

Blanketflower (*Gaillardia aristata*)

AUTHORSHIP

Gucker, Corey; Shaw, Nancy

PUBLICATION DATE

January 2025

Nomenclature

Blanketflower (*Gaillardia aristata* Pursh) belongs to the Gaillardiiinae subtribe and Helenieae tribe of the Asteraceae family (Strother 2006). This species was first collected on July 7, 1806, during the Lewis and Clark expedition. It was growing on a dry low-elevation hillside in the Rocky Mountains of Lewis and Clark County, Montana, where it was still common in vegetation surveys conducted in the late 1990s (Reveal et al. 1999).

Family

Asteraceae – Aster family

Genus

Gaillardia

Species

aristata

NRCS Plant Code

GAAR (USDA NRCS 2024).

Subtaxa

There were no subtaxa recognized as of 2024 (USDA NRCS 2024).

Synonyms

None

Common Names

Blanketflower, brown-eyed susan, common gaillardia, gaillardia, great blanketflower, Indian blanketflower (Strother 2006; Winslow 2011a; LBJWC 2022).

Chromosome Number

Chromosome numbers are: $2n = 34, 36, 68, 72$ (Cronquist 1994; Strother 2006).

Hybridization

No natural hybrids have been described. Stoutamire (1977) reported that blanketflower is partially infertile with but geographically isolated from Indian blanket (*Gaillardia pulchella*). Horticulturalists, however, have produced many cultivars through controlled hybridization, especially between *G. aristata* and *G. pulchella* (more information available in the Horticulture section).

Distribution

Blanketflower is broadly distributed in Canada and the United States. It occurs in nearly all Canadian provinces, is well distributed to common and abundant in the northern and western United States (Strother 2006). Populations beyond its native range have established by spread from reclamation, roadside, and horticultural plantings (Dorn and Dorn 2007; Keil 2012).

In the western United States, blanketflower is widespread east of the Cascade Mountains in the Pacific Northwest (Hitchcock and Cronquist 2018). It occurs in all counties in Montana, more than half of Wyoming's counties (Winslow 2011b), and Daggett, Duchesne, and Uintah Counties in northern Utah (Welsh et al. 2015). It is uncommon in California (Hickman 1993).

Habitat And Plant Associations

Blanketflower occurs in a variety of communities and habitats. It is common in open or recently disturbed vegetation with good drainage receiving 10 to 30 in (250-760 mm) of annual precipitation (Cronquist 1994; Winslow 2011b; Pratt et al. 2024). The species tolerates harsh environmental and weather conditions (Pratt et al. 2024), and dense populations are frequent along roadsides (Taylor 1992). Potential habitats include prairies, mountain grasslands (Fig. 1), sagebrush (*Artemisia* spp.) shrublands (Fig. 2), gamble oak (*Quercus gambelii*), pinyon-juniper (*Pinus-Juniperus* spp.), and quaking aspen (*Populus tremuloides*) woodlands, conifer forests, and riparian areas (Link 1993; Strother 2006; Welsh et al. 2015; Winslow et al. 2023).



Figure 1. Blanketflower plant in full bloom growing in a Montana rangeland. Photo: USDI Bureau of Land Management (BLM) MT050 Seeds of Success (SOS).

Blanketflower occurs in prairies and sagebrush grasslands in southern Canadian provinces. Near Penticton, British Columbia, blanketflower grew in big sagebrush/bluebunch wheatgrass (*A. tridentata*/*Pseudoroegneria spicata*) transitional communities between big sagebrush and ponderosa pine (*Pinus ponderosa*) on steep northern slopes at elevations of 1,800 to 2,460 ft (550-750 m) (Pitt

and Wikeem 1990). In southern Alberta and Saskatchewan, blanketflower commonly grew in fescue (*Festuca* spp.) grasslands (Moss 1955; Ayyad and Dix 1964). In northern prairies near Saskatoon, Saskatchewan, blanketflower primarily occupied northern aspects of fescue grasslands where annual precipitation averaged 13.7 in (348 mm) (Ayyad and Dix 1964). In northern prairies blanketflower was more common on gentle than steep slopes, associates included common yarrow (*Achillea millefolium*), manyflowered aster (*Symphyotrichum ericoides* var. *pansum*), prairie sagewort (*Artemisia frigida*), spiny phlox (*Phlox hoodii*), and broom snakeweed (*Gutierrezia sarothrae*) (Currah et al. 1983).



Figure 2. Blanketflower growing in a big sagebrush shrubland in Oregon. Photo: BLM OR135 SOS.

In the northwestern United States, blanketflower is common in Idaho fescue (*F. idahoensis*) and bluebunch wheatgrass grasslands and open, dry conifer forests. It was frequent in open park-like grasslands with widely scattered Douglas-fir (*Pseudotsuga menziesii*) in the Upper Columbia Valley (McLean and Holland 1958). Along the Spokane River in eastern Washington, blanketflower and arrowleaf balsamroot (*Balsamorhiza sagittata*) were the dominant forbs in gravelly prairie adjacent to ponderosa pine forests (Turesson 1914). It was also common in bluebunch wheatgrass and Idaho fescue grasslands in southeastern Washington and adjacent Idaho, where it was more common on northeastern than southwestern exposures (Weaver 1914; Daubenmire 1942). In western Montana, blanketflower occurred in Idaho fescue-western wheatgrass (*Pascopyrum smithii*) and Idaho fescue-bluebunch wheatgrass grasslands growing primarily east of the Continental Divide on gentle slopes (<15%) at elevations of about 3,900 to 5,900 ft (1,200-1,800 m) (Mueggler and Stewart 1980; Mueggler 1983). In a study of western Montana grasslands, blanketflower preferred north-facing, high-elevation sites within an insolation range of 27.43 to 31.86 MJ/m² and an elevation range of 3,700-5,480 ft (1,130-1,670 m). Specific leaf area of blanketflower decreased with increasing insolation ($P = 0.011$) and increased with increasing elevation ($P = 0.015$) (Victor et al. 2023). Blanketflower is a prevalent forb in the shrubby cinquefoil/rough fescue (*Dasiphora fruticosa*/*F. campestris*) rangeland type, occurring mostly north of the border between North and South Dakota and east of the Continental Divide. This rangeland type occupies gentle slopes at 4,600 to 5,900 ft (1,400-1,800 m) where annual

precipitation averages 20 to 30 in (510-760 mm), and temperatures range from -50 to 100 °F (-50 to 40 °C) (Shiflet 1994).

In Colorado, blanketflower is characteristic of xeric early-seral and stable grasslands, meadows, and riparian areas (Reed 1917; Vestal 1917). On the Colorado Front Range, blanketflower occurred in early seral grasslands with sparse vegetation on gravel slides with high wind and sun exposure. It also grew in grasslands dominated by blue grama (*Bouteloua gracilis*) with higher total vegetation cover on more stable soils (Vestal 1917). In Boulder Park, northern Colorado, blanketflower was abundant in meadows at 8,890 ft (2,710 m) where a week without frost was rare and the annual temperature averaged 40 °F (4 °C). It was also abundant in streamside communities (Reed 1917).

Elevation

Blanketflower occurs at elevations from about 160 to 9,500 ft (50-2,900 m) throughout its range (Cronquist 1994; Strother 2006). The elevation range is 160 to 5,200 ft (50-1,600 m) for populations in Oregon, less than 8,200 ft (2,500 m) in California (Keil 2012), and 7,060 to 9,120 ft (2,140-2,780 m) in Utah (Welsh et al. 2015).

Soils

Blanketflower grows in well-drained, loamy to rocky, gravelly, or sandy soils that range from slightly acidic to mildly alkaline (Winslow 2011b). It is particularly common on dry, sandy benches (Strother 2006). In northern prairies near Saskatoon, Saskatchewan, blanketflower primarily occurred on rolling hills of glacial till with dark brown loam soils (Ayyad and Dix 1964). In dry fescue grasslands in southwestern Montana, it was associated with soils derived from highly weathered residual limestone (Mueggler 1983). Near Georgetown, north-central Colorado, it occurred in coarse sand and disintegrating granite (Ramaley 1919a) and in Rocky Mountain National Park, blanketflower grew in rich black loams and in loose sand covering rich soils (Holch et al. 1941). In Hungary where invasiveness of blanketflower was evaluated, blanketflower abundance was greatest in sandy or loose textured soils in old fields (Süle et al. 2023).

