, 2010.

Collection methods. Because orange agoseris plants typically occur in low densities, wildland seed is hand collected. Seeds are hand stripped by clasping the base of the seed head between two fingers and pulling upward while keeping the hand closed to reduce losing mature seeds (Jensen 2007).

Several collection guidelines and methods should be followed to maximize the genetic diversity of wildland collections: collect seed from a minimum of 50 randomly selected plants; collect from widely separated individuals throughout a population without favoring the most robust or avoiding small stature plants; and collect from all microsites including habitat edges (Basey et al. 2015). General collecting recommendations and guidelines are provided in online manuals (e.g. ENSCONET 2009; USDI BLM SOS 2016). As is the case with wildland collection of many forbs, care must be taken to avoid inadvertent collection of weedy species, particularly those that produce seeds similar in shape and size to those of orange agoseris.

Post-collection management. Jensen (2007) recommends storing seed (Fig. 10) in breathable bags in cool, dry, rodent-free conditions until it can be cleaned.

Figure 10. Individual orange agoseris seeds with visible ribs and stigma and style still attached. Photo: J. Pawek, CalPhotos, 2012.

Seed Cleaning. Small hand-harvested seed collections can be cleaned of larger chaff by hand sifting or screening. Seed can then be carefully rolled between two boards covered with soft leather until the pappus is removed from the seed. The final cleaning can be done using air columns or screen separators (Jensen 2007). Although seed will germinate with the stigma and style attached, removal of the pappus and other reproductive structures is necessary if orange agoseris will be used in a seed mix or be seeded using equipment (S. Jensen, USFS, personal communication, March 2021).

Seed Storage. Orange agoseris produces orthodox seed. Seed viability was 79% for dry seed stored for 34 days at 15% relative humidity and -4 °F (-20 °C) (RBG Kew 2021).

Seed Testing. There is no Association of Official Seed Analysts (AOSA) rule for testing germination or AOSA protocol for examining the viability of orange agoseris seed (AOSA 2010; 2016).

Tetrazolium chloride testing (TZ) should follow that suggested for other Asteraceae species, which includes cutting seeds longitudinally leaving the distal end intact, soaking for 6 to 12 hours in 0.1% TZ concentration at (86- 95 °F [30-35 °C]). The embryos of viable seed will be entirely stained (AOSA 2010).

Germination. Seed germinates soon following stratification. Jensen (2007) found that following 3 weeks of stratification most seed germinated within 2 weeks of being transferred to a greenhouse. Seed was planted in trays filled with moist soil that were wrapped in plastic and placed in a cold room. Trays were then placed in a greenhouse at 70 °F (21 °C) during the day and 50 °F (10 °C) at night. Seed germinated within 5 weeks but most germinated by week 2. The optimal duration of stratification likely varies by seed source (Jensen 2007).

Germination trials conducted by the Royal Botanic Gardens, Kew (RBG Kew 2021) reported 50% germination after 70 days for unstratified seed germinated on 1% agar and exposed to an 8 hr/16 hr light/dark cycle at 41 °F (5 °C). Germination was 58% for unstratified seed germinated on 1% agar for 140 days on a 77/50 °F (25/10 °C) (8 hr light/16 hr dark).

Wildland Seed Yield and Quality. Post-cleaning seed yield and quality of seed lots collected in the Intermountain region are provided in Table 1 (USFS BSE 2017). Orange agoseris seed can generally be cleaned to high levels of purity. For fresh seed, fill is generally high, but viability is variable. Other sources report values within the range reported in Table 1 (281,215-304,772 seeds/lb [619,963-671,896 seeds/kg) (USFS GBNPP 2014; RBGKew 2021).

Table 1. Seed yield and quality of orange agoseris seed lots collected in the Intermountain region, cleaned by the Bend Seed Extractory, and tested by the Oregon State Seed Laboratory or the USFS National Seed Laboratory (USFS BSE 2017).

Seed lot characteristic	Mean	Range	Samples (no.)
Bulk weight (lbs)	0.34	0.02-1.3	11
Clean weight (lbs)	0.08	0.003-0.49	11
Clean-out ratio	0.17	0.04-0.37	11
Purity (%)	94	88-99	11
Fill (%)[1]	89	80-95	11
Viability (%)[2]	86	25-97	11
Seeds/lb	188,955	132,600-330,000	11
Pure live seeds/lb	143,525	78,375-182,089	11

[1] 100 seed X-ray test
[2] Tetrazolium chloride test

AGRICULTURAL SEED PRODUCTION

Field production of orange agoseris seed was not reported in the literature as of 2021. The indeterminate seed set, and readily wind-dispersed seed will make field production challenging (see Nursery Practice section). Jensen and Jones (2008) attempted greenhouse seed production, but few plants flowered the first growing season and plants were not grown through their second year.

