WESTERN FORBS: BIOLOGY, ECOLOGY, AND USE IN RESTORATION

ASPEN FLEABANE

Erigeron speciosus (Lindl.) DC.

Asteraceae – Aster family

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ORGANIZATION

NOMENCLATURE

Erigeron speciosus (Lind.) DC., hereafter referred to as aspen fleabane, belongs to the Astereae tribe of the Asteraceae or aster family (Nesom 2006).

NRCS Plant Code. ERSP4 (USDA NRCS 2018).

Synonyms. *Erigeron conspicuus* Rydberg; *E. macranthus* Nuttall; *E. speciosus* var. *conspicuus* (Rydberg) Breitung; *E. speciosus* var. *macranthus* (Nuttall) Cronquist; *E. subtrinervis* Rydberg ex Porter & Britton subsp. *conspicuus* (Rydberg) Cronquist; *E. subtrinervis* var. *conspicuus* (Rydberg) Cronquist, *Stenactis speciosa* Lindley (Nesom 2006).

Common Names. Aspen fleabane, Oregon fleabane, Oregon wild-daisy, showy daisy, showy fleabane (USDA FS 1937; Nesom 2006; AOSA 2016; USDA NRCS 2018).

Subtaxa. No varieties or subspecies are currently recognized by the Flora of North America (Nesom 2006).

Chromosome Number. Chromosome numbers are 2n = 18, 36 (Jones and Young 1983; Welsh et al. 1987).

Hybridization. Distributions of aspen fleabane and threenerve fleabane (*E. subtrinervis*) have considerable overlap, and although they are considered at least partially reproductively isolated, intermediate forms are common (Nesom 2006).

DISTRIBUTION

Aspen fleabane is widely distributed throughout western North America. In Canada, it occurs in British Columbia and Alberta. In the United States it occurs in western South Dakota and all states to its west, except

California. However, there is a population in Baja California that is disjunct from the nearest southernmost populations in Arizona (Nesom 2006). Aspen fleabane is particularly common in the Great Basin and Intermountain regions (Hermann 1966).

Plants tolerate cold temperatures during the growing season, although flowering may be reduced with growing season frosts (Caradonna and Bain 2016). In experiments using tissue collected from plants growing near the Rocky Mountain Biological Laboratory (RMBL) in Gothic, Colorado, frost damage to 10% of leaf tissue occurred at 22 ºF (-5.4 ºC) and to 90% at 12 ºF (-10.5 ºC). Flowers were significantly more frost sensitive than leaves ($P < 0.0001$) for this late-flowering species. Ten percent of flowers were damaged at 26 ºF (-3.2 ºC) and 90% at 20 ºF (-6.7 ºC) (Caradonna and Bain 2016).

Habitat and Plant Associations. Aspen fleabane is widely distributed throughout wet and dry habitats (Ellison 1954; Inouye 2008; Pavek et al. 2012). It is common in upper elevation meadows, big sagebrush (*Artemisia tridentata*) communities, quaking aspen (*Populus tremuloides*) woodlands, and coniferous forests (Nesom 2006; UW Ext. 2018).

Herbaceous communities. Aspen fleabane is found in dry to wet grasslands and meadows. It is common in the tall forb rangeland cover type occurring between 6,300 and 9,900 feet (1,900-3,000 m) on deep soil (>1.5 feet [0.5 m]) sites in Montana, Idaho, Wyoming, Utah, Nevada, and Colorado (Fig. 1) (Shiflet 1994). It is commonly associated with Thurber's fescue (*Festuca thurberi*) grasslands and pristine condition, upper elevation herbaceous communities (Hermann 1966). In Crested Butte, Colorado, aspen fleabane occurred in both dry, rocky and wet montane meadows (Inouye 2008) and was common in Thurber's fescue grasslands at 9,500 to 10,500 feet (2,900-3,200 m) where soils had high clay content (Fall 1992, 1997). In these grasslands, aspen fleabane constancy was 84% and cover was 3.7% between 8,500 and 12,500 feet (2,600-3,800 m) on steep, south slopes (Langenheim 1962). In eastern Oregon and Washington, aspen fleabane was associated with greenleaf fescue (*F. viridula*) subalpine grasslands (Franklin and Dyrness 1973).

Figure 1. Aspen fleabane growing in a central Idaho meadow. Photo: USFS.

Shrubland and woodland communities. Aspen fleabane is commonly found with big sagebrush (Costello 1944; Reed 1952; Langenheim 1962), quaking aspen (Reed 1952; Langenheim 1962; Robberecht and Caldwell 1987), bigtooth maple (*Acer grandidentatum*), and Gambel oak (*Quercus gambelii*) (Allman 1953; Robberecht and Caldwell 1987). Aspen fleabane was abundant in big sagebrush and hillside aspen vegetation types in the Jackson Hole Wildlife Park in Teton County, Wyoming. Hillside quaking aspen stands had relatively open canopies and occurred primarily on southern slopes. Aspen fleabane did not occur in quaking aspen stands on level terrain with dense shade and moist soils (Reed 1952). In the Crested Butte area of Gunnison County, Colorado, aspen fleabane constancy was 82% and average cover was 1.5% in big sagebrush communities, which were common on southern slopes at 8,500 to 9,500 feet (2,600-2,900 m). Aspen fleabane also occurred in quaking aspen woodlands but was much more common (100% constancy and 5% average cover) in younger woodlands with a Thurber's fescue understory than in mature woodlands with a forb-dominated understory (Langenheim 1962). Aspen fleabane was noted in the understory of bigtooth maple thickets on eastern slopes near Logan, Utah (Robberecht and Caldwell 1987) and in bigtooth maple-Gambel oak vegetation in the Wasatch Mountains near Provo, Utah (Allman 1953). In the Rocky Mountain foothills in Alberta, aspen fleabane was much more frequent in quaking aspen stands that were adjacent to grasslands than those adjacent to shrublands (Hersperger and Forman 2003).

Forest communities. Aspen fleabane often occurs in openings and understories of pine (*Pinus* spp.), Douglas-fir (*Pseudotsuga menziesii*), and spruce-fir (*Picea-Abies* spp.) forests. In southern Alberta, aspen fleabane was a common associate of Douglas-fir forests on sandy-gravelly foothills or rocky ridges in the montane zone at 4,500 to 6,500 feet (1,400-2,000 m) (Moss 1955). On the Wasatch Plateau, Utah, aspen fleabane occurred in Engelmann spruce-subalpine fir (*P. engelmannii-A. lasiocarpa*) forests without dense tree cover. Although aspen fleabane was more abundant on mesic sites, it also occupied dry, south slopes, with prevailing western winds that lacked overstory shade (Ellison 1954). Constancy of aspen fleabane was 80% in bristlecone pine (*Pinus aristata*)/ Thurber's fescue vegetation at 9,500 to 10,200 feet (2,900-3,100 m) in the Front, San Juan, and Mosquito mountain ranges in southern Colorado (Ranne et al. 1997). In the Rincon Mountains of Pima County, Arizona, aspen fleabane occurred between 6,300 and 8,300 feet (1,900-2,500 m) in rich soils or on rock slopes in pine-oak, pine, or mixed-conifer forests (Bowers and McLaughlin 1987).

Elevation. Aspen fleabane typically occurs at elevations of 2,000 to 11,220 feet (600-3,420 m) (Welsh 1983; Nesom 2006). Its range in Utah is reported as 5,770 to 11,220 feet (1,760-3,420 m) (Welsh 1983).