Depth of soils was rarely reported but in the shrubby cinquefoil-rough fescue rangeland type where blanketflower is prevalent, soils were described as moderately deep, of limestone or sandstone origin with a rooting depth of 10 to 18 in (25-46 cm). This type occurs mostly north of the border between North and South Dakota and east of the Continental Divide (Shiflet 1994).

Blanketflower tolerates low fertility and slightly acidic or alkaline soils (pH < 6.8-9) (McLean and Holland 1958; LBJWC 2022). It grew in fescue grasslands in western Canada with low nitrogen and phosphorus (Looman 1969). In grasslands in the Upper Columbia River Valley, it was associated with dark brown soils on gravelly parent materials. These soils had a shallow A1 horizon and a strong lime concentration at 8 to 11 in (20-28 cm) below the surface where the pH was 8.4 to 9 (McLean and Holland 1958). Blanketflower was absent from sites invaded by sweetclover (*Melilotus* spp.) in Rocky Mountain National Park. In soil comparisons between invaded and predominantly native grasslands, mineralization and nitrogen availability were lower and soil moisture content and C:N ratios were higher in invaded than uninvaded sites (Wolf et al. 2004).

Blanketflower grows in dry to mesic soils. It was an indicator of dry-mesic grasslands and occurred across a broad range of moisture regimes in grasslands of Saskatchewan (Looman 1963). The semi-arid grasslands received annual precipitation of 11 to 17 in (280-432 mm) with fluctuations of +175% and -70% recorded. The frequency of blanketflower was greatest in the middle moisture classes but also extended to dry and mesic classes along a moisture gradient where +300 was entirely arid and -300 was entirely wet (Table 1; Looman 1963).

Table 1. Frequency of blanketflower in Saskatchewan grasslands that occupied a moisture gradient from entirely dry (+300) to entirely wet (-300) (Looman 1963).

Moisture class	+250	+200	+150	+100	+50	0	-50	-100	-150	-200	-250
Frequency (%)	0	9	16	31	42	51	52	39	16	0	0

Blanketflower occurred in xerophytic grasslands and riparian habitats in Colorado (Reed 1917; Ramaley 1919b). In Boulder and Gilpin Counties, it grew in grasslands with soils of disintegrated rock and rather coarse-grained pebbles or boulders. These soils dried quickly and averaged 7% water content (Ramaley 1919b). In meadows

in Boulder Park, northern Colorado, blanketflower was abundant in streamside communities and in gravelly soils well supplied with water (Reed 1917).

In a controlled study, container-grown blanketflower plants subjected to drought conditions had similar biomass as those watered moderately (Wang et al. 2017). The study began with 40-day old blanketflower seedlings subjected to

drought conditions (watered to saturation 1-2 times/wk) or moderate moisture conditions (watered to saturation every other day). At the end of the trial (70 days), biomass differences for the treatments were not significant (Wang et al. 2017).

In another drought exposure experiment, blanketflower displayed drought avoidance strategies in a study conducted outdoors at Greenville Agricultural Research Farm in North Logan, Utah (Zollinger et al. 2006). Blanketflower was grown in 10-gallon (38-l) pots for 1 year before the irrigation treatments, which included watering containers to capacity at 1-, 2-, and 4-week intervals. Biomass was six times greater for plants watered each week compared to plants watered at 4-week intervals ($P < 0.05$). Plants died back to the ground in 4-week watering interval trials but regrew with irrigation. Researchers suggested that blanketflower might perform better under drought conditions where root growth is not confined (Zollinger et al. 2006).

Description

Blanketflower is a perennial plant with a simple crown or loosely few-branched caudex. It sometimes flowers in its first year (Cronquist 1994; Strother 2006). Plants have one to several, erect, simple or sparingly branched stems 8 to 30 in (20-80 cm) tall (Strother 2006; Lesica 2012; Pavék et al. 2012; Hitchcock and Cronquist 2018). Plants grow taller at lower elevations and are often dwarfed at high elevations (De Santo 1989). Each stem is topped by a single flowerhead (Fig. 3) (Taylor 1992). Plants are covered in fuzzy hairs giving the herbage a gray-green color that sometimes has reddish tones (Andersen and Holmgren 1996; LBJWC 2022). The plants form clumps of up to 16 in (40 cm) in diameter, which can be larger in disturbed sites (Currah et al. 1983).



Figure 3. Blanketflower plant with fully open flowers and tightly closed flower buds growing in Oregon. Photo: BLM OR135 SOS.

Plants produce tapering taproots, numerous fibrous roots, and sometimes spread by slender creeping roots (Coupland and Johnson 1965; Currah et al. 1983; Cronquist 1994). In northern prairies, blanketflower taproots reached up to 6 in (15 cm) deep with numerous fibrous roots in the top 4 in (10 cm) of soil. Roots had mycorrhizal associations (Currah et al. 1983). Three blanketflower plants excavated

from native grasslands in southern Saskatchewan had taproots that penetrated 4.3 to 5.6 ft (1.3-1.7 m) deep, but the taproots were indistinguishable in size from laterals at about 6 in (15 cm) depths (Coupland and Johnson 1965). Plants produced several large laterals near the soil surface. Fine root branches were not abundant (Coupland and Johnson 1965). In Rocky Mountain National Park, a blanketflower with two stems and flowers stalks 20 in (50 cm) tall produced roots reaching 30 in (80 cm) deep with well-branched lateral spread of 17 in (43 cm) near the soil surface (Holch et al. 1941).

Blanketflower produces variable alternate, basal and cauline leaves. Basal leaves are petiolate and larger than the reduced, sessile, and sometimes absent stem leaves (Currah et al. 1983; Strother 2006; Lesica 2012; Welsh et al. 2015). Petioles and blades are 2 to 6 in (5-15 cm) long and blades are 0.2 to 1.5 in (0.5-4 cm) wide. Blades are often narrow, oblanceolate to lanceolate with entire to coarse irregularly toothed or even somewhat pinnatifid margins (Hermann 1966; Cronquist 1994; Strother 2006; Hitchcock and Cronquist 2018). Blade faces range from minutely scabrous to sparsely to densely villous with jointed hairs and sometimes a red midvein (Strother 2006; Pavék et al. 2012).

Flower heads are typically terminal on long peduncles up to 12 in (30 cm) long. Involucre are large with bracts arranged in whorls of two or three (Cronquist 1994; Lesica 2012; Hitchcock and Cronquist 2018). Bracts have long hairs at their bases and become strongly reflexed in fruit (Goodrich and Neese 1986; Lesica 2012; Welsh et al. 2015). Flower heads are showy, large (up to 2.5 in (6.4 cm) across) and variable (Figs. 4 and 5) (Cronquist 1994; Andersen and Holmgren 1996; Dorn and Dorn 2007; Lesica 2012; Pavék et al. 2012). Heads include 6 to 18 or more sterile ray florets that surround 60 to 120+ bisexual and fertile disk florets (Strother 2006; Hitchcock and Cronquist 2018). Ray florets are typically bicolored, orange, red, or purple near the disks and yellow to orange distally. They are about 1 in (2.5 cm) long with 3- to 5-lobed notched tips (Hermann 1966; Currah et al. 1983; Taylor 1992; Andersen and Holmgren 1996; Strother 2006; Lesica 2012; Pavék et al. 2012; Hitchcock and Cronquist 2018). The disk is about 0.6 to 1.2 in (1.5-3 cm) wide with brownish-purple florets (Currah et al. 1983; Taylor 1992; Cronquist 1994; Strother 2006). Flower variability was studied in 500 heads on plants growing near Boulder, Colorado (Robbins 1908). While flower heads normally produced 13 ligulate ray florets, some produced up to 33 rays. Those with greater than 13 rays produced a mix of ligulate and tubular ray florets with 4-lobed tips. Plants growing in aspen groves produced larger rays than plants growing in the open (Robbins 1908).



Figure 4. Close-up of a single blanketflower flower head with less than 25 deeply 4-cleft yellow tubular ray florets growing in Montana. Photo: BLM MT050 SOS.



Figure 5. Close up of a single blanketflower flower head with many (>40) ray ligulate orange and red bicolored florets lacking deep clefts. This plant photographed in Wyoming. Photo: BLM WY080 SOS.

