WESTERN FORBS: BIOLOGY, ECOLOGY, AND USE IN RESTORATION

TAPERTIP HAWKSBEARD

Crepis acuminata Nutt.
Asteraceae – Aster family

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NOMENCLATURE

Crepis acuminata Nutt., commonly called tapertip hawksbeard, belongs to the Chichorieae tribe (USFS 1937) of the Asteraceae or Aster family (Bogler 2006; USDA NRCS 2017).

NRCS Plant Code. CRAC2 (USDA NRCS 2017).

Subtaxa. No subspecies are recognized by the Flora of North America (Bogler 2006).

Synonyms. *Crepis acuminata* subsp. *pluriflora* Babcock & Stebbins, *C. angustata* Rydberg, and *C. sesselifolia* Rydberg (Bogler 2006).

Common Names. Tapertip hawksbeard, long-leaf hawksbeard, mountain hawksbeard, tall hawksbeard (Applegate 1938; Welsh et al. 1987; Taylor 1992; USDA NRCS 2017).

Chromosome Number. Chromosome number varies: 2n = 22, 33, 44, 55, 88 (Bogler 2006) and distinguishes sexual and apomictic plant types. Diploid plants (2n = 22) are sexual, and polyploid plants are apomictic (Babcock and Stebbins 1938; Cronquist et al. 1994). Plant forms with 33 or 44 chromosomes are found practically throughout the species range. Forms with 55 chromosomes are rare and derived from hybridization with nakedstem hawksbeard (*C. pleurocarpa*) (Babcock and Stebbins 1938). Ploidy is discussed more in the Distribution and Reproduction sections below.

DISTRIBUTION

Tapertip hawksbeard occurs in all states west of Montana, Wyoming, Colorado, and New Mexico (Bogler 2006). It is common in and east of the Cascade and Sierra mountain ranges and found in the northern parts of Arizona and New Mexico (Cronquist et al. 1994; LBJWC 2018). Populations are most common in the Columbia Plateau and Great Basin provinces (Babcock and Stebbins 1938) and exist in most, if not all, counties in Utah (Welsh et al. 1987). In general, tapertip hawksbeard occurs in regions with continental climates that experience dryness in all seasons (Babcock and Stebbins 1938).

In a thorough study of hawksbeards (*Crepis* spp.), Babcock and Stebbins (1938) mapped the distribution of the diploid sexual and polyploid apomictic tapertip hawksbeard forms (Fig. 1). The diploid sexual form is most widespread. It predominates in the northern part of the species range and overlaps the distribution of the polyploid apomictic forms in many areas (Babcock and Stebbins 1938).

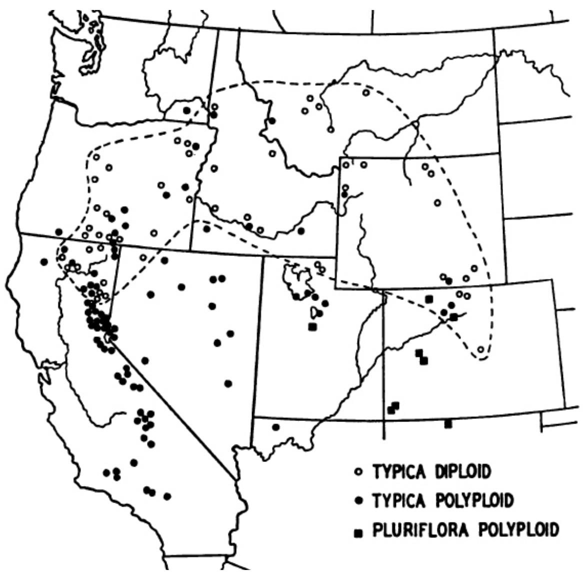

Figure 1. Distribution of tapertip hawksbeard and its sexual diploid (typica diploid) and apomictic polyploid forms (typica polyploid and pluriflora polypoid) (Babcock and Stebbins 1938).

Habitat and Plant Associations. Tapertip hawksbeard is widespread but rarely found in great abundance (USFS 1937). It occurs on open, dry sites in sagebrush (*Artemisia* spp.) grasslands, mountain brush communities, pinyon-juniper (*Pinus*-*Juniperus* spp.) and quaking aspen (*Populus tremuloides*) woodlands, and conifer forests (Munz and Keck 1973; Welsh et al. 1987; Bogler 2006). It is especially frequent in mid-elevation grassland and sagebrush vegetation adjoining the lower edge of the ponderosa pine (*Pinus ponderosa*) zone (Babcock and Stebbins 1938; Hermann 1966). Populations are also found in upper elevation spruce-fir (*Picea*-*Abies* spp.) forests (Welsh et al. 1987; Cronquist et al. 1994). Tapertip hawksbeard is commonly found with the following forbs and grasses: arrowleaf balsamroot (*Balsamorhiza sagittata*), buckwheats (*Eriogonum* spp.), lupines (*Lupinus* spp.), Sandberg bluegrass (*Poa secunda*), and other bunchgrasses (*Pseudoroegneria*, *Agropyron*, *Elymus* spp.) (Fig. 3) (USFS 1937).

Shrublands. Tapertip hawksbeard is commonly associated with sagebrush (Fig. 2) and mountain brush communities. In a 10-year study of plant communities, soil, and vegetation relationships in near climax sagebrush communities in northern Utah, southern Idaho, northeastern Nevada, and west-central Wyoming, tapertip hawksbeard occurred in 47 of 85 sagebrush-grassland plots (Passey et al. 1982). In descriptions of rangeland cover types of the US, tapertip hawksbeard was described as frequent in basin big sagebrush (*Artemisia tridentata* subsp. *tridentata*), mountain big sagebrush (*A. t.* subsp. *vaseyana*), threetip sagebrush (*A. tripartita*), and more mesic parts of Wyoming big sagebrush (*A. t.* subsp. *wyomingensis*), and black sagebrush (*A. nova*) communities (Shiflet 1994). In the Blue and Ochoco mountains of Oregon, tapertip hawksbeard was frequent but cover was low in antelope bitterbrush/Idaho fescue-bluebunch wheatgrass (*Purshia tridentata*/*Festuca idahoensis*-*Pseudoroegneria spicata*) and mountain big sagebrush/Idaho fescue-prairie Junegrass (*Koeleria cristata*) communities (Johnson and Swanson 2005).

Figure 2. Tapertip hawksbeard growing in Oregon. Photo: USDI BLM OR030 Seeds of Success (SOS).

In southern Idaho, tapertip hawksbeard was reported in sagebrush kipukas, which are islands of vegetation isolated by lava flows (Passey and Hugie 1963; Tisdale et al. 1965). Near Craters of the Moon National Monument, tapertip hawksbeard was most frequent in threetip sagebrush/Idaho fescue kipukas on moist, cool, north and east slopes with relatively deep and fertile soils. It also occurred, but was poorly represented, in big sagebrush/Idaho fescue-bluebunch wheatgrass vegetation on warm, dry, southern and western slopes (Tisdale et al. 1965).