Soils. Aspen fleabane is found on dry to moist sites with well-drained sandy, gravelly, or clay-loam calcareous or non-calcareous soils (Allman 1953; Craighead et al. 1963; Neely and Barkworth 1984; Holiday 2000; Nesom 2006).

Although found on dry and moist sites, studies suggest aspen fleabane abundance decreases at soil moisture extremes. In Teton County, Wyoming, aspen fleabane occurred in quaking aspen stands on south slopes with xeric, coarse, rapidly draining soils but not in stands on level terrain with dense shade and moist soils (Reed 1952). In warming experiments at the dry zone of a montane meadow at RMBL, aspen fleabane abundance was lower on warmed than control plots. Warmed plots had earlier snowmelt, lower soil moisture, higher soil temperatures, and higher nitrogen mineralization rates than control plots. Adding water to warmed plots increased biomass and flowering ($P = 0.03$). Adding nitrogen increased biomass ($P = 0.08$) it did not increase flowering (de Valpine and Harte 2001).

Sandy to clay loam to gravelly soil textures were reported in aspen fleabane habitats. In Tsegi Canyon, northeastern Arizona, aspen fleabane was associated with quaking aspen stands on sandy soils (Holiday 2000). In subalpine Thurber's fescue grasslands in the White River National Forest of western Colorado, aspen fleabane made up 1 to 4% of the vegetation composition where soils were 18 to 48 inches (46-122 cm) deep and averaged 32% sand, 46% silt, and 22% clay with 30% gravel (Klemmedson 1956). The species was also common (production of up to 39 lbs/acre), in high-elevation, Letterman's needlegrass (*Achnatherum lettermanii*) communities where soils averaged 17% sand, 35% silt, and 48% clay with 9.2% gravel and 54% total porosity. Soils contained 6% organic matter, 0.3% total nitrogen, 0.14% total phosphorus, and 9,400 ppm potassium on average (Laycock and Richardson 1975). In bigtooth maple-Gambel oak vegetation in Utah's Wasatch Mountains where aspen fleabane was common, soils were classified as silt loams, loams, or clay loams. Soil pH averaged 6.6 to 7.2 for the A to C horizons, and moisture-holding capacity averaged 78% for the A horizons and 49% for the B and C horizons. Soluble salts averaged 255 ppm in A, 305 ppm in B, and 310 ppm in C horizons (Allman 1953).

Aspen fleabane was reported on both calcareous and noncalcareous soils (Neely and Barkworth 1984). In big sagebrush in the Bear River Range of southeastern Utah, aspen fleabane was slightly more common on calcareous dolomite than noncalcareous quartzite soils. Dolomite soils had significantly higher pH levels and calcium and magnesium content than quartzite soils. Clay content was similar but sand content was significantly lower and silt content greater in dolomite than quartzite soils ($P < 0.01$) (Neely and Barkworth 1984). In the Crested Butte area of west-central Colorado, aspen fleabane was common in big sagebrush on limestone or shale soils (Langenheim 1962).

DESCRIPTION

Aspen fleabane is a long-lived perennial with a thick, branching fleshy to woody caudex, rhizomes, and a taproot and fibrous root system (Ellison 1954; Craighead et al. 1963; Paulsen 1970; Welsh 1983; Welsh et al. 1987; Caradonna and Bain 2016). Small colonies are common (Mee et al. 2003), and plants may live for decades (Inouye 2008). Clusters of mostly erect leafy stems that range from 6 to 40 inches (15-100 cm) tall develop from the caudex (Fig. 2) (Welsh 1983; Nesom 2006; LBJWC 2018). Plants growing in montane meadows in Gothic, Colorado, averaged 15 stems per plant (Pardee et al. 2018).

Figure 2. Aspen fleabane growing in Utah. Photo: USDI BLM UT933 SOS.

Stems generally have sparse long hairs but are hairless just below the inflorescence (Weber 1976; Nesom 2006; Pavek et al. 2012). Stem and basal leaves are variable, oblanceolate, spatulate, elliptic, or oval (Nesom 2006). Leaves generally have clasping to subclasping petioles, three main veins, and are glabrous, except for the margins, which are often fringed with hairs (Cronquist 1943; Craighead et al. 1963; Weber 1976; Pavek et al. 2012). Basal leaves range from 1 to 6 inches (3-15 cm) long and 0.2 to 0.8 inch (4-20 mm) wide and usually wither by time of flowering (Nesom 2006). Stems leaves (0.8-4 inches [2-11 cm] long, 0.2-1 inches [0.5-2.8 cm] wide) are generally reduced upwards (Mee et al. 2003) and even-sized along the bottom half or largest at the midpoint or base of the stems (Cronquist 1943; Welsh 1983; Welsh et al. 1987; Nesom 2006).

Flower heads are terminal and number 1 to 20 or more per stem (Welsh 1983; Welsh et al. 1987; Pardee et al. 2018). Flower heads are up to 2 inches (5 cm) wide (Fig.3) (Shaw 1995; LBJWC 2018). They are comprised of 75 to 150 purple, blue, pink, or less commonly white, pistillate, fertile, ray flowers each with a narrow petal (1 mm wide), which surround yellow to orange, bisexual, fertile disk flowers (Craighead et al. 1963; Weber 1976; Welsh et al. 1987; Nesom 2006; LBJWC 2018). Fruits are 2- to 4-nerved, oblong and compressed or flattened cypselas up to 1.8 mm long (Nesom 2006). Fruits are hairy with two, tan, bristly, pappi, the inner of which have 20 to 30 bristles (Cronquist 1943; Welsh 1983; Welsh et al. 1987; Nesom 2006). Fruits are dark brown when mature (Luna 2005). Aspen fleabane cypselas although not true achenes, are often referred to as achenes or seeds (Hermann 1966; Luna 2005). Throughout this review, seed will be used to refer to the cypsela and the seed it contains.

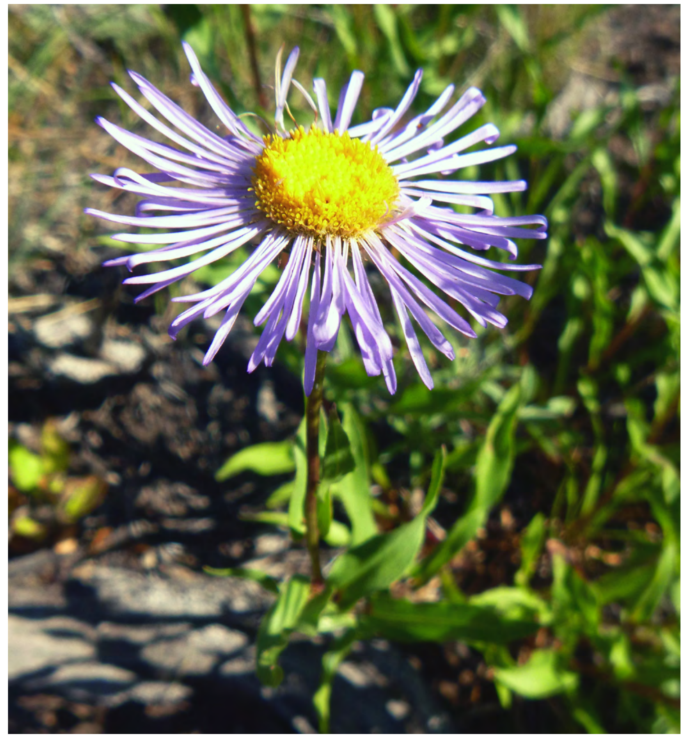

Figure 3. Aspen fleabane flower. Photo: USDI BLM OR931 SOS.