Agricultural Seed Certification. It is essential to maintain and track the geographic source and genetic purity of native species produced in cultivated seed fields. This means following Pre-Variety Seed Germplasm (PVG) Certification requirements and standards as administered by state AOSCA offices. The PVG protocols track source and generation of planting stock and require field inspections for compliance. Isolation and control of prohibited weeds or other species are required. Proper seed harvesting, cleaning, sampling, testing, and labeling for commercial sales are monitored (Young et al. 2003; UCIA 2015).

Growers should apply for certification of their production fields prior to planting and plant only certified stock seed of an allowed generation. The systematic and sequential tracking through the certification process requires preplanning, knowing state regulations and deadlines, and is most smoothly navigated by working closely with state certification agency personnel. See the Wildland Seed Certification section for more on stock seed sourcing.

Pollinator and Pest Management. High orange agoseris seed yields will require pollinators (Jensen and Jones 2008), and farming operations that encourage visitation from native pollinators will likely help with seed production (Cane 2008).

The following fungi have been collected from orange agoseris: *Entyloma polysporum*, *Leptosphaeria erigerontis*, *Mycosphaerella tassiana*, *Ovularia compacta*, *Phyllosticta* spp., *Puccinia agoseridis*, *P. dioicae*, *P. hieracii*, *P. troximontis*, *Ramularia compacta*, and *Sphaerotheca macularis*. It is unknown if any of these fungi would be problematic in nursery or field production of orange agoseris (Farr and Rossman 2017).

NURSERY PRACTICE

Jensen (2007) produced orange agoseris plugs in the greenhouse. Seed was collected from Juab County, Utah (5,950 ft [1,800 m]). It was planted in 5.5 in^3 (90 cm^3) root trainers filled with two parts sieved peat, two parts vermiculite, 1 part montmorillonite clay, 1 part #20 quartz silica sand, 1 part native soil, and fertilizer with micronutrients. The potting mix was steam aerated at 140 °F (60 °C) for 30 minutes before seeds were planted vertically to a depth equal to the seed body. Seeded trays were moistened, wrapped in plastic bags, and placed in a cold room. After three weeks of stratification, trays were moved to a greenhouse (December), and watered as needed through establishment. The greenhouse was kept at 70 °F (21 °C) during the day and 50 °F (10 °C) at night. All germination occurred within 5 weeks, but most germination occurred in week 2. Seedlings were watered every 2 to 3 days through the active growth phase, which took at least 8 weeks (Jensen 2007).

WILDLAND SEEDING AND PLANTING

Reported use of orange agoseris in revegetation efforts has been limited. It was experimentally seeded in barren subalpine habitat created by the eruption of Mount St. Helens in Washington. It was one species in a mixture of 22 species seeded in October. Initial emergence was about 15%, but by September of the second post-seeding year, survival was around 1%. The seed used in this revegetation experiment was collected from nearby plants (Wood and del Moral 1987).

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RESOURCES

AOSCA NATIVE PLANT CONNECTION
https://www.aosca.org/wp-content/uploads/Documents///AOSCANativePlantConnectionBrochure_AddressUpdated_27Mar2017.pdf

BLM SEED COLLECTION MANUAL
https://www.blm.gov/sites/blm.gov/files/programs_natural-resources_native-plant-communities_native-seed-development_collection_Technical%20Protocol.pdf

ENSCONET SEED COLLECTING MANUAL
https://www.publicgardens.org/resources/ensconet-seed-collecting-manual-wild-species

HOW TO BE A SEED CONNOISSEUR
http://www.utahcrop.org/wp-content/uploads/2015/08/How-to-be-a-seed-connoisseur20May2015.pdf

OMERNIK LEVEL III ECOREGIONS
https://www.epa.gov/eco-research/ecoregions

CLIMATE SMART RESTORATION TOOL
https://climaterestorationtool.org/csrt/

SEED ZONE MAPPER
https://www.fs.fed.us/wwetac/threat-map/TRMSeedZoneMapper.php

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