Tapertip hawksbeard often occurs in mountain brush communities. In 60 stands from 18 northeastern Nevada mountain ranges, tapertip hawksbeard constancy (percentage of plots within a vegetation type on which tapertip hawksbeard occurred) was nearly 100% in mountain snowberry (*Symphoricarpos oreophilus*) and mountain big sagebrush communities. Cover of tapertip hawksbeard ranged from 0.1 to 0.4% in these communities (Tueller and Eckert 1987). Constancy was high (>20%) and cover ranged from 1 to 4% in Saskatoon serviceberry (*Amelanchier alnifolia*) mountain brush sites in eastern Idaho (Major and Rejmanek 1992).

Woodlands/Forests. Tapertip hawksbeard was considered a major associate species in western juniper (*J. occidentalis*) woodlands characteristic of shallow soils in Oregon's Blue Mountains (Franklin and Dyrness 1973). It also occurred in Utah juniper/low sagebrush (*J. osteosperma*/*A. arbuscula*)/Sandberg bluegrass on north and east slopes with very fine soils in Nevada's Cow Creek Watershed (Blackburn et al. 1969). In Underdown Canyon, Lander County, Nevada, tapertip hawksbeard was found in singleleaf pinyon (*Pinus monophylla*) woodlands on 7,200- to 7,300-foot (2,195-2,225 m) north-facing slopes with intermediate levels of tree cover (MontBlanc et al. 2007).

When riparian and terrestrial ecosystems were surveyed for an entire catchment in Glacier National Park, tapertip hawksbeard was restricted to low-elevation forests and not found in riparian areas, floodplains, or subalpine or alpine forests (Mouw and Alaback 2003). In Jackson Hole Wildlife Park, Wyoming, tapertip hawksbeard occurred along streams and was also found in the understory of lodgepole pine forests (Reed 1952).

Elevation. Tapertip hawksbeard occurs in habitats at elevations of 2,600 to 10,800 feet (790-3,300 m) (Munz and Keck 1973; Welsh et al. 1987; Cronquist et al. 1994; Bogler 2006), but it is most frequent at mid-elevations (Babcock and Stebbins 1938; Smith 1960; Hermann 1966).

Soils. In tapertip hawksbeard habitats, soils are typically well-drained, neutral to slightly alkaline, non-saline, and fine to coarse or sandy or stony textures (USFS 1937; Stubbendieck et al. 1986; Taylor 1992; Eldredge et al. 2013; LBJWC 2018).

Tapertip hawksbeard is common in dry habitats with coarse-textured soils, but it is also found on sites with fine-textured soils. In a greenhouse study, tapertip hawksbeard emergence was significantly greater in sandy loam than clay loam soils ($P = 0.004$) (Rawlins et al. 2009). In big sagebrush/bluebunch wheatgrass kipuka north of Blackfoot, Idaho, soils were well-drained silt loams leached of carbonates in the top 14 to 26 inches (36-66 cm). In this kipuka, western hawksbeard (*Crepis occidentalis*) and tapertip hawksbeard made up 5 to 8% of the species composition (Passey and Hugie 1963). In contrast, tapertip hawksbeard was associated with grassland sites on northeastern aspects on soils with high water-holding capacities and clay levels in central Idaho (Mueggler and Harris 1969). In Grand Teton National Park, Wyoming, tapertip hawksbeard occurred in 60% of mountain big sagebrush and antelope bitterbrush stands and 17 to 20% of low sagebrush or mixed sagebrush stands, where soils were more coarsely textured (Sabinske and Knight 1978). In the Wasatch Mountains of Utah, the importance value (a product of constancy and average cover) for tapertip hawksbeard was greater in Utah serviceberry (*Amelanchier utahensis*) foothills than in Gambel oak (*Quercus gambelii*)-dominated vegetation when 25 stands were compared (Yake and Brotherson 1979). Soil pH levels, sand content, and bare ground were significantly greater and clay content significantly lower in Utah serviceberry foothills than Gambel oak stands ($P \leq 0.05$). Soil pH averaged 7.9 and composition was 64% sand and 25% clay in the Utah serviceberry foothill stands (Yake and Brotherson 1979).

Revegetation guidelines recommend tapertip hawksbeard for fine silt loam, silt, and sandy to coarse-textured soils on sites receiving 8 to 20 inches (20-50 cm) of precipitation (Walker and Shaw 2005; Ogle et al. 2012). Recommendations for restoration are discussed in the Wildland Seeding and Planting section.

Figure 3. Tapertip hawksbeard growing in Nevada. Photo: USDI BLM NV020 SOS.

DESCRIPTION

Tapertip hawksbeard is a perennial plant that produces a milky sap (USFS 1937; Lambert 2005a; LBJWC 2018). One to five erect stems develop from a caudex and deep, tough, branching taproot (Fig. 3) (USFS 1937; Welsh et al. 1987; Bogler 2006). Stems are stout (2-4 mm diameter), moderately tall (8-33 in [20-85 cm]), and covered with dense, short, soft hairs, especially when young. Upper stem parts become hairless with age (Babcock and Stebbins 1938; Stubbendieck et al. 1986; Welsh et al. 1987; Cronquist et al. 1994). Stems branch near or above the midpoint and end in erect inflorescences with yellow flowers. Rosettes of coarse, pinnately lobed leaves surround the stem bases (Bogler 2006). Plants are described as short-lived (Eldredge et al. 2013) and long-lived (Ogle et al. 2012), but no study directly investigating life span was found.

Plants produce both basal and stem leaves that are 3 to 16 inches (8-40 cm) long and 0.4 to 4 inches (1-10 cm) wide, alternate, and petiolate. Basal and lower stem leaves have 5 to 10 pairs of lobes and are more numerous (2-7) and larger than the remote and reduced 1 to 3 upper stem leaves, which are more entire with 1 to 3 clefts (USFS 1937; Babcock and Stebbins 1938; Hermann 1966; Munz and Keck 1973; Welsh et al. 1987; Bogler 2006). Lobes are entire to somewhat toothed or cleft to about halfway to the mid vein (Cronquist et al. 1994). Leaves, especially the lower ones, are gray-green, tapered at the tips, and coated with cottony pubescence.

Tapertip hawksbeard produces an abundance of flower heads (20-100 or more) (Fig. 4), which are arranged in compound corymbiform inflorescences (Munz and Keck 1973; Bogler 2006). Flower heads are narrow, erect, and made up of 5 to 12 petal-like, perfect, ray flowers with 5-toothed tips (USFS 1937; Babcock and Stebbins 1938; Hermann 1966; Anderson and Holmgren 1976; Welsh et al. 1987; LBJWC 2018). Flower heads are enclosed by conspicuous, smooth, equal bracts with a few very short outer bracts at the base (USFS 1937). Fruits are 6 to 9 mm long, nearly cylindric cypselas (false achenes) with pointed tips and a white pappus with barbed bristles. Fruits are yellow, buff, or brown with 10 to 12 longitudinal ribs. Length of the ribs equals or exceeds pappus length (USFS 1937; Babcock and Stebbins 1938; Munz and Keck 1973; Cronquist et al. 1994; Bogler 2006). Tapertip hawksbeard fruits are cypselas, but they are often referred to as achenes or seeds because seeds are not removed from the fruits in the cleaning process. Throughout this review, the term seed will refer to the fruit or cypsela and the seed it contains.