Blanketflower produces achenes that are obconic or obpyramidal, brown to gray or black, and 2 to 6 mm long (Currah et al. 1983; Lesica 2012; Welsh et al. 2015; Hitchcock and Cronquist 2018; Chambers 2020). They are densely hairy or bristly with a pappi of 6 to 10 awned scales measuring 5 to 10 mm long (Currah et al. 1983; Strother 2006; Lesica 2012; Chambers 2020). Awns are twice the length of the scales (Hermann 1966; Goodrich and Neese 1986; Hickman 1993).

Reproduction

Blanketflower reproduces from seed.

Phenology

In northern prairie and grassland habitats, blanketflower germinates or emerges from April to June. Plants generally flower in July and August, but throughout its range, flowering can occur from May to September. Seeds ripen and disperse in late July to September (Currah et al. 1983; Strother 2006; Dorn and Dorn 2007; Hegstad and Maron 2019; Chambers 2020).

Studies tracking phenology in Canada and western Montana found that regrowth of blanketflower with a second round of flowering and seed production can occur in the fall (Pitt and Wikeem 1990), and seed production may be delayed in years with above average spring precipitation (Mueggler 1983). In 10 years of monitoring in Swift Current, Saskatchewan, the average first flowering date was June 23 with an earliest date of June 10 and a latest date of July 6. The average latest flowering date was August 22, and the average number of flowering days was 40 (Budd and Campbell 1959).

Phenology of blanketflower was also evaluated in a big sagebrush/bluebunch wheatgrass community on steep north to northeast slopes near Penticton, British Columbia (Pitt and Wikeem 1990). Study sites were visited during near normal precipitation and temperature conditions. Blanketflower growth began in March to May, flowering started in May or June, and plants were in full flower by July. Seed set and dissemination occurred from June to August. Plants had cured as early as July. Regrowth occurred in September. Plants were in full flower again in October and November with another round of seed set in October and plants cured again in December (Pitt and Wikeem 1990).

Over a 10-year period in a mountain grassland on a southwestern slope in western Montana at 7,100 ft [2,160 m] elevation, blanketflower was one of the latest forbs to begin growth in the spring (Mueggler 1983). The timing of seed ripening was correlated with spring precipitation and was delayed in years with above average precipitation from May to June. The average emergence date for blanketflower was May 17 with a range of May 3 to May 28. The average date of first blooms was July 15 with a range of July 11 to July 22. The average date that flowering ended was August 1 but varied from July 18 to August 12. Seed dissemination began on August 11 and continued through September 3 with an average date of August 17. Plants were cured between August 20 and September 24 with an average date of September 6 (Mueggler 1983).

Pollination

Good seed production likely requires pollinator visitation. Blanketflower is an important pollinator plant visited by many pollinating insects such as soft-winged flower beetles (*Amecocerus senilis*), golden northern bumblebees (*Bombus fervidus*), brown-belted bumblebees (*B. griseocollis*), long-horned bees (*Melissodes rivalis*), sweat bees (*Halictus ligatus*, *Lasioglossum leucocomum*, *L. pectorale*, *L. semicaeruleum*), leafcutter bees (*Megachile montivaga*), and blanketflower moths (*Schinia masoni*) (Brower and Brower 1956; Ferner and Rosenthal 1981; Mawdsley 1999; Ogle et al. 2011; Discover Life 2024).

In a field study in Missoula, Montana, blanketflower received 56% of observed European honey bee (*Apis mellifera*) visits to common gardens. Blanketflower had significantly more pollinator visits ($P < 0.05$) when grown with another flowering forb, Lewis flax (*Linum lewisii*) (4.4/sampling period), than when grown alone (2.6/sampling period) (Debnam et al. 2021).

Ecology

Blanketflower is a colonizing and pioneer species (Link 1993; Luna et al. 2008) that also occurs in open late-seral communities (Weaver et al. 1993). In Glacier National Park, Montana, plants grew on road cuts and in adjacent late-seral fescue grasslands (Weaver et al. 1993).

Seed And Seedling Ecology

Each seedhead contains many seeds but up to 50% may be empty. Germination is variable (45-90%) based on the seed lot (Currah et al. 1983). Blanketflower seeds are large and fall directly beneath the maternal plant even in heavy winds. Seeds are readily consumed by deer mice (*Peromyscus maniculatus*) (Hegstad and Maron 2019).

Researchers estimated that blanketflower flower heads produced an average of 230 seeds (Maron et al. 2018). This was based on counting the number of seeds in one undamaged seed head from a minimum of five randomly selected plants from four sites in Blackfoot Valley, western Montana. Average seed weight was 3.9 mg (Maron et al. 2018).

Deer mice preferred blanketflower seeds to those of spotted knapweed (*Centaurea stoebe*) in controlled cafeteria style trials ($P < 0.01$), and blanketflower showed a strong trend to increase when rodents were excluded in a field experiment (Pearson et al. 2011). In field studies in grasslands in Montana's Blackfoot Valley, recruitment of blanketflower was significantly ($P < 0.05$) reduced in the presence of rodents, where deer mice were the primary seed consumers (Maron et al. 2019). In this area, predispersal predation by insects was low, averaging just 0.9% (Palmer et al. 2021).

Researchers concluded that recruitment of blanketflower was safe site limited in highly productive resource-rich sites and seed limited in low productivity sites with fewer resources (Hegstad and Maron 2019). This was determined through field studies in semi-arid rough fescue grasslands in western Montana. Researchers added blanketflower

seed to low- and high-productivity plots where deer mice were and were not excluded. After 2 years, recruitment of blanketflower was highest at sites with low productivity and soil nutrients. Survival, however, increased with productivity and soil nutrients. Seed predation strongly reduced recruitment in both years but impacts of seed predation on recruitment were greater at sites with low productivity than at high productivity sites. Across sites, seed predation by deer mice strongly reduced blanketflower recruitment (59% in 2015 and 73% in 2016). In plots where rodents were excluded, increasing the density of blanketflower seed resulted in increased average recruitment across sites ($P < 0.0001$). Seed was added at 0.1 to 3 times the average fecundity of an individual plant. Across all seed densities in rodent excluded plots, recruitment decreased relative to increasing productivity and soil nutrients (Hegstad and Maron 2019).

A seedbank study in British Columbia's southern Okanagan Valley recovered blanketflower seed stored at least one season in the soil (Clements et al. 2007). The study occurred in a semi-desert antelope bitterbrush (*Purshia tridentata*) shrubland. Soil cores (depth: 4 in [10 cm], diameter: 0.75 in [1.9 cm]) were collected between May 24 and June 4, which is prior to current year seed production by blanketflower. Density of blanketflower above ground was 4/ft² (47/m²) and in the seedbank was 0.03/ft² (0.3/m²) (Clements et al. 2007).

Disturbance Ecology

Blanketflower is disturbance tolerant (Fig. 6), and its abundance often increases with mechanical disturbance, fire, and grazing (Antos et al. 1983; Maron et al. 2012; Byers 2017; Lyseng et al. 2018). Blanketflower abundance increased significantly with disturbance treatments in a study investigating rodent seed predation, disturbance, and seed size on recruitment of native and nonnative vegetation in semi-arid grasslands in western Montana (Maron et al. 2012). Disturbed plots were glyphosate treated in July 2009, dead vegetation was removed, and the top 4 in (10 cm) of soil cultivated. Blanketflower seed was added to disturbed plots in August 2009 (Maron et al. 2012).

An exponential increase in the abundance of blanketflower occurred on many sites within a year after a fire near Boulder, Colorado (Byers 2017). Blanketflower was predicted to become uncommon after several decades without fire (Byers 2017). One year after a 'hot' fire in a species-rich foothills grassland (rough fescue, Idaho fescue, and bluebunch wheatgrass) near Missoula, Montana, blanketflower cover was greater on burned than unburned plots but differences were not significant (Antos et al. 1983).



Figure 6. Blanketflower growing on a burned site in Wyoming. Photo: BLM WY070 SOS.

Cover of blanketflower was significantly greater outside than inside grazing exclosures in mixed-grass prairie in south-central Alberta ($P = 0.044$). Sites were grazed for more than 15 years primarily by cattle and stocking rates averaged 0.3 to 0.4 AUM/ac (0.7-1.0 AUM/ha) (Lyseng et al. 2018).

Wildlife And Livestock Use

Blanketflower provides cover and food to pollinators, wildlife, and livestock (Winslow 2011b). Although it is generally considered to be of low palatability to livestock, it was reportedly good sheep forage in the Colville National Forest, Washington, and flowers were regularly eaten by cattle and sheep in the Helena National Forest, Montana. Grazing of blanketflower is more likely to occur early in the growing season (Hermann 1966).