Site conditions and weather can affect the appearance and size of aspen fleabane plants. In the Elk Mountain Range near Crested Butte, Colorado, plants growing in full sun were smaller than those growing in shade. Plants in the sun averaged 13 inches (32 cm) tall and in the shade averaged 16 inches (40 cm) tall ($P = 0.02$). Leaf length averaged 1.8 inches (4.6 cm) in the sun and 2.1 inches (5.3 cm) in shade ($P = 0.03$) (Louda et al. 1987). In montane meadows near the RMBL in Gothic, Colorado, experimentally produced frosts occurring when flower buds were first visible (mid- to late June) reduced plant height 29% ($P < 0.001$) and flower head size by 7.8% ($P = 0.03$) compared to controls (Pardee et al. 2018).

Reproduction. Aspen fleabane reproduces from seed. Plants also produce rhizomes, and colony formation has been noted (Mee et al. 2003). Reproductive potential varies with climate and may be impacted by future predicted changes in climate. When frost conditions were experimentally applied to plants near the RMBL when the first flower buds were visible (mid- to late-June), total number of aspen fleabane flowers produced was 40% less than that produced by non-frosted controls ($P = 0.01$) (Pardee et al. 2018). In warming experiments at the same location, 40% more flowers were produced in warmed than control plots ($P = 0.05$) (Lambrecht et al. 2007). Flower size, however, was significantly reduced by warming ($P < 0.001$). Reproductive effort or the relative amount of available carbon allocated to reproduction was not different between warmed and control plots. Yet, seed production per plant was significantly lower in warmed than control plots ($P = 0.02$) (Lambrecht et al. 2007).

Flowering and fruiting phenology. Aspen fleabane is a late-flowering species. Flowers appear from June to October (Paulsen 1970; Holiday 2000; Nesom 2006), and seed production generally follows flower production by 1 to 2 months (Paulsen 1970; West and Reese 1984). Climate and site conditions influence the timing and speed of reproduction (Paulsen 1970; Weaver and Collins 1977; West and Reese 1991).

Timing of flowering is likely closely linked to timing of snow melt. In subalpine vegetation in Ephraim Canyon, Utah, flowering began about 55 days after snow melt and continued for about 35 days (Ellison 1954). In subalpine meadows in the Wasatch Mountains of northern Utah, flowering began about 60 days after snow melt, and the period from flowering to plant senescence was about 2 months (West and Reese 1984). In bigtooth maple-Gambel oak vegetation in the Wasatch Mountains, aspen fleabane flowers were observed from early July through early September over a 0.8 acre (3,216 m^2) area (Allman 1953). Based on 41 years of records, the average date for peak flowering in an alpine meadow near the RMBL was August 3 (Caradonna and Bain 2016). In Tsegi Canyon, northeastern Arizona, aspen fleabane flowered in June and July (Holiday 2000).

Phenology and flower production varies with site and weather conditions and can be delayed with shading, increased moisture, and decreased temperature. In Utah's Bear River Range, peak flowering for aspen fleabane was 22 days later in aspen woodlands than in meadows (West and Reese 1991). In a high-elevation Thurber's fescue meadow in southwestern Colorado, aspen fleabane flowered from about June 20 to August 5 and produced its first mature seeds near the end of July in the warmest driest summer over a 4-year period. Flowering occurred from June 30 to August 20 and seed maturation began around August 20 in the coolest wettest summer (Paulsen 1970). In 30 years of monitoring dry and wet montane meadows at RMBL, Inouye (2008) noted a strong relationship between snow melt dates and summer flowering abundance. Greater snowpack and later snowmelt was associated with later initiation of growth and lower flower bud mortality. Earliest flowering was July 9 and latest was August 17. If snow melted before May 19 or if snowpack was less than 3 feet (1 m) on April 30, frost damage and reduced flowering were likely. The average number of years that all 15 plots had some flowering was 22.3 years (Inouye 2008).

Experiments also reveal links between phenology timing, weather, and climate conditions. Aspen fleabane flowering was earliest at normal snowpack levels (2 feet [0.6 m]) and latest at 8-foot (2.4 m) snowpack levels created by snow fences in meadows (Idaho fescue-bearded wheatgrass [*F. idahoensis*-*Elymus caninus*]) in the Bridger Mountains near Bozeman, Montana. Flowering duration was shortest at 4-foot (1.2 m) snowpack levels and longest at normal snowpack levels (Weaver and Collins 1977). At the RMBL, flowering was significantly earlier ($P < 0.001$) and longer ($P = 0.051$) on experimentally warmed than control plots. Earlier snow removal (conducted experimentally without warming) also resulted in significantly earlier flowering than on control plots ($P = 0.017$) (Dunne et al. 2003).

Breeding system. Aspen fleabane is weakly self-compatible, but insect pollination is important for good seed production (Pardee et al. 2018).

Pollination. Aspen fleabane attracts and is important to a diversity of pollinating insects. Experiments at the RMBL highlighted the importance of pollinators for seed production in general and in recovering seed production following sub-optimal weather conditions (Pardee et al. 2018). Frosts experimentally applied in mid- to late June when the first aspen fleabane flower buds appeared resulted in 40% fewer total flowers ($P = 0.01$) and 48% fewer pollinator visits ($P = 0.04$) than on control plots. On frost plots, however, pollinators spent 33% more time visiting individual flowers. Frost plants had fewer total flowers ($P < 0.01$) and smaller flower heads ($P < 0.01$), which attracted fewer pollinator visits, but these floral traits were not associated with overall time spent on individual flowers. Seed production increased with total pollinator visits ($P = 0.001$), and this relationship was stronger for frost treatments, which suggested frost had a negative effect on plant reproduction, but increased duration of pollinator visits helped to partially, but not fully, salvage seed production (Pardee et al. 2018).

Aspen fleabane flowers are visited by and provide an important food source to a variety of insects. In a survey of montane bee fauna on the Tonasket Ranger District of the Okanogan-Wenatchee

National Forest in northern Washington, 42 bee species were collected from aspen fleabane from June 28 to July 9 and August 9 to August 14. The following bees: bumblebees (*Bombus bifarius*, *B. insularis*, *B. mixtus*), leafcutter bees (*Megachile relativa*), long-horned bees (*Melissodes microsticta*, *M. pallidisignata*), and mason bees (*Osmia coloradensis*, *O. subaustralis*) were collected more than 5 times from aspen fleabane flowers (Wilson et al. 2010). In a study from 2005 to 2007 in meadows near the RMBL, Burkle and Irwin (2009) observed plant-pollinator interactions between aspen fleabane and the following insect families: Andrenidae, Anthomyiidae, Apidae, Bombyiidae, Braconidae, Calliphoridae, Cleridae, Halictidae, Hesperiidae, Ichneumonidae, Lycaenidae, Megachilidae, Muscidae, Noctuidae, Nymphalidae, Rhagionidae, Sarcophagidae, Sphecidae, Stratiomyidae, Syrphidae, and Tachinidae. In a mountain fescue (*Festuca* spp.) grassland in central Colorado, flowers were visited by Queen Alexandra's sulphur butterflies (*Colias alexandra*) (Watt et al. 1974). In Glacier National Park, moths (*Scrobipalpula erigeronella* and *Coleophora brunneipennis*) were collected from aspen fleabane which was thought to be a larvae food source (Braun 1921). The northern checkerspot butterfly (*Chlosyne palla*) uses aspen fleabane as a host plant (Scott cited in Wahlberg 2001).