Figure 4. Tapertip hawksbeard inflorescences, note the indeterminate flowering. Photo: USDI BLM OR030 SOS.

Diploid and polyploid plants are not always distinguishable morphologically (Babcock and Stebbins 1938). Flower heads of diploid plants typically contain 5, or rarely 6, individual flowers from bases measuring 0.9 to 1.2 cm tall. Polyploid plants have as many as 8 to 12 individual flowers from bases up to 1.5 cm tall. In areas where the distributions of diploid forms overlap those of polyploid forms and limestone hawksbeard (*Crepis intermedia*), distinguishing the forms and species can be difficult (Babcock and Stebbins 1938; Hitchcock et al. 1955). Diploid and polyploid plants can quite reliably be distinguished through stomata and pollen comparisons. Stomates are larger and pollen is absent or irregular in polyploid forms (Babcock and Stebbins 1938).

Below-Ground Interactions. Tapertip hawksbeard roots were colonized by vesicular-arbuscular mycorrhizae (*Glomus fasiculatum*) in a semiarid rangeland in northern Nevada (Bethlenfalvay and Dakessian 1984).

Reproduction. Tapertip hawksbeard reproduces from seed (Fig. 5), which is produced sexually in diploid plant forms and asexually through apomixis in polyploid forms (Babcock and Stebbins 1938).

For individual plants, the flowering window is quite narrow, but flowers are produced from May to August across the species' range (Munz and Keck 1973; Anderson and Holmgren 1976; Cronquist et al. 1994; Bogler 2006; Tilley et al. 2012). Phenology varies from year to year depending on weather conditions. Blaisdell (1958) monitored tapertip hawksbeard for 9 to 16 years in threetip sagebrush at the USFS Sheep Experiment Station (USSES) near Dubois, Idaho. Seasonal development of tapertip hawksbeard was slow. Blooms generally appeared in mid-June, and seeds dispersed in early August. Over the 9-year period, the average date for growth initiation was April 12, flower stalk appearance May 11, first bloom appearance June 18, full flowering July 1, seed dispersal began July 16 and ended August

9, and plants were dry on August 3. The variation in date range for these stages was 42 days for appearance of flower stalks, 40 days for first blooms, 43 days for full blooming, and 20 days for ripe seed (Blaisdell 1958).

Figure 5. Open and closed tapertip hawksbeard seed heads. Photo: USDI BLM CA370 SOS.

Heavy spring precipitation may severely limit tapertip hawksbeard reproduction (Bates et al. 2006). In field experiments, tapertip hawksbeard failed to reproduce when 80% of total moisture was delivered in the spring (April-July) at a northern Great Basin site. After 6 years of the experiment, reproductive success was greater for winter precipitation (≥60%) than for normal (≤30%) and spring precipitation (0%) treatments. Plant density was significantly greater ($P < 0.05$; about 0.2 plant/ft^2 [2/m^2]) where 80% of total moisture was delivered in winter (October-March) than for spring moisture treatments (< 0.09 plant/ft^2 [1/m^2]) or when moisture timing and amount matched the area's 50-year average (Bates et al. 2006).

Sexual and asexual forms: Sexual diploid plants are widely distributed and highly variable morphologically. Polyploid plants are often apomictic. They fail to produce pollen or they produce highly abnormal pollen the further they are from diploid plants. New apomictic forms may occasionally be adapted to new habitats and allow for "aggressive" colonization of open or new sites (Babcock and Stebbins 1938).

Pollination. Sexual tapertip hawksbeard plants are likely insect pollinated. Twenty-eight bees were collected from 169 plants growing at three sites in Utah and Idaho (Cane and Love 2016). Of these, 40% were mason bees (*Osmia* spp.), 11% mining bees (*Andrena* spp.), 11% bumblebees (*Bombus* spp.), 10% furrow bees (*Halictus* spp.), 8% sweat bees (*Agapostemon* spp.), 8% *Lasioglossum* spp., and less than 5% of each of the following genera were collected: plasterer bees (*Colletes* spp.), long-horned bees (*Eucera* spp.), mason bees (*Hoplitis* spp.), leafcutter bees (*Megachile* spp.), and cuckoo bees (*Nomada* spp.) (Cane and Love 2016).

ECOLOGY

Tapertip hawksbeard tolerates early seral to climax conditions (Eggler 1941) but is often more abundant in mid-seral communities (Daubenmire 1975; Koniak 1985; Walker and Shaw 2005). It has been described as a short-lived (Eldredge et al. 2013) and as a long-lived perennial (Ogle et al. 2012), but no study has directly investigating its lifespan was found.

In early succession on volcanic deposits at Craters of the Moon National Monument, tapertip hawksbeard occurred on cinder cones before any shrub established (Eggler 1941). When mountain big sagebrush and western juniper stands were compared in west-central Owyhee County, Idaho, tapertip hawksbeard occurred in both early to mid-seral and climax stands. It was present in 5 of 11 seral stands where tree age ranged from 33 to 88 years and crown cover averaged 22% and in 1 of 7 climax stands where tree age ranged from 185 to 365 years and crown cover averaged 47%. Frequency of tapertip hawksbeard was 15% in seral stands and 12% in the climax stand (Burkhardt and Tisdale 1969). In the Shoshone Mountains of central Nevada, tapertip hawksbeard occurred in mountain big sagebrush where cover of singleleaf pinyon and Utah juniper was low to moderate, but it was absent from where woodland cover was high (Allen and Nowak 2008).

Because tapertip hawksbeard is rarely present in high abundance, study area size and sampling effort may influence ecological findings. Tapertip hawksbeard was restricted to mid-seral conditions when a single burned area and adjacent habitats were evaluated in the Sweetwater Mountains of California (Koniak and Everett 1982), but it occurred across the range of early, mid-, and late seral communities when 21 burned sites in California and Nevada were evaluated (Table 1; Koniak 1985). Tapertip hawksbeard was found only in mid-seral shrub-tree communities in the Sweetwater Mountains near Walker, California. Plants were absent from early seral sites dominated by grasses, forbs, and juvenile shrubs

Table 1. Occurrence and cover of tapertip hawksbeard across a post-fire chronosequence in Nevada and California (Koniak 1985).

Seral stage, yrs since fire	Early, 1	Early-Mid, 4-8	Mid, 15-17	Mid-Late, 22-60	Unburned
Frequency (%)	40a*	24b	29b	36ab	13c
Cover (%)	5ab	6ab	16a	<5b	<5b

*Values in the same row followed by a different letter are significantly different (P <0.05).

and absent from late seral tree-shrub sites with high densities of singleleaf pinyon and limited understories. Cover of tapertip hawksbeard was 0.3% in mid-seral sites with good shrub growth and scattered trees (Koniak and Everett 1982). In a study of 21 burns in Nevada and California, tapertip hawksbeard was found in early to late-seral communities burned 1 to 60 years prior and in long unburned singleleaf pinyon-Utah juniper (Table 1). Frequency was greatest in the earliest seral communities, but cover was greatest in mid- to late-seral communities (Koniak 1985).