Blanketflower was preferentially grazed by domestic sheep in a study evaluating the use of sheep to control nonnative invasive forbs. The study occurred in invaded grasslands near Missoula, Montana. Sheep were preconditioned for 3 weeks on plots heavily invaded by leafy spurge (*Euphorbia esula*). Blanketflower was preferentially grazed when sheep were put in plots with both native and nonnative species from 9 June to 19 July in 2010 (Masin et al. 2018).

Various wildlife uses of blanketflower were reported in the literature. Thompson Indians in the British Columbia region reported that blanketflower was a spring food for grizzly bears (*Ursus arctos horribilis*) (Turner et al. 1990). Blanketflower contributed 2% to the August diets of bighorn sheep (*Ovis canadensis*) in southcentral British Columbia, making it the most preferred late summer forb (Wikeem and Pitt 1979). It was also eaten by mule deer (*Odocoileus hemionus*) in the Bridger Mountains of southwestern Montana. It made up a trace of rumen samples in summer, fall, and winter and 1% of observed plant use in summer (Wilkins 1957). Blanketflower made up a high of 10.3% frequency of occurrence and 0.9% volume in the diets of desert cottontails (*Sylvilagus audubonii*) collected in northcentral Colorado. It was only detected in desert cottontail diets in summer 1967 and not recovered in samples collected in summer 1966 or spring 1967 (deCalesta 1979). Blanketflower was a preferred food of Richardson's ground squirrel (*Citellus richardsonii*) at Prairie Divide in Larimer County, northern Colorado. It received a food preference index of 5, which was calculated

by dividing mean dry weight of blanketflower in diets by its mean dry weight in the community (Hansen and Ueckert 1970).

Blanketflower is an important host plant and nectar and pollen source for many pollinators. Bee pollinator associates include golden northern bumblebees (*Bombus fervidus*), brown-belted bumblebees, long-horned bees, leafcutter bees, several species of sweat bees, and blanketflower moths (Brower and Brower 1956; Discover Life 2024).

Soft-winged flower beetles (*Amecocerus senilis*) feed on blanketflower nectar and pollen. In the Village of Estes Park, Colorado, a total of 660 adults were collected, 48 of these from blanketflower flowers (Mawdsley 1999).

Blanketflower is a good nectar plant for adult butterflies (Tilley et al. 2019) and host to blanketflower moths (Byers 2017; Robinson et al. 2023). In observations made from 15 June to 10 July in 1955 in foothill and montane zones of Boulder County, Colorado, blanketflower moths were found only where blanketflower was in bloom (Brower and Brower 1956). The coloring of the blanketflower moths matches blanketflower flowers, allowing them to be cryptic when feeding. This suggests an intimate relationship or co-evolution (Brower and Brower 1956). In a 2-hour census conducted on June 21, 1979, at Boulder Mountain Park west of Boulder, Colorado, 21 blanketflower moths were found on 16 of 208 blanketflower flowers censused (Ferner and Rosenthal 1981).

Nutritional Value

Blanketflower outplanted into a field garden in Stillwater, Maine, had an averaged nectar volume of 0.11 µg/capitulum. At this site, blanketflower flowers were visited by bumblebees (*Bombus* spp.), European honey bees, orange-belted bumblebees (*B. ternarius*), and other solitary bees (Leach et al. 2021).

Ethnobotany

There are many Indigenous medicinal and tool uses of blanketflower. Thompson Indians of British Columbia took a decoction of blanketflower for headaches and general illnesses (Turner et al. 1990). A poultice of lightly toasted then pounded plant was mixed with bear grease and used to treat mumps. A decoction of the whole plant was taken for tuberculosis. The resulting color when blanketflower was boiled was used to predict if a patient would die. A clear to white liquid signified death, while red or well-colored water predicted survival (Turner et al. 1990).

Okanagan-Colville people of British Columbia and Washington applied a poultice of mashed plant wrapped in cheesecloth to sore backs. A tea of boiled blanketflower was drunk for kidney problems, and soaking in a bath where the whole plant was steeped was said to cure venereal disease (Turner et al. 1980).

Blackfeet Indians used blanketflower as a medicine and a tool for humans and livestock (Hellsen 1974 cited in Moerman 2003). Infusions of the plant were used as eyewash, nose drops, and to relieve the sore nipples of nursing mothers. A poultice of chewed or powdered roots was used to treat skin disorders. An infusion of

blanketflower roots was taken for gastroenteritis and an infusion of flower heads was used as a foot wash. An infusion of roots was used to treat saddle sores or other areas where horses were losing hair. This infusion was also used to treat minor lacerations and eye conditions of horses. Blanketflower flower heads were used as spoons to feed the sick and invalid, and rubbing flower heads on rawhide bags improved waterproofing (Hellsen 1974 cited in Moerman 2003).

Current Medicinal Use

Current medicinal uses of blanketflower were not reported in the literature, but research indicates the plant has medicinal properties (Kim 2016; Bosco et al. 2021). Researchers found pulchelloid A, a sesquiterpene lactone that inhibits mitosis in human cells in blanketflower. This compound is important to understanding cell biology and potentially useful to medical research (Bosco et al. 2021). Extracts from blanketflower flower have anti-melanogenic and antioxidant properties potentially useful in skin care products (Kim 2016).

Horticulture

Blanketflower is widely used and available in horticulture with more than 30 known blanketflower and Indian blanketflower cultivars (Hammond et al. 2007; Love 2014). Many horticultural plants are derived from controlled hybridization (e.g., *Gaillardia* × *grandiflora* van Houtte). These cultivars sometimes persist and spread sporadically beyond the natural range of the parent species and have been observed in scattered locations in Arizona and California (Strother 2006).

Ease of growing, drought and some salt tolerance, showy flowers, and pollinator attractiveness have all helped to make blanketflower an important horticultural plant (Andersen and Holmgren 1996; Mee et al. 2003; Parkinson 2003; Winslow 2011b). Plants grow quickly, reseed well, grow in full sun to part shade, and are suitable to USDA Plant Hardiness Zones 2 or 3 (Mee et al. 2003; Parkinson 2003). Blanketflower is also considered deer resistant (Parkinson 2003) and has low flammability (Carter et al. 2023).

Horticultural blanketflower hybrids are considered less drought tolerant than wild blanketflower (Love 2014). Regardless, hybrid cultivars and native blanketflower provide season-long color to native gardens and low maintenance landscapes in almost any soil except those that are heavy and wet. Seed requires no pretreatment or scarification and high rates of germination and blooms in the establishment year can be expected (Love 2014).

Gaillardia × *grandiflora* (a tetraploid hybrid) Hort. ex Van Houtte is available as several cultivars: 'Arizona Sun', 'Arizona Red Shades', 'Mesa Peach', and 'Mesa Red' (PFAF 2019). These horticultural hybrids prefer well drained soils but tolerate nutritionally poor and acidic soils. They are short-lived perennials hardy to USDA Zone 3 (PFAF 2019).

Pollinator visitation of horticultural plants was evaluated in California (Frankie et al. 2018) and Florida (Kalamian et al. 2022). Horticultural cultivar 'Oranges and Lemons' was planted near farms in Brentwood, California, to encourage

pollination of crops. It rated high in pollinator attractiveness with at least 15 bee species visitors recorded. Visitors included digger bees (*Anthophora* spp.), bumblebees, sweat bees (*Halictus* spp.), and long-horned bees (*Melissodes-Svastra* spp.) (Frankie et al. 2018). In Florida, the ornamental Barbican™ Yellow-Ring Blanketflower ('Gaiz005') was visited by honey bees, large-bodied bees, other bees, butterflies/moths, and wasps (Kalamian et al. 2022). Over 6 months at two sites, average pollinator visitation per 5-minute observation period was 25.3 for other bees (small to medium-bodied primarily solitary native bees), 1.18 for honey bees, 1.16 for butterflies/moths, 0.97 for large-bodied bees (bumblebees and carpenter bees), and 0.77 for wasps (Kalamian et al. 2022).