In subalpine meadows near RMBL, aspen fleabane was the primary nectar source for the Mormon fritillary (*Speyeria mormonia*), likely because aspen fleabane flowering coincides with the peak male and female butterfly flight season (mid- to late July and August). In years when there were 300 or more flowers in the survey plots (23 of 35 years), 70 to 90% of all female visits and 60 to 90% of all male visits were to aspen fleabane flowers (Boggs and Inouye 2012).

In the same general area, aspen fleabane was also important to bumblebees (*Bombus* spp.) Almost 80% of bee visits were from *B. bifarius*, *B. occidentalis*, and *B. flavifrons* (Pleasants 1980). Bumblebees spent an average of 0.8 second handling aspen fleabane flowers, 0.14 second traveling between flowers (average flight time between flowers within an inflorescence), and the interval between successive different flower visits between and within plants was 7,900 seconds. Net energy intake was 0.08 J/s, which ranked fourth among the 9 species evaluated (Pleasants 1981).

Flower color and size factor into pollinator visitation. In subalpine meadows near RMBL, blue copper butterflies (*Lycaena heteronea*) preferred the white flowers of common yarrow (*Achillea millefolium* var. *alpicola*) over purple aspen fleabane flowers ($P < 0.05$), even when aspen fleabane flowers were painted white ($P < 0.05$). When given a choice between large and small aspen fleabane flowers, blue copper butterflies preferred large flowers ($P < 0.05$). Ruddy copper butterflies (*L. rubidus*) preferred aspen fleabane over common yarrow ($P < 0.0001$), and small wood-nymphs (*Cercyonis oetus*) preferred large aspen fleabane flowers over small flowers ($P < 0.002$). Researchers found that white flower color preference was stronger than other flower characteristic preferences (Pohl et al. 2011).

ECOLOGY

Aspen fleabane is a long-lived, somewhat shade tolerant species capable of colonizing early seral sites, and it is also associated with communities in near pristine condition. It was noted in the early colonization of sites in primary succession (Ellison 1949; Langenheim 1956) and was common in pristine upper elevation herbaceous communities (Hermann 1966). In the subalpine zone of central Colorado, aspen fleabane occurred in early seral perennial forb and Thurber's fescue communities present by 1947 after a 1923 landslide (Langenheim 1956). It was also noted in early surveys of patchy vegetation recovery on severely over-grazed and subsequently flooded sites on the Wasatch Plateau in central Utah. Aspen fleabane was most frequent within patches of established penstemon (*Penstemon* spp.) or yarrow (*Achillea* spp.), and once established, it spread quickly (Ellison 1949).

Although commonly found in both sun and shade conditions, aspen fleabane abundance is typically greater in sunny than shady sites. In the Elk Mountain Range near Crested Butte, Colorado, frequency of aspen fleabane was greater in sunny meadows than in shaded quaking aspen woodlands (1.2 sun:shade) (Louda et al. 1987). When effects of clearcutting were examined in Utah's Fish Lake National Forest, researchers reported that aspen fleabane directly benefitted from quaking aspen removal (Mueggler and Bartos 1977).

Seed Ecology. Aspen fleabane produces light-weight, wind-dispersed seeds (Luna 2005), but once deposited in the soil, their longevity is unknown. Aspen fleabane was often encountered in what were likely 1-year-old or current year's seed banks (Willms and Quinton 1995; Reynolds and Cooper 2011).

Aspen fleabane germinated from soil samples collected in June from riparian sites in northeastern Arizona's Canyon de Chelly National Monument (Reynolds and Cooper 2011). Although the exact June sampling date was not reported, soil samples likely captured banked seed, because earliest flowering occurs in June and seed maturation follows that by a month or more (see Flowering and Fruiting Phenology section).

In studies conducted by Wills and Quinton (1995) in rough fescue (*F. campestris*) grasslands in southwestern Alberta, aspen fleabane did not emerge from seed bank samples collected in April but did emerge from a single sample collected in October. Researchers evaluated emergence from samples gathered by vacuuming soil surfaces in April and October for 2 years. Emergence of aspen fleabane was 0.9 seedling/ft^2 (10/m^2) from material collected at a site with moderate cattle use. Aboveground abundance of aspen fleabane in the study area was not reported (Willms and Quinton 1995).

Burned sites may be particularly conducive to aspen fleabane colonization. Abella (2009) found emergence was significantly greater when seeds were watered with a 10% aqueous smoke solution than with water alone ($P < 0.05$). Emergence was 27% from smoke-treated and 8% from untreated soil. Emergence was monitored for 60 days in a greenhouse kept at 75 ºF (24 ºC) with 14 hours of light. All seed had been stored at 23 ºF (-5 ºC) for 4 months following harvest (Abella 2009). In northern New Mexico, a single aspen fleabane seedling emerged from soils collected one year following a May fire in ponderosa pine (*Pinus ponderosa*)forests. It emerged from soils collected on low-severity burned areas. There was no emergence from collections made on moderately or severely burned areas, which were artificially seeded with cultivated grasses (Hunter and Omi 2006).

Disturbance Ecology. Aspen fleabane abundance can be increased by fire but is often reduced by grazing. Frequency of aspen fleabane increased following fire and fire and thinning in ponderosa pine forests in east-central Arizona. Frequency of aspen fleabane averaged 0.7% before treatments and 5.3% five years after treatments on burned sites and 1% before and 7% five years after treatments on thinned and burned sites. Increases in aspen fleabane frequency also occurred on untreated sites but differences between the pre- and post-treatment years were smaller than those on treated sites (Strahan et al. 2015). Aspen fleabane was common (88% constancy, 5.5% cover) in spruce-fir forests in the Crested Butte area of west-central Colorado that burned 55 to 65 years earlier. Post-fire communities were dominated by blueberries (*Vaccinium* spp.) and Thurber's fescue (Langenheim 1962). Aspen fleabane abundance was greatest on sites with moderate amounts of litter and bare soil when unburned, moderately burned, and severely burned ponderosa pine forests were compared in northern Arizona. Aspen fleabane was absent from sites with the lowest and highest amounts of litter and bare soil (Crawford et al. 2001).

Several studies found decreased abundance of aspen fleabane with grazing. Abundance of aspen fleabane decreased with either cattle or sheep grazing in subalpine Thurber's fescue grasslands in southern New Mexico (Moir 1967). In Letterman's needlegrass-Kentucky bluegrass (*Poa pratensis*) vegetation southeast of Cedar City, Utah, aspen fleabane was absent from sites with prolonged sheep grazing but production averaged 23 lbs/acre (26 kg/ha) on relatively ungrazed sites (Bowns and Bagley 1986). Aspen fleabane frequency increased from 26% to 54% after protection from grazing for 18 years in mountain brush (bigtooth maple-Gambel oak) vegetation at about 6,500 feet (1,980 m) in the central Wasatch Mountains of Utah (Eastmond 1968). In subalpine Thruber's fescue grasslands on the White River National Forest in western Colorado, aspen fleabane made up 1.2% of the vegetation composition on good, 2.8% on fair, and 0.9% on poor range condition plots (Klemmedson 1956).