Seed Ecology. It is common to find seeds destroyed by insect larvae in nearly every flower head (Babcock and Stebbins 1938), and reductions in seed yield can be substantial (Tilley et al. 2012).

Tapertip hawksbeard fruits contain pappi with barbed bristles (Bogler 2006), which are adaptive characteristics for long-distance wind dispersal. Hawksbeard (*Crepis* spp.) seed (0.8 seed/liter) was collected in September from ant mounds that were 6.6 feet (2 m) or further from hawksbeard plants. Seeds were recovered from mounds in 3-year old burned big sagebrush-yellow rabbitbrush (*Chrysothamnus viscidiflorus*) shrublands in southeastern Idaho (Nowak et al. 1990).

Dormancy varies among seed lots, which may be a product of population differences, site differences, seed age, storage conditions, or other factors. Some sources suggest seed is non-dormant (Young and Young 1986; Karrfalt and Vankus 2012), but others indicate that cold stratification is needed for germination (Jensen and Stettler 2012). Regardless of stratification needs, it is unlikely that tapertip hawksbeard banks seed. Studies conducted by the Great Basin Research Center in Ephraim, Utah, found that most tapertip hawksbeard seed imbibed water quickly when available. When bagged seeds were buried in September and retrieved in late November, about 7% had germinated, about 80% were fully imbibed, and the rest were dead (Vernon et al. 2007).

Establishment of tapertip hawksbeard from seed requires seed burial or protection from the elements (Eckert et al. 1986; Rawlins et al. 2009). In experimental seedings in big sagebrush communities north of Elko, Nevada, establishment was best (47-52 seedlings/9 m^2) when seeds were placed in naturally occurring trenches or cracks in the soil surface and seedlings were protected from cattle for 1 year. Establishment was significantly higher for seeds in natural cracks and trenches (25-26 seedlings/9 m^2) than on the soil surface (7-9 seedlings/9 m^2) even without protection from cattle ($P \leq 0.05$) (Eckert et al. 1986). Establishment is considered quick from wind-dispersed seed (Laycock 1967).

Disturbance Ecology. Tapertip hawksbeard is common in early post-disturbance communities. It often recovers to pre-fire abundance levels within the first few years following fire (Poreda and Wullstein 1994). It may take longer to re-colonize abandoned crop fields. In southeastern Washington, tapertip hawksbeard was found in older abandoned crop fields (abandoned 39 years) but not in younger fields (abandoned 1-12 years) (Daubenmire 1975). Tapertip hawksbeard is sensitive to grazing, especially spring grazing by sheep (Mueggler 1950). It may also have reduced abundance in drought years. At the US Sheep Experiment Station (USSES) near Dubois, Idaho, density of tapertip hawksbeard in a severe drought year (1934) was just 9.4% of that in a normal precipitation year, a significant decrease (P < 0.01) (Pechanec et al. 1937).

Fire Response. In general, fires do not cause dramatic changes in tapertip hawksbeard abundance. Frequency of tapertip hawksbeard was greatest in the earliest seral communities, but cover was greatest in mid- to late-seral communities in a 60-year post-fire chronosequence in California and Nevada (Koniak 1985).

In the small number of studies available, summer fires seemed to do more damage to tapertip hawksbeard abundance than spring fires. Spring fires favored tapertip hawksbeard establishment and growth at sites in California and Nevada. At Lava Beds National Monument, northern California, spring prescribed fires favored post-fire colonization by tapertip hawksbeard in areas where pre-fire mountain big sagebrush vegetation was dominated by native species (Ellsworth and Kauffman 2017). Biomass and nitrogen concentration of plant tissue were increased for tapertip hawksbeard after a spring prescribed fire in mountain big sagebrush and singleleaf pinyon vegetation in the Shoshone Mountains of central Nevada. This suggests that fire increased nutrient availability, which was in turn utilized by tapertip hawksbeard to increase growth by the second post-fire year. The fire was set in May when soil and fuel moistures were high, resulting in a patchy burn (Rau et al. 2008).

The fire response was more variable following summer fires. Frequency and cover of tapertip hawksbeard were higher on unburned than on 1-year old burned sites near Heber Valley, Utah (Poreda and Wullstein 1994). The August fire was described as severe. In Gambel oak vegetation, tapertip hawksbeard frequency was 47.1% on unburned and 3.6% on burned and cover was 1.4% on unburned and 0.02% on burned plots. In big sagebrush-grassland vegetation, tapertip hawksbeard frequency was 54.5% on unburned and 4.9% on burned and cover was 2.2% on unburned and 0.07% on burned plots one year after fire (Poreda and Wullstein 1994). Cover of tapertip hawksbeard (averaging 1%) was not different before, 1 year after, or 5 years after a moderate- to low-severity August fire in late-seral Idaho fescue-bluebunch wheatgrass vegetation in northeastern Oregon (Johnson 1998). Following a summer fire in big sagebrush/Thurber's needlegrass (*Achnatherum thurberiana*) vegetation north of Reno, Nevada, frequency of tapertip hawksbeard was 3% in the first post-fire year but 0% in the third and fourth post-fire years (Young and Evans 1978).

Although slight damage has been reported from fall fires in sagebrush (Wright cited in Britton and Ralphs 1979), frequency of tapertip hawksbeard was not significantly different (P = 0.6) on unburned and 1 to 2-year-old burned plots following a fall prescribed fire on South Steens Mountain in Oregon (McDowell 2000).

With increasing time since fire, tapertip hawksbeard abundance was greater on burned than unburned plots following summer fires in two southern Idaho studies. Cover of tapertip hawksbeard was greater on 6-year-old burned (1.9%) than unburned (0.6%) plots in sagebrush steppe and western juniper woodlands that burned on July 6 on the Owyhee Plateau (Weiner et al. 2016). Production of tapertip hawksbeard was greater on burned than unburned plots 12 years after an August fire in big sagebrush-grasslands on the Upper Snake River Plain in Clark County, Idaho (Blaisdell 1953). Production of tapertip hawksbeard was 0.3 lb/acre (0.6 kg/ha) on unburned, 1.4 lbs/acre (1.6 kg/ha) on lightly burned, 0.9 lb/acre (1 kg/ha) on moderately burned, and 3 lbs/acre (3.4 kg/ha) on severely burned plots. Light burns consumed only big sagebrush leaves, moderate burns consumed leaves and small stems, and severe burns consumed everything including the trunk or main stem of big sagebrush plants (Blaisdell 1953).

Wildlife and Livestock Use. Tapertip hawksbeard is utilized by wildlife and livestock. It is an important greater sage-grouse (*Centrocercus urophasianus*) food and is highly preferred by domestic sheep.