Revegetation Use

A widespread distribution, quick establishment, moderate growth rate, extended flowering period, and likely flowering in its first year makes blanketflower a good addition to restoration seed mixes (USDA NRCS n.d.; Dorn and Dorn 2007; Winslow 2011b; Ogle et al. 2019; Tilley et al. 2019). Plants are drought tolerant and recommended where annual precipitation ranges from 10 to 30 in (250-760 mm) (USDA NRCS n.d.; Winslow 2011b; Ogle et al. 2019; Tilley et al. 2019). Flowers provide nectar and attract bees, moths, and butterflies (Ley et al. 2007; Ogle et al. 2019). Tender young plant growth and insect-rich blooms are important to upland game birds (USDA NRCS n.d.).

Blanketflower has a low flammability rating suggesting it may be useful in fuel breaks and fire-wise landscaping (Carter et al. 2023). It is also recommended for wildfire and pollinator habitat and for use in energy reclamation (Utah State University 2024).

Developing A Seed Supply

For restoration to be successful, the right seed needs to be planted in the right place at the right time. Coordinated planning and cooperation is required among all partners to select appropriate species and seed sources; these are determined by site conditions and current or projected revegetation requirements and goals (PCA 2015) and consultation with land managers and stakeholders.

Developing a seed supply begins with seed collection from native stands. Collected seed is distributed for restoration or production of nursery stock. Increase in agricultural seed fields may be required to provide a supply of seed (PCA 2015). Production of nursery stock requires less seed than large-scale seeding operations. Regardless of the size and complexity of any revegetation effort, seed certification is essential for tracking seed origin from collection through use (UCIA 2015).

Seed Sourcing

Because empirical seed zones are not currently available for blanketflower, 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 average minimum winter temperatures and aridity (annual heat to moisture index). In Figure 7, Omernik Level III Ecoregions (Omernik 1987) overlay the provisional seed 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 (USDA FS WWETAC 2017) Threat and Resource Mapping (TRM) Seed Zone application provides links to interactive mapping features useful for seed collection and deployment planning. The Climate Smart Restoration Tool (Richardson et al. 2020) can also guide revegetation planning, seed collection, and seed deployment, particularly when addressing climate change considerations.

Occurrence Map

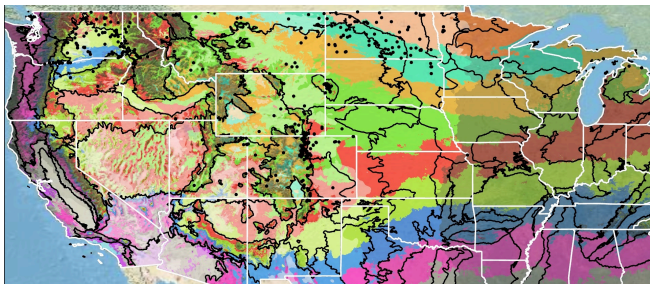


Figure 7. Distribution of blanketflower (black circles) based on geo-referenced herbarium specimens and observational data from 1828-2019 (CPNWH 2020; SEINet 2020; USDI USGS 2020). Generalized provisional seed zones (colored regions) (Bower et al. 2014) are overlain by Omernik Level III Ecoregions (black outlines) (Omernik 1987; USDI EPA 2018). Interactive maps, legends, and a mobile app are available (USDA FS WWETAC 2017; <https://www.fs.usda.gov/wwetac/Seedzonemapping.php>). Map prepared by Sarah Barga and Benton Spendlove USFS RMRS.

Releases

Meriwether Germplasm Selected Class blanketflower represents a composite of 15 accessions evaluated over 10 years (USDA NRCS n.d.). The accessions came from 14 native populations in Montana and one in Wyoming. Selections were made based on abundant seed production and uniformity of flowering, stature, and seed maturity. Meriwether Germplasm blanketflower is expected to be adapted to sites in Montana, most of northern and central Wyoming, and extreme eastern North Dakota (USDA NRCS n.d.).

Meriwether Germplasm blanketflower was released in 2011 by the USDA Natural Resources Plant Materials Center in Bridger, Montana, in cooperation with the agricultural experiment stations of Montana State University and the University of Wyoming. This release was named in honor of Meriwether Lewis who collected blanketflower on July 7, 1806 along the Blackfoot River in Montana (Winslow 2011b).

Wildland Seed Collection

Blanketflower seed maturation is indeterminate (Fig. 8) (Skinner 2006) with a wide collection window, although most harvests occur from late June to September (Redente et al. 1982; Winslow 2002; Luna et al. 2008; BLM SOS 2020). Collection sites where blanketflower populations may have originated from escaped cultivated plants or revegetation projects should be avoided. Wildland seed is generally hand collected. Skin protection can minimize irritations and rashes caused by exposure to plant sap or foliage (Skinner 2006; Winslow 2011a).



Figure 8. Single blanketflower plant with seed heads, fully open flower heads, and unopened flower buds growing in New Mexico. Photo: BLM NM930 SOS.

Wildland Seed Certification

Verification of species and tracking of geographic source is important whether wildland seed is collected for immediate project use or for cultivated increase. There is an official Source Identification process available for commercially produced seed that follows procedures established by the Association of Official Seed Certifying Agencies (AOSCA) Pre-Variety Germplasm Program (UCIA 2015; Young et al. 2020). Certification is optional but provides assurance of species identification and seed source for buyers. Seed certification is not always necessary, especially when seed is being locally produced and redistributed between cooperating agencies or parties. If wildland-collected seed is to be certified prior to sale for direct use in ecological restoration projects, collectors or those who contract for collection must apply for Source-Identified certification prior to making collections. Pre-collection applications, site inspections, and species and seed amount verification are handled by the AOSCA member state agency where seed collections will be made (see listings at [AOSCA.org](https://www.aosca.org)). Seed certification can increase seed price and marketability. It is important to become acquainted with state certification agency procedures, regulations, and deadlines.

If wildland collected seed is to be used to produce source-identified certified seed in seed production fields or nursery stock propagation (See Agricultural Seed Certification section), detailed information regarding collection site and collecting procedures are required. Wildland seed collections acquired within established

protocols of recognized public agencies, however, are normally eligible to enter the certification process as stock seed without routine certification agency site inspections. Photos and herbarium specimens may be required. If seed is not certified by the collector or the contractor, this collection site information must be provided to the grower to enable certification.

Collection Timing

Blanketflower seed is mature and ready for harvest when seed is easily detached or begins falling from the seedhead (Skinner 2006; Luna et al. 2008). Seed collection dates range from late June to September for this indeterminate seed producer (Redente et al. 1982; Luna et al. 2008; BLM SOS 2020).

Based on nine collections made from 2004 to 2020 in five western states, the earliest collection date was June 24 and the latest was September 18 (USDI BLM SOS 2020). Seed was harvested by the Bureau of Land Management, Seeds of Success (SOS) program in Washington, Montana, Wyoming, Colorado, and New Mexico. The earliest collection (June 24, 2016) was made in Lincoln County, Washington, at 2,116 ft (645 m) elevation. The latest collection (September 18, 2018) was made in Los Alamos County, New Mexico, at 6,656 ft (2,029 m). At most SOS sites, two or more collections were made within a day to two weeks of the first (USDI BLM SOS 2020).

Collection Methods

Seed is hand collected by plucking or clipping (Fig. 9) the seedheads when they are globe-like with open pappi and the achenes detach easily (Link 1993; Winslow 2002; Robson and Kingery 2006; Luna et al. 2008). Seed (Fig. 10) can also be collected by vacuuming (Skinner 2006). This method removes just mature seed (Fig. 11), leaving immature seed to continue ripening. Vacuumed seed collections include less plant material and are easier to clean than hand-collected seed (Skinner 2006). Seed should be collected in breathable containers (Luna et al. 2008). Skin rash or irritation after contact with plant sap or foliage has been reported (Winslow 2011a).



Figure 9. Blanketflower seedhead being clipped from the stem during seed collection in Colorado. Photo: BLM CO932 SOS.

Several collection guidelines and methods should be followed to maximize the genetic diversity of wildland collections: 1) collect seed from a minimum of 50 randomly selected plants; 2) collect from widely separated individuals

throughout a population without favoring the most robust or avoiding small stature plants; and 3) collect from all microsites including habitat edges (Basey et al. 2015). General collecting recommendations and guidelines are provided in online manuals (e.g., ENSCONET 2009; USDI BLM SOS 2023).

It is critical that wildland seed collection does not impact the sustainability of native plant populations. Collectors should take no more than 20% of the viable seed available within a population, and when possible, it is advised to make multiple collections over time (USDI BLM SOS 2023). Additionally, care must be taken to avoid the inadvertent collection of weedy species, particularly those that produce seeds similar in shape and size to those of blanketflower.