Wildlife and Livestock Uses. Aspen fleabane is eaten by mule deer (*Odocoileus hemionus*) (Deschamp et al. 1979), mountain goats (*Oreamos americanus*) (Chadwick 1974), northern pocket gophers (*Thomomys talpoides*) (Ward and Keith 1962), golden-mantled ground squirrels (*Spermophilus lateralis*) (Carleton 1966), and domestic sheep (Ellison 1954). It is also likely consumed and preferred by greater sage-grouse (*Centrocercus urophasianus*) (Dumroese et al. 2016).

Large mammals feed on aspen fleabane in summer. Aspen fleabane made up 18% of tame mule deer diets at a wet meadow site on the Ashley National Forest in northeastern Utah (Deschamp et al. 1979). Mountain goats fed on aspen fleabane in July, August, and September in subalpine vegetation in the Swan Mountains of western Montana. Feeding observations were made from March 1971 to October 1972. Use was greatest in July when there were a total of 116 bites on aspen fleabane, which represented just 0.5% of total bites n July (Chadwick 1974).

Aspen fleabane is an important northern pocket gopher food and is also eaten, although not preferred, by golden-mantled ground squirrels. Aspen fleabane was the most important food for northern pocket gophers in grasslands in Black Mesa, west-central Colorado (Ward and Keith 1962). It was 24% by volume and 56% by occurrence in northern pocket gopher stomachs where aspen fleabane production averaged 72 lbs/acre (81 kg/ha) and it made up 5.2% of the vegetation composition. Northern pocket gophers consumed roots and above-ground plant parts. Consumption was greatest in July (Ward and Keith 1962). In captive feeding trials, northern pocket gophers consumed an average of 0.12 lb (53 g) of aspen fleabane daily (Tietjen et al. 1967). Consumption was even greater for herbicide (2,4-D)-treated plants (0.13 lb [57 g]/day). Herbicide treatments were targeting forbs in the area. Whole plants were collected from the mountain meadow on southwestern Colorado's Black Mesa and fed to 3 northern pocket gophers from July 14 through August 11 (Tietjen et al. 1967). At rocky meadow sites near Gothic, Colorado, plants were sometimes eaten but not highly preferred by golden-mantled ground squirrels based on food choice tests and observations from June through September (Carleton 1966).

Aspen fleabane is highly palatable and preferred by domestic sheep, and its abundance is typically much less on grazed than ungrazed sites (Ellison 1954). Plants were absent from grassland sites subjected to prolonged sheep grazing but averaged 23 lbs/acre (26 kg/ha) production in relatively ungrazed grasslands near Cedar City, Utah (Bowns and Bagley 1986). On Utah's Wasatch Plateau, aspen fleabane production was 0 lb/acre on sheep grazed, 5 lbs/acre (6 kg/ha) on plots protected from sheep but not from northern pocket gophers, and 39 lbs/acre (44 kg/ha) on plots protected from both grazers. Sites had been protected for about 30 years (Laycock and Richardson 1975).

Nutritional value. For aspen fleabane seeds, oil content averaged 22% and protein content averaged 26.1% (Barclay and Earle 1974). Summer nutritional content of aspen fleabane growing in Idaho is reported for the summer months (Table 1; Elliott and Flinders 1984).

Table 1. Average monthly nutrient and moisture content (%) of aspen fleabane growing in a cold meadow summer range in the River-of-No-Return Wilderness, Idaho (Elliott and Flinders 1984).

Month	Crude fiber	Crude protein	Calcium	Phosphorus	Moisture
	--------------------------%------------------------------				
June	18	19	0.56	0.16	75
July	20	16	0.65	0.16	69
August	24	13	1.03	0.20	58

Ethnobotany. Navajo and Thompson peoples may have used aspen fleabane medicinally. A decoction of aspen fleabane was used by the Navajo to ease menstrual pain and as a contraceptive (Moerman 2003). They may have also used it to treat head and abdominal pains (Shemluck 1982). The Thompson may have used fleabanes (*Erigeron* spp.) to treat sore throats and as a salve for other pain and swellings (Shemluck 1982).

Horticulture. Aspen fleabane is an attractive, pollinator friendly (Ley et al. 2007; Byrne et al. 2013), and easy to grow plant, which has been developed into a least two cultivars that are available, sold, and utilized as ornamentals (UW Ext. 2018). Many plant characteristics make aspen fleabane a desirable garden plant: it grows rapidly, tolerates most soils, has low to moderate water needs, grows well in both full sun and partial shade, is easy to propagate from seed or by dividing, has few known insect or disease problems, and produces an abundance of attractive flowers (Mee et al. 2003; UW Ext. 2018). There are cultivars available (Cornell University 2006).

This species also demonstrated molluscicidal and antifungal properties when investigated for potential pest management (Meepagala et al. 2002).

REVEGETATION USE

Many aspen fleabane characteristics make it a good choice for restoration. These characteristics include tolerance of early seral conditions (Fig. 4) (Ellison 1949; Langenheim 1956), ability to establish with competition (S. Monsen, USFS-retired, personal communication, July 2018), persistence as a long-lived and somewhat shade-tolerant species (Louda et al. 1987; Caradonna and Bain 2016), wide distribution, broad adaptation and tolerance of soil types and moisture regimes (see Soils section), and attractiveness to a diversity of pollinators (Watt et al. 1974; Wilson et al. 2010). Aspen fleabane's production of a taproot and rhizomes also make it useful for soil stabilization (Shaw and Monsen 1983).

Figure 4. Aspen fleabane growing along a roadside in central Idaho. Photo: USFS.

Aspen fleabane is a potentially useful pollinator species for use in conservation, habitat improvement, and restoration in semideserts, open woodlands, coniferous forests, or alpine meadows in the mountains of Arizona and New Mexico (Ley et al. 2007). It also provides habitat for monarch butterflies (*Danaus plexippus*) in the Southwest and is recommended for use on utility rights of way (Byrne et al. 2013).

Aspen fleabane may also have potential for use in mine reclamation (Brown et al. 2007). It was a volunteer species on phytotoxic, acidic, high-metal mine tailings in Leadville, Colorado, after sites were treated with biosolids and woody debris to attain target C:N ratios of 8:1 to 50:1. Mine waste was devoid of vegetation for 70 years. Treatments were applied in 2000, and aspen fleabane occurred on amended mine sites in 2005 although not seeded (Brown et al. 2007).

DEVELOPING A SEED SUPPLY

For restoration to be successful, the right seed needs to be planted in the right place at the right time. This involves a series of steps that require coordinated planning and cooperation among partners to first select appropriate species and seed sources and then properly collect, grow, certify, clean, store, and distribute seed for use in restoration projects.

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.

Seed Sourcing. Warming experiments showed that aspen fleabane growth and reproduction were reduced by heating, suggesting that restoration success might be improved by matching seed origin to restoration site conditions. When researchers compared artificially warmed and control plots at the RMBL, they found lower soil moisture, higher soil temperatures, earlier snowmelt, and higher nitrogen mineralization rates on warmed plots. Aspen fleabane abundance was lower on warmed than control plots. Adding water increased biomass and flowering on warmed plots (P = 0.03) and additions of nitrogen also resulted in increased biomass (P = 0.08), but not flowering (de Valpine and Harte 2001).

Because empirical seed zones are not currently available for aspen fleabane, 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 5, 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 Seedlot Selection Tool (Howe et al. 2017) can also guide restoration planning, seed collection, and seed deployment, particularly when addressing climate change considerations.