Bighorn sheep (*Ovis canadensis*), elk (*Cervus canadensis*), mule deer (*Odocoileus hemionus*), and white-tailed deer (*O. virginianus*) utilize tapertip hawksbeard at low levels (Robinson 1937; Smith 1960; Schallenberger 1966; Lauer and Peek 1976). In big game winter range in the Sun River Canyon of west-central Montana, tapertip hawksbeard made up less than 3% of total observed instances of winter (January-March) feeding by bighorn sheep, elk, mule deer, and white-tailed deer. In this area, frequency of tapertip hawksbeard was 15% or less (Schallenberger 1966). Tapertip hawksbeard was described as a decreaser when bluebunch wheatgrass-needle and thread (*Hesperostipa comata*) grasslands near Jackson Hole, Wyoming, receiving elk winter use were compared with exclosures. Sites were compared in the summer and only used by native ungulates, primarily elk (Smith 1960). In northwestern Wyoming grasslands and shrublands, year-round elk and summer cattle grazing was evaluated through the use of exclosures. Tapertip hawksbeard was significantly reduced ($P < 0.05$) on elk-grazed but not significantly changed on cattle-grazed sites (Jones 1965). Bighorn sheep, mule deer, and cattle utilized tapertip hawksbeard at low levels from December to June along the East Fork of the Salmon River in Idaho. In this study area, tapertip hawksbeard abundance was low (Lauer and Peek 1976).

Tapertip hawksbeard is also utilized somewhat by small mammals. It was found in hay piles or food caches constructed by American pikas (*Ochotona princeps*) in Washoe County, Nevada (Beever et al. 2008). It was also found in 6% of the stomachs of Townsend's ground squirrel (*Spermophilus townsendii*) collected in March from a Sandberg bluegrass-dominated site in southwestern Idaho, but not from collections made in May or June (Yensen and Quinney 1992).

Tapertip hawksbeard is an important food source for greater sage-grouse hens and chicks (Klebenow and Gray 1968; Drut et al. 1994) and is often found in utilized habitats (Wik 2002; Lambert 2005a). Tapertip hawksbeard was commonly found in greater sage-grouse brood-rearing habitats in south-central Owyhee County, Idaho, and north-central Elko County, Nevada (Wik 2002).

Frequency of tapertip hawksbeard in greater sage-grouse diets was high in studies conducted in Idaho and Oregon. Tapertip hawksbeard made up 25% of the volume and frequency of crops from 2-week old chicks (n=4), 50% frequency and a trace of the volume from crops of 3-week old chicks (n=2), and 14% frequency and a trace of the volume of crops of 5-week old chicks (n=7) taken from big sagebrush-grasslands in Clark County, Idaho. Researchers noted that decreased use with increasing chick age may have been related to plant phenology. Tapertip hawksbeard in this area matured and dried within a short period (Klebenow and Gray 1968). Hawksbeard leaves were preferentially consumed by pre-laying greater sage-grouse hens in southeastern Oregon from March 4 to April 8 (Barnett and Crawford 1994). Hawksbeard frequency was 37 to 62% and dry weight was 3 to 14% in crops depending on the vegetation type and year. Hawksbeards were the top or second-most selected food by greater sage-grouse in big sagebrush and low sagebrush vegetation (Barnett and Crawford 1994). Hawksbeards were also selected by greater sage-grouse chicks in big sagebrush and bitterbrush communities in southeastern Oregon. Chicks ranged from 1 to 11 weeks old but most were 3 to 10 weeks old. In crops, the frequency of hawksbeards was 29 to 69% and dry mass was 4 to 5% depending on the vegetation type. In the study area, the frequency of hawksbeards was 1 to 2% (Drut et al. 1994).

Livestock. Cattle and sheep feed on tapertip hawksbeard, but preference is highest for sheep, although it has been said to be relished by both cows and sheep (Hermann 1966). Palatability of plants is highest in spring and early summer (USFS 1937). Palatability of tapertip hawksbeard is considered poor to good for horses, fair to good for cattle, and excellent for sheep (USFS 1937; Stubbendieck et al. 1986).

Decreases in tapertip hawksbeard with sheep grazing were commonly reported (Ellison 1954; Mueggler and Stewart 1980). At the USSES, tapertip hawksbeard decreased dramatically or was lost ith heavy continuous spring grazing paired with late fall grazing and heavy early spring grazing paired with late fall grazing by sheep. Palatability of tapertip hawksbeard to sheep was highest of all forbs listed (Craddock and Fording 1938). In other studies at the USSES, sheep use of tapertip hawksbeard was 33 to 56% in threetip sagebrush-grasslands grazed heavily in the summer. Use was greater in early summer than late summer (Harniss and Wright 1982).

Tapertip hawksbeard is especially sensitive to spring grazing by sheep. In several studies conducted at the USSES, spring sheep grazing resulted in reduced tapertip hawksbeard abundance (Mueggler 1950; Laycock 1967; Bork et al. 1998; Roselle et al. 2010). Production of tapertip hawksbeard decreased from 24 to 3 lbs/acre (27 to 3.4 kg/ha) when sites at the USSES fall grazed for 20 years were switched to spring sheep use for 13 years (Laycock 1967). Production was also much lower when spring and fall and fall only grazed sites were compared. Prior to initiation of the study, abundance of tapertip hawksbeard was very similar on the two sites, but after 25 years of grazing, production was 2.5 lbs/acre (2.8 kg/ha) in the spring and fall grazed area and 15 lbs/acre (17 kg/ha) in the fall only grazed area. Stocking rate in the fall-grazed area averaged 42.6 sheep days/acre and in the spring and fall grazed area averaged 19.2 spring and 10 fall sheep days/acre (Mueggler 1950).

Tapertip hawksbeard abundance was also often lower on cattle-grazed than ungrazed sites. Density was significantly greater ($P < 0.05$) in a 16-year-old exclosure (0.9 plant/ft^2 [6.9/m^2]) than in a cattle-grazed semi-arid rangeland (0.1 plant/ft^2 [1.3/m^2]) in northern Nevada (Bethlenfalvay and Dakessian 1984). The area was heavily grazed for 58 years, but in the 6 years prior to evaluating effects, grazing was changed to a 3-pasture rest-rotation regime. This regime included a year of rest, a year of April to December use, and a year of mid-July to January use at a stocking rate of 9.5 acres (3.85 ha) per animal unit month (Bethlenfalvay and Dakessian 1984). Tapertip hawksbeard frequency was not significantly different ($P > 0.05$) on 1- to 3-year rested or immediately spring or summer grazed post-fire sites in the Owyhee Mountains of southwestern Idaho (Clark et al. 2016, 2018). Frequency differences for tapertip hawksbeard on rested and ungrazed sites were not statistically significant. Summer post-fire grazing was light with about 30 days of use occurring mostly in July at a stocking rate of 11 ha/animal unit month (AUM) (Clark et al. 2018). Spring post-fire grazing use was mostly in May at stocking rates of 45 ha/AUM for the first 15 days and 23 ha/AUM for the second 15 days (Clark et al. 2016).

Nutritive value. Several studies have evaluated the nutritive value of tapertip hawksbeard as a forage over time and with site changes. Hawksbeard plants collected in March or early April in sagebrush habitats in southeastern Oregon averaged 30% crude protein, 0.8% calcium, and 0.5% phosphorus (Barnett and Crawford 1994). At the USSES, crude protein decreased and calcium increased as tapertip hawksbeard plants aged. Phosphorus fluctuations were more variable but tended to increase from mid-May through the end of June (Table 2; Blaisdell et al. 1952).