Figure 10. Closeup of clipped blanketflower seedheads and individual seeds. Photo: BLM WY070 SOS.

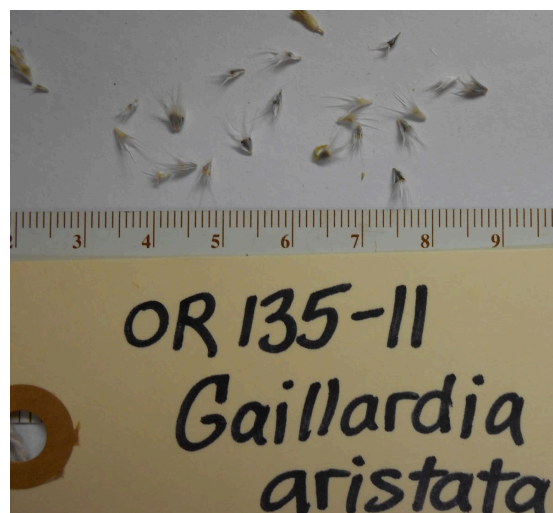


Figure 11. Individual blanketflower seeds with attached pappi (scale in cm). Photo: BLM OR135 SOS.

Collection Rates

Based on wildland seed collections made by the USDA-NRCS Bridger Plant Materials Center (PMC), collectors harvested an average of 0.28 lb (128 g) of clean seed each hour. Collection rates varied by year, stand density, and collector experience (Winslow 2002).

Post-Collection Management

Wildland seed was dried by spreading collections onto a tarp in a dry, sheltered environment at the Bridger PMC. Collections were mixed daily for 3 to 5 days until no moisture or warmth was detected (Winslow 2002).

Seed Cleaning

The bristly pappus on blanketflower seed is difficult to remove and creates flow problems in mechanical seeding equipment, making this species moderately difficult to clean (Winslow 2002; Skinner 2006). Aggressive cleaning to remove the pappus can damage seed and reduce germination. Skinner (2006) recommends using a belt thresher for larger lots or rubbing smaller lots between corrugated rubber sheets (e.g., stair treads), which removes or folds bristles to improve flow. Seed is then cleaned with an air column separator or other air screening equipment.

Because seed size can vary by site and year, screen sizes for seed cleaning equipment are not absolute (J. Scianna, USDA-NRCS retired, personal communication, January 2025). When cleaning blanketflower seed, starting with a large Hammermill screen size is recommended. Screen sizing should allow for rapid seed flow through the chamber to reduce hammering time and thus damage to the seed. Seed should also be inspected using a dissecting microscope after each step of the cleaning process to minimize damage to the embryo (J. Scianna, USDA-NRCS retired, personal communication, January 2025).

Winslow (2002) cleaned blanketflower seed by threshing with a hammermill using an 8/64 in round hole screen followed by air screening using a Clipper M2B or Clipper Eclipse (Hoffman Manufacturing, Corvallis, OR) with a 10/64 or 12/64 in round hole screen and moderate air speeds. The U.S. Forest Service, Bend Seed Extractory cleaned a small lot of blanketflower seed (0.44 lb [200 g]) using a Westrup Model LA-H laboratory brush machine (Hoffman Manufacturing, Corvallis, OR) with a #20 mantel at medium speed. Seed was then air screened using an office Clipper (Hoffman Manufacturing, Corvallis, OR) with an 8 round top screen and a 1/23 round bottom screen, medium speed, and medium air (Barner 2008).

Seed Storage

Blanketflower seed is orthodox. Clean dry seed stored in cold conditions (37-41 °F [3-5 °C]) retains its viability for 5 years or more (Luna et al. 2008). Seed was stored for 5 to 7 years at the Bridger PMC but storage conditions and viability changes, if any, were not reported (Winslow 2002). Long-term storage under the International Plant Genetic Resources Institute's (IPGRI) preferred conditions of low seed moisture and storage in hermetically sealed containers at -0.4 °F (-18 °C) or colder, showed a germination change from 82% to 70% after 11 years of storage (SER, INSR, RBGK 2024).

Seed Testing

Seed testing guidance for viability and germination of blanketflower is presented below.

Viability Testing

Official AOSA tetrazolium (TZ) testing procedures for Asteraceae (AOSA 2010) did not include the *Gaillardia* genus, but Moore (1985) outlined the following steps for conducting TZ tests of the viability of *Gaillardia* species.

1. Moisten seed for 6 to 18 hours.
2. Cut seed longitudinally completely through the midsection of the distal half. Avoid cutting into the embryonic axis at the basal end while cutting full depth at the distal end and remove or sever almost through the distal end of the seed, including the cotyledon tips or edges.
3. Stain seed for 6 to 24 hours.
4. Expose the embryo by gently pressing it through the distal end opening, enlarging the opening if necessary to avoid damaging the embryo.
5. Seed is viable if completely stained or completely stained except for distal third (Moore 1985).

Germination Testing

There is AOSA guidance for testing germination of blanketflower (AOSA 2023). Germination is tested on top of blotter paper. Seed is incubated at 68 to 86 °F (20-30 °C) with the first count made on day 4 and the final count on day 10. Seed requires light to germinate. Low germination may be because of unfilled seed (AOSA 2023).

A 7 g sample is required for purity analysis.

Germination Biology

Generally high germination percentages were reported in the literature. Seed is classified as physiologically dormant and while it does not require cold stratification to break dormancy, brief cold, moist treatments can improve uniformity of germination and final germination percentages (Luna et al. 2008; Winslow 2011a; Krock et al. 2016). For example, blanketflower seed that was dry stored for 3 or more months did not require stratification but germinated more uniformly following 30-day cold, moist stratification based on trials on seed collected on an exposed slope of 6,000 ft (1,800 m) in Glacier National Park, Montana (Luna et al. 2008).

In other seed testing, germination was better at warm than cool or cold temperatures. Blanketflower seed collected at unspecified locations in the United States germinated from 69 to 100% with an 8:16 light-dark cycle. Germination was lowest (69%) at 59 °F (15 °C), higher (96%) at 68 °F (20 °C), and highest (100%) at 77 °F (25 °C) (SER, INSR, RBGK 2023). Based on germination papers by Norman C. Deno, blanketflower germinated to 100% within 6 days at 70 °F (21 °C) (Love and Akins 2019). At temperatures of 40 °F (4 °C), germination was 60% in 2 to 8 weeks. When temperatures were increased to 70 °F (21 °C) the remaining 40% of seeds germinated within 3 days. The Deno findings were the same for fresh seed and dry seed stored 6 months (Love and Akins 2019). Seed collected in

Washington tested within a year of collection germinated at 48% in alternating light-dark conditions at 59 °F (15 °C). Germination improved to 52% in the dark at 68 °F (20 °C), 80% in the dark at alternating temperatures of 68/86 °F (20/30 °C), and just slightly better, 84%, at the same alternating temperatures but with alternating light-dark conditions (Maguire and Overland 1959).

Cold stratification treatments increased germination of blanketflower seed collected from a local native seed farm (Krock et al. 2016). Germination trials of agronomically produced seed tested the following seed treatments: de-ionized water, 1:100 smoke water, or cold stratification (37.4 °F [3 °C]) of 0, 15, 30, 60, 90, and 120 days (Krock et al. 2016). Smoke water applied without stratification had no effect on germination. Seed receiving 90 or 120 days of cold stratification (~50% germination) germinated significantly better than seed stratified 0, 15, 30, or 60 days (<20% germination). Germination of treated and untreated seed was evaluated in a germination chamber with a 12-hour photoperiod and an alternating temperature cycle of (59/43 °F [15/6 °C]) (Krock et al. 2016).

Germination of wild-collected blanketflower seed from the Black Hills of South Dakota improved with stratification at low and high but not moderate germination temperatures in tests of 59 to 86 °F (15-30 °C) (Roemmich 2011). Seed

from the Black Hills was collected in 2008 and 2009 and stored at 10 °F (-12 °C) for less than a year before testing. Germination was high (>70%) for stratified (2 wks at 41 °F [5 °C]) and untreated seed when the temperature of germination boxes was 68 °F (20 °C) or 77 °F (25 °C). At temperatures of 59 °F (15 °C) or 86 °F (30 °C), germination was low (<20%) for untreated seed but better for stratified seed: about 50% germination at 59 °F (15 °C) and about 30% at 86 °F (30 °C) (Roemmich 2011).