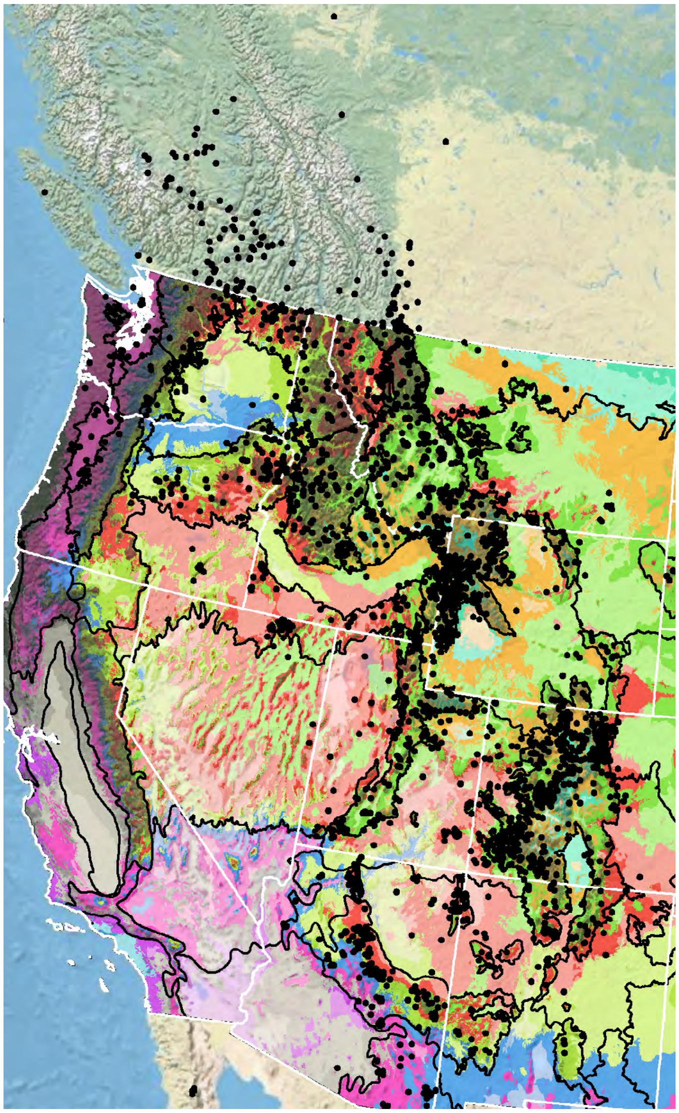

Figure 5. Distribution of aspen fleabane (black circles) based on geo-referenced herbarium specimens and observational data from 1870-2016 (CPNWH 2017; SEINet 2017; USGS 2017). Generalized provisional seed zones (colored regions; Bower et al. 2014) are overlain by Omernik Level III Ecoregions (black outlines) (Omernik 1987; USDI EPA 2017). 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, USGS.

Releases. As of early 2018, there were no aspen fleabane germplasm releases for wildland restoration.

Wildland Seed Collection. Aspen fleabane seed can be harvested about 1 month after flowering. Seed heads typically produce about 100 seeds/head (Mahalovich 2016) and ripen uniformly but mature earlier at low-elevation than high-elevation sites (USDI BLM SOS 2017; S. Jackman, Eastern Oregon Stewardship Services [EOSS], personal communication, March 2018). Although seed heads ripen uniformly, it is common for mature seed heads to occur near the top of the plant while there are still flowers at the base. Seed maturity can also vary among plants within a population (Mahalovich 2016). In one year, earliest flowers were found June 30 at 4,200 feet (1,280 m) and latest flowers on August 3 at 7,300 feet (2,230 m) (S. Jackman, EOSS, personal communication, March 2018). Seed was collected on August 2 from the low-elevation and September 7 at the high-elevation site. Seed was found on completely cured plants, suggesting a long collection window. Collection dates were almost exclusively between July 1 and August 31 for collections made for 7 years (2002-2016) from elevations of 1,050 to 9,570 (320-2,920 m) at sites in Oregon, Washington, Montana, Colorado, Utah, and Nevada (USDI BLM SOS 2017).

In Oregon, aspen fleabane seed collections were made in forest openings, riparian areas, and along roadsides (Fig. 4), but plants were especially common and abundant on burned sites. On one burned site, aspen fleabane occupied several acres. Fungal and insect damage to aspen fleabane seed was rare (S. Jackman, EOSS, personal communication, March 2018).

Several potentially co-occurring species are easily mistaken for aspen fleabane, especially at the seed harvesting stage (Fig. 6). Some of these are: subalpine fleabane (*Erigeron peregrinus*), threenerve fleabane, Unita fleabane (*E. uintahensis*), and western mountain aster (*Symphyotrichum spathulatum*). It is a good idea to have seed vouchers verified prior to collecting large quantities of seed (J. Irwin, USFS, personal communication, March 2018).

Wildland seed certification. Wildland seed collected for direct sale or for establishment of agricultural seed production fields should be Source Identified through the Association of Official Seed Certifying Agencies (AOSCA) Pre-Variety Germplasm Program that verifies and tracks seed origin (Young et al. 2003; UCIA 2015). For seed that will be sold directly for utilization in revegetation, collectors must apply for certification prior to making collections. Applications and site inspections are handled by the state where collections will be made. For seed that will be used for planting agricultural seed fields or nursery propagation more details of the collection site and procedures are required. Seed collected by most public and private agencies following established protocols may enter the certification process directly without certification agency site inspections when protocols include collection of all data required for Source Identified certification (see Agricultural Seed Certification section). Wildland seed collectors should become acquainted with state certification agency procedures, regulations, and deadlines in the states where they collect. Permits or permission from public or private land owners is required for all collections.

Collection timing. Aspen fleabane phenology and seed production is closely linked to snowpack and snowmelt and their relationship to late-season frosts. In an Idaho fescue-bearded wheatgrass meadow northeast of Bozeman, Montana, aspen fleabane flowering duration was shortest with 4-foot (1.2 m) snowpack and longest with normal snowpack (1-2 feet [0.3-0.6 m]). Flowering was earliest with normal snowpack and latest with 8-foot (2.4 m) snowpack (Weaver and Collins 1977). When phenology was monitored for 30 years in dry and wet montane meadows at the RMBL, nonflowering plants were present in most years, but in some years most or all flowers were frost killed. The earliest flowers appeared on July 9 and the latest on August 17. Researchers determined that if snow melted prior to May 19 or snowpack was less than 3 feet (1 m) on April 30, frost damage and reduced flower production was likely (Inouye 2008).

Figure 6. Ripening seed heads on aspen fleabane plants in Oregon. Photo: USDI BLM OR932 SOS.

Because seeds are non-dormant and germinate readily with moisture, wet seed heads should be avoided and collections should only be made when seed heads are dry and humidity levels are low. Seeds are ready for collection when the seeds begin to turn brown and no moisture is exuded when the seeds are squeezed (Mahalovich 2016).

Methods. Clipping mature seed heads into paper bags or other containers is recommended. Because aspen fleabane seed is available commercially, revegetated areas such as roadsides, mine sites, recreation areas, etc. should be avoided for wildland seed collections (Mahalovich 2016).

Several collection guidelines 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, collect from all microsites including the habitat edge and avoid collecting only from the most robust plants. Collectors should also avoid over-collecting from any population or location (Basey et al. 2015). General collecting recommendations and guidelines are provided in online manuals (e.g., ENSCONET 2015; USDI BLM SOS 2016).