Table 2. Seasonal changes in chemical composition of tapertip hawksbeard growing at the USSES near Dubois, Idaho (Blaisdell et al. 1952).

1942 Date	Crude protein (%)	Ca (%)	P (%)
April 30	18.8	0.93	0.39
May 6	18.2	0.87	0.23
May 15	16.0	1.15	0.30
May 27	12.6	1.76	0.46
June 4	12.1	1.85	0.48
June 29	6.6	2.23	0.56

When 1- and 2-year-old burned and unburned plots were compared during the late greater sage-grouse brood rearing period, crude protein was greater for flowers and leaves of burned plants than unburned plants (Table 3; McDowell 2000).

Table 3. Average nutritional and energy content of tapertip hawksbeard plants on burned and unburned sites sampled during the late greater sage-grouse brood-rearing period (late-July-early August) on South Steen Mountain, Oregon (McDowell 2000).

Treatment	Ca(%)	P (%)	Crude protein (%)	Gross energy (cal/g)
Flowers[1]				
Unburned	0.85c	0.40b	11.3a	4155.4a
1-year-old burn	0.65a	0.46a	11.8b	4266.4a
2-year-old burn	0.73b	0.46a	12.5c	4145.7a
Leaves				
Unburned	2.09a	0.26a	10.4a	3847.7a
1-year-old burn	2.24a	0.24a	12.8b	3918.8c
2-year-old burn	2.07a	0.29b	14.3c	3896.2b

[1] Values for flowers or leaves within a column followed by different letters are significantly different (P = 0.1).

Ethnobotany. Limited food and medicinal uses of tapertip hawksbeard are reported in the literature. The Karuk people indigenous to California peeled tapertip hawksbeard stems and ate them raw. The Shoshoni sprinkled pulverized root pieces into the eye to dislodge foreign objects and sooth eye inflammations. They also used a poultice of seeds or entire plants to relieve breast pain and induce milk flow following child birth (Moerman 20

REVEGETATION USE

To improve forage habitat for pollinators and wildlife, tapertip hawksbeard is a restoration species to consider (Eldredge et al. 2013; Dumroese et al. 2016). Although seedling growth is often slow, plants are considered long-lived by those with experience growing the species (Ogle et al. 2012). Once established, long-disance wind dispersal is encouraged by the production of light-weight seeds with pappi with barbed hairs (Bogler 2006). Tapertip hawksbeard has been identified as an important species for seed development because of its importance to greater sage-grouse (Lambert 2005a).

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 restoration.

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. Because empirical seed zones are not currently available for tapertip hawksbeard, 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 6, 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.

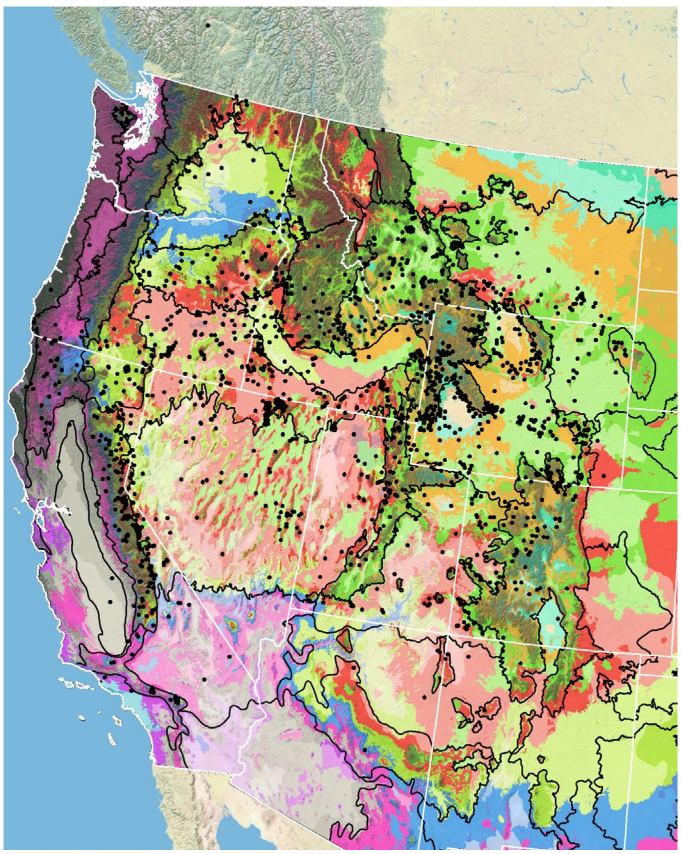

Figure 6. Distribution of tapertip hawksbeard (black circles) based on geo-referenced herbarium specimens and observational data from 1881 to 2016 (CPNWH 2017; SEINet 2017; USGS 2017). Generalized provisional seed zones (colored regions; Bower et al. 2014) are overlain by Omernik Level III Ecoregions (black outlines) (Omernik 1987; USDI EPA 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, USGS.

Releases. As of 2018, there had been no tapertip hawksbeard germplasm releases.

Wildland Seed Collection. Mature tapertip hawksbeard seed is available from mid-June through mid-July (Fig. 7). Presence of a fluffy white pappus is a good indication that seed is ripe. Harvesting seed before the pappus opens dramatically increases the amount of non-viable seed collected (Tilley et al. 2012). Because insect damage to seeds is common, evaluating the damage in potential collection areas can help to plan efforts for maximum seed yield. In wildland stands in central Utah, the percentage of insect-infested flower heads ranged from 0.9 to 80%, and the percentage of seed damage ranged from 0.7 to 22% depending on the site and year (Anderson 2009). Common seed predators included tephritid flies (*Campiglossa* spp.) and snout moths (*Phycitodes albatella*) (Anderson 2009). In 2012 it was reported that wildland collections were not typically available from commercial sources, and contract collecting costs exceeded $100/lb (Tilley et al. 2012).

Figure 7. Uncleaned tapertip hawksbeard seed collected from wildland stands. Photo: USFS, Bend Seed Extractory.

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 on revegetation projects, collectors must apply for certification prior to making collections. Applications and site inspections are handled by the state certification agency 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 collection 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 if the protocol includes 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. For individual tapertip hawksbeard plants, the flowering and seed ripening window is quite narrow, but phenology timing varies from year to year depending on weather conditions (Blaisdell 1958; Bates et al. 2006). Presence of a fluffy white pappus is a good indication that seed is ripe (Tilley et al. 2012). For maximum seed viability of wildland harvests, seed should be collected gently by hand, taking seed only from the open heads, and leaving seed in unopened heads for later collection (S. Jensen, USFS, personal communication, July 2018).