In Hungary where invasiveness of blanketflower was evaluated using controlled studies of germinability, germination was described as outstandingly high in mimicked fall conditions following 1 to 2 months of dry storage and spring conditions after 3 months of cold-wet stratification in the dark at 34 to 39 °F (1-4 °C) (Süle et al. 2023).

Wildland Seed Yield And Quality

Post-cleaning seed yield and quality of seed lots collected in the Intermountain region are provided in Table 2 (USDA FS BSE 2021). The results indicate that blanketflower seed can generally be cleaned to high levels of purity and that seed fill and viability of fresh seed is variable.

Table 2. Seed yield and quality of blanketflower seed lots collected in the Intermountain region, cleaned by the Bend Seed Extractory, and tested by the Oregon State Seed Laboratory or the USDA Forest Service National Seed Laboratory (USDA FS BSE 2021).

Seed lot characteristic	Mean	Range	Samples (no.)
Bulk weight (lbs)	14.4	0.06-50.3	13
Clean weight (lbs)	4.42	0.008-19.2	13
Clean-out ratio	0.26	0.086-0.39	13
Purity (%)	98	95-99	13
Fill (%)¹	90	70-99	13
Viability (%)²	92	69-98	12
Seeds/lb	193,684	114,200-339,267	13
Pure live seeds/lb	173,702	96,248-276,850	12

¹ 100 seed X-ray test

²Tetrazolium chloride test

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 handles less clean seed quite well.

Agricultural Seed Production

Most data for seed production of blanketflower results from research conducted at the Bridger PMC (Winslow 2002). They produced 150 lbs/ac (168 kg/ha) from irrigated plots, with the expectation that production would be better under conventional agronomic conditions (USDA NRCS n.d.).

Agricultural Seed Certification

In order to minimize genetic changes in specific accessions of native species when increased in cultivated fields, it is essential to track the geographic source and prevent inadvertent hybridization or selection pressure. This is accomplished by following third party seed certification protocols for Pre-Variety Germplasm (PVG) as established by the Association of Official Seed Certification Agencies (AOSCA). AOSCA members in the U.S., Canada, and other countries administer PVG requirements and standards that track the source and generation of planting stock. Field and cleaning facility inspections then monitor stand establishment, proper isolation distances, control of prohibited weeds, seed harvesting, cleaning, sampling, testing, and labeling for commercial sales (UCIA 2015; Young et al. 2020).

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

Site Preparation

At the Bridger PMC, blanketflower was seeded into firm, weed-free beds having good field moisture up to 4 in (10 cm) deep (Winslow 2002).

Weed Management

There are no herbicides specifically labeled to control weeds in blanketflower seed production fields (USDA NRCS n.d.). The following results from herbicide testing trials are presented not as guidance but as potential starting points for additional research.

Preemergent herbicides. While emergence and growth of blanketflower were typically lower with preemergence herbicide treatments (Beran et al. 1999; Jacobs et al. 2007; McManamen et al. 2018), one study showed that timing of seeding following herbicide applications and study location (field vs. greenhouse) impacted findings (McManamen et al. 2018).

Emergence, plant density, and flower density of blanketflower were greatest on untreated sites when compared to herbicide-treated (imazapic, imazethapyr, imazaquin) field sites (Beran et al. 1999). The study was conducted in sod fields at John Seaton Anderson Turfgrass and Ornamental Research Facility near Mead, Nebraska. Plots were treated with herbicide 1 to 2 days after single forb species were seeded at rates of 28 PLS/ft² (300 PLS/m²). Effects were evaluated 3 to 4 weeks after treatments. Emergence of blanketflower was greater than 55% at all plots. Rarely were emergence, plant density, or flower density significantly different by treatment, but all were consistently highest on untreated plots (Beran et al. 1999).

Most preemergent herbicides killed or reduced the density of blanketflower germinants when evaluated 28 days following treatments in a greenhouse study (Table 3; Jacobs et al. 2007). Blanketflower was sown in trays (32 × 12 × 1.5 in [80 × 30 × 4 cm]) filled with a 50:50 mix of silt loam and sand. Trays were stratified 10 days in the dark, then sprayed with herbicide on 22 March for trial one and on 6 June for trial two. Trays were then put in the greenhouse with 12-hour light/dark and 77/61 °F (25/16 °C) day/night cycles to encourage germination (Jacobs et al. 2007).

Table 3. Density of blanketflower seedlings in seeded trays (32 × 12 × 1.5 in) sprayed with selected herbicides prior to emergence (Jacobs et al. 2007).

Herbicide	Application rate (oz ai/ac [g ai/ha])	Trial 1 Density 28 d after treatment	Trial 2 Density 28 d after treatment
None	NA	12.7a	7.0a
Sulfentrazone	0.5 (32)	0b	0b
Atrazine	5.2 (367)	0b	0b
Oryzalin	5.3 (370)	4.5b	3.0b
Trifluran	2.6 (184)	16.5a	6.0a

Numbers within a column followed by a different letter are significantly different ($P < 0.05$).

Greenhouse germination of blanketflower was much lower in herbicide-treated than in untreated soils (Table 4; McManamen et al. 2018). In this study, 50 blanketflower seeds were placed on top of herbicide-treated and untreated soil (1 sand: 2 loamy topsoil) filled pots (4 in [10.2 cm] diam × 3.8 in [9.75 cm] deep). Herbicides were applied at the recommended rates for picloram (4.78 L/ha) and for aminopyralid (0.52 L/ha). The greenhouse was not heated through the winter months. Fans and ventilation were used to cool it when temperatures were above 86 °F (30 °C) in the summer (McManamen et al. 2018).

Table 4. Number of blanketflower germinants emerging from seed planted on water (control) and herbicide-treated soils immediately and up to 11 months after treatments (McManamen et al. 2018).

Time since treatment (mo)	Control	Aminopyralid	Picloram
Mean no. of blanketflower germinants			
immediate	16.5	3.0	0.0
3	12.0	0.5	0.1
6	13.7	0.0	0.0
9	13.5	0.2	0.0
11	14.0	2.6	0.8

In a field evaluation of germination on herbicide-treated and untreated soils, emergence was better with fall than spring herbicide applications where fall-treated plots were seeded 5 months and spring-treated plots were seeded less than one month after herbicide applications (Table 5; McManamen et al. 2018). Field plots (11 ft² [1 m²]) were sprayed at the recommended rates with an added surfactant in fall (November 22-23) or spring (March 26). Broadcast seeding of blanketflower occurred on April 16 at a rate of (92 seeds/ft² [1,000 seeds/m²]). The mean rate of blanketflower germination and biomass of blanketflower seedlings were significantly greater in aminopyralid fall-treated plots than controls ($P < 0.05$) and significantly lower in aminopyralid and picloram spring-herbicide treated than control plots ($P < 0.03$). Researchers suggested blanketflower might be an appropriate addition to seed mixes used in invaded areas where chemical control, particularly with aminopyralid, is necessary and seeding will occur soon after to prevent reinvasion. They also cautioned that site-specific conditions affect the actual tolerance of any species being sown on herbicide-treated soils (McManamen et al. 2018).

Table 5. Density of germinants at field sites in Missoula, Montana, emerging from untreated and herbicide-treated soils by season and time since treatment.

Treatment (time since)	Control	Aminopyralid	Picloram
Mean no. germinants/ft ²			
Spring (0.75 mo)	0.9	0.6	0.1
Fall (5 mo)	1.2	1.3	1.2

Post-emergent herbicides. Generally, established blanketflower plants had poorer growth and were injured by herbicide treatments in greenhouse and field studies, although some herbicide tolerance was found. In greenhouse trials, researchers rated blanketflower moderately tolerant of aminopyralid treatments. Plants obtained from a nursery sustained injury levels of 11% at 30g/ha, 25% at 60 g/ha, and 23% at 120 g/ha application rates (Mikkelsen and Lym 2013).