Post-collection management. Thorough drying of aspen fleabane seed is critical for successful storage and cleaning (Fig. 7). Seed will mold if not dried carefully and quickly after harvest. Seed should be dried in an open area with good airflow before transporting and cleaning. Insect larvae present in the seed heads at the time of collection can impact seed yields before and after harvest and cleaning. If seed fill checks at the time of harvest suggest insect damage, freezing or pesticide treatments can be used to reduce seed yield losses to insects (Mahalovich 2016).

Seed Cleaning. The tiny aspen fleabane seeds can be difficult to clean to high purity (Shaw and Monsen 1983). A hammermill and an air column separator are recommended for cleaning large seed lots, and small seed lots can be cleaned by rubbing the seeds over a screen to separate the seeds from their pappi (Fig. 8; Luna 2005).

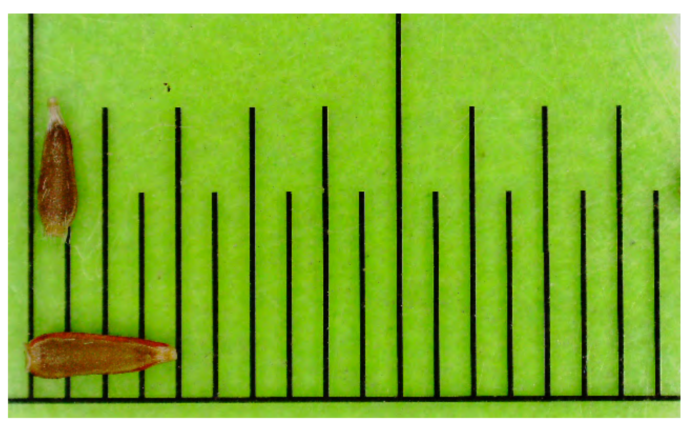

Figure 7. Aspen fleabane seed (scale, mm). Photo: Sustainability in Prisons Project.

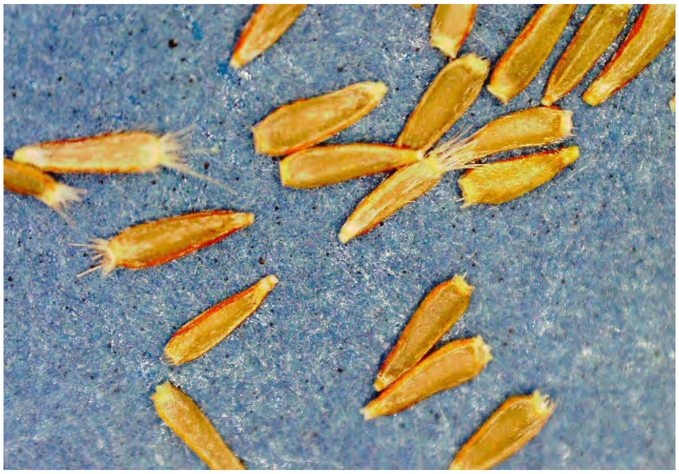

Figure 8. Cleaned aspen fleabane seed, most pappi removed. Photo: Sustainability in Prisons Project.

Seed lots collected by the Great Basin Native Plant Project, were cleaned by processing seed 1) through a small brush machine (mantle #32, speed 1, medium bristle brushes), 2) through a sieve or clipper, and 3) through an air column (J. Irwin, USFS, personal communication, March 2018).

Seed Storage. Dry seed (5-8% moisture) stored at temperatures of 32 to 36 °F (0-2 °C) will remain viable for many years (Huang 2015).

Seed Testing. There is no official AOSA procedure for examining viability, so viability is tested using the general procedures described for other Asteraceae genera. There is a rule for testing germination of aspen fleabane seed (AOSA 2016). Germination is tested at 59 °F (15 °C) with light. The first emergence count is made at 6 days and the last count at 16 days. Purity is evaluated using standard AOSA procedures. Minimum seed weight for purity testing is 0.8 g and for noxious-weed seed or bulk examination is 8 g. Approximately 3,010 seeds weigh 1 gram (AOSA 2016).

Germination. Many studies report high germination of aspen fleabane seed over a range of temperatures with and without prechilling and regardless of light conditions (Springer 2001; Huang 2015; Kramer 2016). Although seed will germinate without pretreatment, cold stratification for 30 to 60 days encouraged more uniform germination of seed collected in Glacier National Park (Luna 2005). These different germination requirements suggest that germination conditions may vary by population or be affected by storage conditions and durations.

The Kew Royal Botanical Gardens (RBG Kew 2018) obtained 100% germination after 7 days for seeds incubated on a 1% agar medium, exposed to 8/16 hour light-dark conditions and a constant temperature of 59 °F (15 °C). Germination was slower (24 days) when the temperature was warmer (68 °F [20 °C]) and about 50% lower when the temperature was cooler (50 °F [10 °C]) (RBG Kew 2018). In other studies on field-collected seed, 74% germination was achieved after 7 days and 98% germination after 21 days at temperatures of 68/59 ºF (20/15 °C) and a 8/16 hour light-dark cycle (Paulsen 1970). At the Rocky Mountain National Park Native Plant Nursery, aspen fleabane seed germinated uniformly, rapidly, and to high percentages at warm temperatures (55-70 ºF [13-21 ºC]) (Springer 2001; Huang 2015).

Kramer (2016) found cooler temperatures resulted in greater germination than warmer temperatures for seed collected from the Colorado Plateau. Germination was nearly 100% when seed was incubated in a growth chamber set to reflect early spring conditions (4 weeks at 52/34 ºF [11/1 ºC], 12 hour light/dark cycles). Germination was also high in simulated winter conditions (12 weeks at 34 ºF [1 ºC] followed by 4 weeks at 52-68 ºF/34-50 ºF [11-20 ºC/1-10ºC]). Germination was less than 50% with 4 weeks at 59/41º F (15/5 ºC) and less than 10% with 4 weeks at 68/50 ºF (20/10 ºC) (Kramer 2016).

In other studies, stratification impacted light requirements for germination (Hoffman 1985). Germination was significantly better when non-stratified seed was exposed to light (68%) than when kept in the dark (16%) at a constant temperature of 75 ºF (24 ºC) ($P < 0.05$). Seeds were collected from aspen woodlands in Routt County, Colorado, in late August or early September. For seeds given a long-duration stratification (120 days), germination was significantly greater in the dark (68%) than in the light (56%) ($P < 0.05$) (Hoffman 1985).

Wildland Seed Yield and Quality. Aspen fleabane seeds are tiny, ranging from about 1 to 3 million seeds/lb (2.2-6.6 million/kg) (Hassell et al. 1998; RGB Kew 2018). Post-cleaning seed yield and quality of seed lots collected in the Intermountain region are provided in Table 2 (USFS BSE 2017). The results indicate that aspen fleabane seed can generally be cleaned to high levels of purity and that seed fill and viability of fresh seed is generally high. Seed purity was 88% for collections made from a high-elevation Thurber's fescue meadow in southwestern Colorado (Paulsen 1970), within the range reported in Table 2.

Table 2. Seed yield and quality of aspen fleabane 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).