Based on 44 wildland seed collection records from 8 consecutive years (2009-2016), the earliest collection made by BLM SOS field crews was June 6, 2013 from a 3,900-foot (1,200 m) site in Malheur County, Oregon. The latest collection was made September 26, 2016 from a 5,700-foot (1,700 m) site in Washoe County, Nevada. The date range for the largest collection year (17 collections in 2010), was July 7 at 5,200 feet (1,600 m) in Humboldt County, Nevada, and August 4 at 5,180 feet (1,580 m) in Malheur County, Oregon (USDI BLM SOS 2017). Phenology variations by year and weather conditions are also discussed in the Reproduction section.

Collection methods. Staff and researchers at the USDA FS Provo Shrub Sciences Laboratory (PSSL) in Utah, developed several tools and techniques for collecting small lots of tapertip hawksbeard (Jensen 2004). They built seed collection hoppers by sewing heavy-duty nylon cloth to a round frame such that the midpoint of the cloth dropped to form a basket to capture seeds. Hoppers also included adjustable straps to be worn around the collector's neck and back to distribute the weight and bulk of the hopper. For plants with open seed heads, badminton racquets were used to sweep ripe seeds into the hopper. If conditions were windy however, seeds were hand-plucked from the heads (Jensen 2004).

Because tapertip hawksbeard seeds are easily wind-dispersed, collecting seed heads early in the day or ripening process when heads are closed is an option (Fig. 8). However, Jensen (2004) found that viability of closed seed heads was 40% and of open seed heads was 61%. Comparisons of the collections were made on the same site on the same day.

Figure 8. Tapertip hawksbeard producing seed heads in the Ruby Mountains of Nevada. Photo: S. Jensen, USFS.

Several collection guidelines and methods can 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 also presented in available manuals (e.g., USDI BLM SOS 2016; ENSCONET 2018).

Post-collection management. Because seed insects are common, seed lots should be frozen or pesticide treated as soon as possible following thorough drying and before storing or processing.

Seed Cleaning. Tapertip hawksbeard seed can be cleaned of chaff and seed contaminants without any mechanical equipment, but if pappus removal is necessary, some mechanical processing is likely necessary (Fig. 9).

Figure 9. Cleaned tapertip hawksbeard seed. Photo: USFS PSSL, SOS.

At the PSSL, staff cleaned small seed lots of tapertip hawksbeard of chaff and seed contaminants by tossing seed against a steeply inclined board covered in felt material. The contaminant grass seeds, which were commonly squirreltail (*Elymus elymoides*) and cheatgrass (*Bromus tectorum*) for Utah collections, stuck to the felt while the tapertip hawksbeard seed bounced off or quickly fell when the board was shaken or tapped. This cleaning process did not remove the pappus, which was left intact for laboratory seed studies (Jensen 2004).

For internal seed studies and uses requiring pappus removal, the following two guidelines were described for small seed lots:

Process seed using a brush machine with the gate closed to remove the pappus. Final cleaning can be done using a multi-deck air screen cleaner with a 4-mm hole screen on top, 1.4-mm slot screen on the bottom, and light air (Tilley et al. 2012).

Process seed through a brush machine (Westrup Model LA-H, Westrup A/S, Slagelse, Denmark, in this case) using a #10 mantel and medium speed. Air-screen the seed using an office clipper with a 1/14 X 1/2 slot top screen, 1/18 round bottom screen, and medium speed and air (Barner 2007).

Seed Storage. Tapertip hawksbeard seed is orthodox, meaning seed can be dried and stored and seed longevity increases with reductions in both moisture content and storage temperature (RGB Kew 2018). No reports of seed viability retention with duration of storage were available.

Seed Testing. A tetrazolium chloride viability testing procedure was developed by the International Seed Testing Association for the *Crepis* genus (Moore 1985). There is no Association of Official Seed Analysts (AOSA) rule for testing germination.

Germination. Chilling requirements for germination vary among seed lots, which may reflect population variation, seed lot age, storage conditions, or other factors. Some indicate that tapertip hawksbeard seed germinates without pretreatment (Young and Young 1986; Karrfalt and Vankus 2012), but several others report that cold-stratification is necessary for good germination (Vernon et al. 2007; Jensen and Stettler 2012; Tilley et al. 2012). In a review of available germination protocols, Karrfalt and Vankus (2012) reported that tapertip hawksbeard germinated well at 50, 59, and 68 °F (10, 15, 20 °C) with or without 4 weeks of prechilling. Substantial cold stratification may be required for some seed lots. Researchers at the PSSL reported that germination largely failed without cold stratification (Jensen and Stettler 2012). At the NRCS Plant Materials Center (IDPMC) in Aberdeen, Idaho, germination of tapertip hawksbeard was 0 to 11% without stratification and as high as 75% after 8 months of cold stratification 34 °F (1 °C) in moist peat moss (Tilley et al. 2012).

Wildland Seed Yield and Quality. Post-cleaning seed yield and quality of seed lots collected in the Intermountain region are provided in Table 4. The results indicate that tapertip hawksbeard seed can generally be cleaned to high levels of purity and that viability and fill of fresh seed can be variable (USFS BSE 2017).

Seeds are small averaging about 150,000/lb (333,000/kg) (Table 4). Other sources, including the IDPMC with more than 20 accessions, report similar values ranging from 85,800 to 261,000 seeds/lb (188,900-575,000/kg) (Tilley et al. 2012; USFS GBNPP 2014; RGB Kew 2018).

Table 4. Seed yield and quality of tapertip hawksbeard 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)	0.78	0.08-6	37
Clean weight (lbs)	0.08	0.004-0.31	37
Clean-out ratio	0.14	0.006-0.68	37
Purity (%)	97	89-99	37
Fill (%)[1]	90	60-99	37
Viability (%)[2]	92	61-98	27
Seeds/lb	149,624	99,473-227,020	37
Pure live seeds/lb	133,803	90,600-203,002	27

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

Figure 10. Tapertip hawksbeard growing in research plots at Oregon State University's Malheur Experiment Station in Ontario, OR. Photo: N. Shaw, USFS.

Marketing Standards. Acceptable seed purity, viability, and germination specifications vary with revegetation plans. Purity needs are highest for precision seeding equipment used in nurseries, while some rangeland seeding equipment is able to handle less clean seed.

Wildland-collected seed viability can be highly variable (Tilley et al. 2012); 80 to 90% viability and 90% purity are recommended marketing standards (Walker and Shaw 2005).

AGRICULTURAL SEED PRODUCTION

Some initial investigations related to establishment and maintenance of tapertip hawksbeard stands for seed production have been made (Fig. 10).

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 procedures. State seed certification offices administer the Pre-Variety Germplasm (PVG) Program for field certification for native plants, which tracks geographic origin, genetic purity, and isolation from field production through seed cleaning, testing, and labeling for commercial sales (Young et al. 2003; UCIA 2015). Growers should use 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 regulators.

Seeding. Greenhouse studies indicate that seeds must be buried (Rawlins et al. 2009). Recommended seeding depths ranged from 0.13 to 0.75 inch (0.3-1.9 cm) (Vernon et al. 2005; Rawlins et al. 2009). Stand emergence and persistence is unlikely in clay soils and better in sandy loam soils (Rawlins et al. 2009).

Establishment and Growth. Stand establishment is reportedly difficult (Tilley et al. 2012). Direct fall seeding of tapertip hawksbeard in fields in central Utah in 2005 resulted in some emergence, spotty stand establishment, but some plants were flowering in 2006 (Vernon et al. 2007). Jones and Whittaker (2009) reported good emergence following direct fall seeding to establish seed fields in central Utah. Flea beetle (Chrysomelidae) infestations in the establishment year, however, decimated the crop.

Pollinator Management. In studies at the USDA ARS Bee Biology and Systematics Lab in Logan, Utah, researchers increased managed populations of mason bees (*Osmia montana*) on tapertip hawksbeard (Cane 2005). This mason bee is an easily managed pollinator and can be transported to field locations in portable ground nests or hives to encourage pollination of sexual tapertip hawksbeard stands (Cane 2008; Cane et al. 2012).

Pest Management. Tapertip hawksbeard vegetation, flowers, and seeds are host to a variety of pests.

The following fungi utilize tapertip hawksbeard as a host: *Aecidium crepidicola*, *Cercospora stromatis*, *Erysiphe cichoracearum*, *Phyllosticta eximia*, *Puccinia crepidis-acuminatae*, *P. crepidis-montanae*, *P. hieracii*, and *P. stipae* (Reed 1913; Wehmeyer 1947; Farr and Rossman 2017).

Insect larvae (tephritid flies [*Campiglossa* spp.] and snout moths [*Phycitodes albatella*] are frequent in seed heads, and insect damage can significantly reduce seed yields (Anderson 2009; Tilley et al. 2012). Indian rock buprestid (*Acmaeodera idahoensis*) was collected from tapertip hawksbeard flowers in Crook County, Oregon (MacRae and Basham 2013). In central Utah, a systemic pesticide application of imidacloprid was effective in reducing seed damage on one of three sites (Anderson 2009).

Seed Harvesting. Although some tapertip hawksbeard plants flowered the year after planting in central Utah fields (Vernon et al. 2007), most report that it takes 3 to 5 years before seeded plants produce seed (Jensen 2011; Tilley et al. 2012). Because flowering and seed ripening are indeterminate, multiple seed harvests may be necessary for maximum seed yield and to obtain maximum genetic diversity (Tilley et al. 2012).

Because seed is easily wind-dispersed and the seed ripening window for plants and populations can be narrow, close monitoring is necessary and harvesting should begin before all seed heads have expanded if harvesting by flail vac, suction, or racquet and hopper methods (S. Jensen, USFS, personal communication, July 2018).

NURSERY PRACTICE

Success has been limited in production of tapertip hawksbeard nursery stock. Researchers reported that tapertip hawksbeard failed to produce the mass of roots necessary to hold the plant media and make for easy transplanting (Vernon et al. 2005). Tilley et al. (2012) reported that the long delicate taproot produced by tapertip hawksbeard seedlings was easily damaged during transplanting and that outplanting of bare root and container stock had variable success. Studies did not allow researchers to evaluate the time to seed production from container stock (Tilley et al. 2012).

WILDLAND SEEDING AND PLANTING

Fall seeding tapertip hawksbeard as part of a seeding mixture is recommended for fine sandy loams, silts, coarse-textured, or gravelly soils receiving at least 8 to 20 inches (200-500 mm) of precipitation (Walker and Shaw 2005; Vernon et al. 2007; Ogle et al. 2012; Tilley et al. 2012).

Figure 11. Tapertip hawksbeard transplant growing in research plots near Nephi, UT. Photo: S. Jensen, USFS.

Seed mixes. Tapertip hawksbeard is typically recommended as part of a wildland seed mix, often making up a minor proportion (<10%). Full seed rates reported were: 18 seeds/ft² (198/m²) at the 1lb (0.45 kg) pure live seed (PLS) rate/acre, and a pure stand seeding rate of 3 lbs PLS/acre (3.4 kg/ha) (Ogle et al. 2012), and for 25 to 30 PLS/feet (100/m) at 12-inch row spacing is 7 PLS lb/acre (8 kg/ha) (Tilley et al. 2012). For a seed mixture, adjust these rates according to the desired proportion. In big sagebrush seed mixes, tapertip hawksbeard was recommended at 0.2 PLS lb/acre (0.2 kg/ha) where 7.8 to 8.4 PLS lbs/acre (8.7-9.4 kg/ha) of shrubs, grasses, and forbs were to be drill seeded (Lambert 2005b).

Seeding. Greenhouse studies conducted to develop seeding depth recommendations for seed fields and wildlands indicated that seed must be covered, but depth recommendations varied [0.13-0.75 in (0.3-2 cm)] (Vernon et al. 2005; Rawlins et al. 2009). Shallower recommendations [0.13-0.5 inch (0.3-1.3 cm)] were more common in the literature (Rawlins et al. 2009; Ogle et al. 2012; Tilley et al. 2012). When seeding depths of 0 to 1 inch (30 cm) were evaluated in sandy loam and clay loam soils, emergence was greatest at 0 to 0.6 cm, but survival to 45 days was significantly lower with surface seeding ($P = 0.017$) (Rawlins et al. 2009). Emergence was greater in sandy loam than clay loam soils ($P = 0.004$). At the conclusion of the study, researchers recommended planting tapertip hawksbeard 0.3 to 0.6 cm deep on sandy soils and avoiding seeding in clay soils, where emergence was less than 12% (Rawlins et al. 2009). In germination trials conducted by the Great Basin Research Center, seeding depths of 0.25 to 0.75 inch (0.6-2 cm) were considered best (Vernon et al. 2005).

Seed burial and protection from trampling was best for seedling establishment in experimental seedings in big sagebrush communities north of Elko, Nevada (Eckert et al. 1986). Seedling establishment was best (0.47-0.52 seedlings/ft² [5.2-5.8/m²]) when seeds were placed into naturally occurring trenches or cracks in the soil surface on sites protected from cattle for 1 year. Establishment was significantly higher (2.7-2.9 seedlings/m²) for seeds in natural cracks and trenches than those on the soil surface (0.8-1 seedling/m²) even with cattle use. Some natural protection of seedlings, which came from seeds falling into natural soil crevices, was most important to establishment (Eckert et al. 1986). At least two full growing seasons of grazing protection are recommended on newly seeded sites to allow for full stand establishment (Tilley et al. 2012).

Establishment largely failed and no seedlings survived a year when tapertip hawksbeard was seeded into Wyoming big sagebrush vegetation in Toole County, Utah. Tapertip hawksbeard was broadcast seeded (season not reported) at 0.5 PLS/ft² (5.2/m²) and had less than 1% establishment when seeding was followed by Ely chaining (Gunnell and Summers 2016).

Planting. In one study, outplanting of nursery stock was unsuccessful in north Logan, Utah. Whitcomb (2011) had difficulty producing tapertip hawksbeard seedlings in the greenhouse (see Nursery Practice section above). When the few greenhouse-grown seedlings were planted in plots at the Utah State University Green Canyon Ecology Center in May, all died within the 3 weeks of discontinuing watering, which occurred in mid-June (Whitcomb 2011).

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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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