Characteristic	Mean	Range	Samples (#)
Bulk weight (lbs)	1.04	0.06-5.13	9
Clean weight (lbs)	0.20	0.01-1.46	9
Clean-out ratio	0.16	0.03-0.32	9
Purity (%)	95	75-99	9
Fill (%)[1]	92	80-98	9
Viability (%)[2]	93	79-97	8
Seeds/lb	2,460,105	1,597,183-3,194,366	9
Pure live seeds/lb	2,078,285	1,439,775-2,716,669	8

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

Marketing Standards. Acceptable seed purity, viability, and germination specifications vary with revegetation plans. Purity needs are highest for precision seeding equipment like that used in nurseries, while some rangeland seeding equipment handles lower purity seed. Seed companies in Utah that buy, clean, and market wildland seed reported that they clean seed to 80% purity (S. Monsen, USFS-retired, personal communication, July 2018).

AGRICULTURAL SEED PRODUCTION

Aspen fleabane produces seed in its first year under cultivation (Hottes cited in Bender et al. 2000) and is long-lived (Caradonna and Bain 2016), suggesting seed could possibly be harvested for several years, provided certification requirements are met. Detailed recommendations are lacking for establishment and care of aspen fleabane seed production fields. In 2018, wildland seed distributors located in Utah reported limited to no availability of wildland seed collections suggesting that seed production fields may be needed for this species (S. Monsen, USFS-retired, personal communication, July 2018).

Field experiments suggest that fertilization would not benefit aspen fleabane stands but that certain herbicides could be used to control weeds in seed fields. In a Thurber's fescue grassland, aspen fleabane decreased in abundance with additions of nitrogen and phosphorous (Paulsen 1970). In meadows near RMBL, nitrogen additions had no strong effect on per-flower reproduction (Burkle and Irwin 2010). In an evaluation of spotted knapweed (*Centaurea stoebe* subsp. *micranthos*) control and native forb recovery with herbicide only and fire followed by herbicide treatments, aspen fleabane density was not significantly affected by the treatments ($P < 0.1$). Study sites were invaded grasslands near Missoula, Montana. Herbicides tested were picloram, clopyralid, picloram plus clopyralid, and metsulfluron methyl. Although aspen fleabane density differences were not significant, there were observed patterns 13 months following treatments. More aspen fleabane plants occurred on burned and herbicide-treated than on unburned and herbicide-treated plots, and aspen fleabane appeared more sensitive to clopyralid and metsulfuron methyl than picloram (Carpenter 1986).

Aspen fleabane is a fungal host for *Crocicreas nigrofuscum*, *Entyloma compositarum*, *Erysiphe cichoracearum*, *Puccinia dioicae*, *P. extensicola* var. *erigerontis*, and *Ramularia macrospora* (Farr and Rossman 2018). Fleabanes are also noted hosts for gall-forming fungi (*Asteromyia modesta*) (Stireman et al. 2010). The extent to which these fungi may be problematic in seed field or nursery production was not reported. Any weed or fungal control measures in seed fields should be timed properly to avoid injury to the myriad of pollinators attracted to aspen fleabane flowers (see Pollination section).

Agricultural Seed Certification. It is essential to maintain and track the genetic identity and purity of native seed produced in seed fields. Tracking is done through seed certification processes and procedures. State seed certification offices administer the Pre-Variety Germplasm (PVG) Program for native field certification for native plants, which tracks geographic source, genetic purity, and isolation from field production through seed cleaning, testing, and labeling for commercial sales (Young et al. 2003; UCIA 2015). Growers should plant certified seed (see Wildland Seed Certification section) and apply for certification of their production fields prior to planting. The systematic and sequential tracking through the certification process requires pre-planning, understanding state regulations and deadlines, and is most smoothly navigated by working closely with state certification agency personnel.

NURSERY PRACTICE

Aspen fleabane nursery stock has been grown successfully by the Glacier and Rocky Mountain National Park (GNP and RMNP) Plant Nurseries. At the GNP Nursery, firm root plugs with multiple true leaves were produced from cleaned aspen fleabane seed (Luna 2005). Seeds were sown into a nursery soil mix with timed release fertilizer and kept in a fully automated greenhouse. Containers were spaced to maintain good airflow. An emphasis was placed on keeping containers evenly moist during germination and establishment. Plants took 1 month to establish, the active growth phase was 2 months, and by mid- to late summer, seedlings were moved outdoors to harden (Springer 2001; Luna 2005). The hardening phase lasted 3 months, after which time plugs were either fall planted or overwintered with protective Microfoam sheets and outplanted in the spring (Luna 2005).

At the RMNP Nursery in Estes Park, Colorado, seedlings were grown from seed collected at McGraw Ranch (Huang 2015). Seed was manually sown in a 4 × 8 flats and covered lightly with a superfine soil mix. Seed germinated uniformly after 7 days in a greenhouse, which was 65 to 70 ºF (18-21 ºC) during the day and 55 ºF (13 ºC) at night. Germination containers were kept under tents and on heated pads (70 ºF [21 ºC]). Containers were misted for about 15 minutes every 12 hours. After seeds germinated, the tents were removed but misting continued for another week. After this, seedlings were watered deeply every other day and provided water-soluble fertilizer with micro-nutrients each week for a month. Plants were moved to a cold frame in late March or early April to harden for 1 to 3 weeks prior to planting (Huang 2015).

In greenhouse experiments, aspen fleabane survival was high when present at a very low level in a seed mixture (Paulsen 1970). Five-gallon containers were seeded with 192 total seeds and varying proportions of 2 grass species (Thurber's fescue and Letterman's needlegrass, 44 to 86% of seeds) and 3 forb species (Fremont's geranium [*Geranium caespitosum* var. *fremontii*], beautiful cinquefoil [*Potentilla pulcherrima*], and aspen fleabane, 14-56% of seeds). The total number of aspen fleabane seeds planted per container ranged from 4 to 16. Survival of aspen fleabane ranged from 87 to 100% after 267 days in normal water treatments. Survival was lower (57-97%) in low water treatments and when just 4 aspen fleabane seeds were present in the containers (Paulsen 1970).

In restoration of several disturbed sites in the Manti-La Sal and Uinta-Wasatch-Cache National Forests of Utah, aspen fleabane was successfully seeded using an imprint seeder. Seeding with conventional seeders, which planted seeds too deep (> 0.5 inch depths), resulted in little to no establishment. Aspen fleabane was seeded with about 20 other tall forb species at the restoration sites and across all sites remained a dominant species for at least 5 years after seeding (S. Monsen, USFS-retired, personal communication, July 2018).

Aspen fleabane survival was good from nursery stock (plugs) planted on the Rocky Prairie Preserve south of Olympia, Washington. Survival of aspen fleabane outplanted in March remained high by late May of the same year. Monitoring in the following years revealed that plants established well, reached reproductive maturity, and produced new seedlings (Thomas and Gamon 1997).

WILDLAND SEEDING AND PLANTING

Aspen fleabane can be broadcast seeded if seed is subsequently covered. It can also be drill seeded or cultipacker seeded as part of a mixture (Shaw and Monsen 1983). Field observations and greenhouse experiments suggest aspen fleabane may do well in seeding mixtures. In surveys of denuded and patchy vegetation recovery on the Wasatch Plateau, central Utah, aspen fleabane was frequently found establishing where penstemon or yarrow plants had already established. Once established, aspen fleabane spread out beyond the penstemon and yarrow patches (Ellison 1949).

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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.kew.org/sites/default/files/ENSCONET_Collecting_protocol_English.pdf

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

SEEDLOT SELECTION TOOL

https://seedlotselectiontool.org/sst/

SEED ZONE MAPPER

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

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