Herbicide-treated seedlings displayed chlorosis, stunted growth, yellowing, twisted leaves, and often lower biomass than untreated seedlings in a greenhouse study (Wiese et al. 2011). The greenhouse was maintained at 16:8 hour day/night and 77/59 °F (25/15 °C) temperature cycles. One trial ran from January 12 to April 30 and the other from May 22 to September 22. Five blanketflower seedlings in rectangular pots (10 × 2 × 6 in [26 × 6 × 15 cm]) were herbicide treated once they had at least three true leaves. The herbicides and rates tested were: linuron (0.5 lb ai/ac [0.56 kg ai/ha]), halosulfuron (0.042 lb ai/ac [0.048 kg ai/ac]), imazapic (0.125 lb ai/ac [0.14 kg ai/ha]), and pendimethalin (1.69 lb ai/ac [1.9 kg ai/ha]). Seedlings sprayed with linuron, halosulfuron, and imazapic had lower biomass than untreated controls, but biomass of seedlings

sprayed with pendimethalin was similar to controls and higher than those treated with halosulfuron ($P = 0.001$) or linuron ($P = 0.01$) (Wiese et al. 2011).

In a field study (soil pH 5.5 and organic matter 2%, location unknown), blanketflower was injured but stand density and flowering were not reduced when transplants were sprayed with metolachlor and isoxaben herbicides alone or with a mix of simazine or oxadiazon. Plants were treated twice in 2 years and plots were irrigated within 2 hours of herbicide applications (Derr 1993).

Seeding

Plant Materials Centers in Pullman, Washington, and Bridger, Montana, both reported better stand development of blanketflower with spring than fall seeding (Winslow 2002; Skinner 2006). Spring seeding after risk of frost is recommended for establishment of blanketflower seed fields (Winslow et al. 2023). At Bridger PMC, blanketflower was drill seeded 0.5 in (1.3 cm) deep at a rate of 25 to 30 PLS/ linear ft (82-98 PLS/linear m), in rows spaced 36 in (91 cm) apart (USDA NRCS n.d.; Winslow 2002).

Row spacing depends on a facility's planting and cultivation equipment (USDA NRCS n.d.). The seeding rate for 24-in (61 cm) rows is 2.5 PLS lbs/ac (2.8 kg/ha), 30-in (76 cm) rows is

2.2 PLS lbs/ac (2.5 kg/ha), and for 36-in (91 cm) rows is 1.9 PLS lbs/ac (2.1 kg/ha). At the Bridger PMC, mowing seed fields in year one provided adequate weed control. Row spacing of 24 to 26 in (61-66 cm) is recommended for mechanical cultivation (USDA NRCS n.d.).

Establishment And Growth

At Bridger PMC, blanketflower seed production plots were irrigated and kept moist through the 14-day germination and emergence period. Fertilizing in the first growing year stimulated weed competition and is not recommended (Winslow 2002).

Irrigation

Blanketflower is considered drought tolerant, needing supplemental moisture only during extended hot, dry conditions (Winslow 2011a). Root rot can be a problem in poorly drained soils especially at times of high precipitation (Winslow 2011b). At Bridger PMC, however, blanketflower seed production plots were irrigated through the budding stage, after anthesis, and after harvest through pre-freeze conditions. To encourage pollination, plots were not irrigated when plants were flowering (Winslow 2002).

Pollinator Management

Blanketflower seed production is improved with pollination and flowers are attractive to a variety of pollinators (see Pollination and Wildlife and Livestock Use sections). Blanketflower is visited by the European honey bee (Cane et al. 2012), a manageable bee that can be transported to field locations in portable ground nests or hives. Introducing new bee populations may not be feasible or necessary and any management practices to encourage and sustain native bee populations will benefit production of blanketflower crops (Cane 2008).

Pest Management

No serious insect or disease problems were encountered when blanketflower was grown for seed production at the Bridger PMC. Powdery mildew occurred at times of high humidity but rarely had a long-term negative impact (Winslow 2011b). Blanketflower is susceptible to aster yellows, fungal leaf spot disease, and oat blue dwarf virus (Winslow 2011a), but again, these diseases may not be problematic in a crop or nursery setting. Blanketflower is also a host for following fungal species: *Bremia lactucae*, *Coleosporium asterum*, *C. solidaginis*, *Entyloma calendulae*, *E. compositarum*, *Liriomyza trifolii* (Stegmaier 1968; Farr and Rossman 2024) but damage or issues associated with these species were not reported in the literature.

Seed Harvesting

At the Bridger PMC, blanketflower seed was harvested when seeds began falling from the seed heads using a small Wintersteiger plot combine (Wintersteiger, Salt Lake City, UT) (Winslow et al. 2023).

Seed Yields And Stand Life

Meriwether Germplasm blanketflower at Bridger PMC yielded about 150 bulk seed lbs /ac (168 kg/ha), and higher yields were expected under conventional agronomic conditions (USDA NRCS n.d.). The age of the harvested stands was not reported. Blanketflower usually flowers the same year it was seeded (Dorn and Dorn 2007), but timing of the first harvest in seed production studies was not reported.

Nursery Practice

Because of the wide use of blanketflower in horticulture, many studies provide information on growing nursery stock (Skinner 2006; Luna et al. 2008). It can be sown directly into containers without pretreatment and produces a tight root mass in a 10 in³ (164 cm³) cone-tainer in approximately 4 months (Winslow 2011a). A greenhouse study found that in a comparison of growth with low (1 ppm) and high (32 ppm) nitrogen, average root diameter production and root:shoot ratios were not significantly different (Levang-Brilz and Biondini 2003). Blanketflower has also been grown as a sod, this process required a 79 lb/ac (89 kg/ha) seeding rate on layered cheesecloth and misting throughout the germination phase (Airhart and Falls 1988).

The following procedure was used to grow 10 in³ (164 cm³) blanketflower cone-tainers in a greenhouse at the Pullman PMC (Skinner 2006). Seed was sown in January into Ray Leach super cell cone-tainers (Stuewe & Sons, Inc., Tangent, OR) filled with Sunshine #4 media. It was covered lightly with media and a thin layer of pea gravel, leaving 0.25 to 0.5 in (0.6-1.3 cm) head space to allow for deep watering. Soil was kept moist until germination, which began within 5 days and was complete in 16 days. Seedlings established in 2 weeks. Cone-tainers were deep watered every other day and fertilized each week with a complete water-soluble fertilizer containing micronutrients. The active growth phase was 3 months. Plants were moved from the greenhouse to a cold frame in late March. Outdoor plants were watered every other day in cool conditions and every day in hot, dry conditions. The hardening phase was 2 to 4 weeks (Skinner 2006).

Similar procedures were used to grow blanketflower seedlings to an average height of 2.7 in (7 cm) tall with six to ten true leaves and firm roots in 0.3-pt (160 ml) cone-tainers (Luna et al. 2008). Blanketflower seed was collected in late August or early September from an exposed 6,000-ft (1,800 m) slope in Glacier National Park, Montana. It was directly seeded into a growth medium (6:1:1 peat, perlite, vermiculite) with a controlled release complete fertilizer plus micronutrients. Seed was lightly covered with media or grit and watered thoroughly. Germination in the greenhouse was uniform and occurred within 15 days at 72 °F (22 °C). True leaves were produced in 2 weeks. Once seedlings were well established (about 4 wks), cone-tainers were allowed to dry slightly between watering to avoid root rot of the susceptible slender taproots. Root and shoot growth were rapid through the growing season. Plants were fertilized weekly (20:20:20 N-P-K) until fall. Irrigation

was reduced in September and October, and the hardening phase was 2 to 4 weeks. Plants were overwintered in an outdoor nursery under insulating foam and snow (Luna et al. 2008).

Addition of biochar in a soilless media reduced irrigation needs and increased biomass (although not significantly) of blanketflower nursery stock (Matt et al. 2018). Blanketflower seed from a local vendor was sown in a medium (3 peat:1 perlite:1 vermiculite) with 0, 15, 30, and 45% volume rates replaced with biochar. Seedlings were grown in Ray Leach super cell cone-tainers (8.3 in [21 cm] deep, 1.5 in [3.8 cm] diameter). Seed was sown in late April or early June and grown in a greenhouse until December. The greenhouse was kept at 70 to 77 °F (21-25 °C) until August when temperatures were reduced for hardening. Seedlings were fertilized (150 N ppm) each week. Biochar additions had no significant effect on blanketflower growth, but at 26 weeks, total root and shoot biomass and final leaf count were greatest in the 30% biochar treatment. Biochar additions also reduced irrigation needs. The number of irrigation events, which occurred once containers reached a 75% capacity threshold, were 53 for 0%, 51 for 15%, 44 for 30%, and 41 for 45% biochar treatments (Matt et al. 2018).

In a study investigating methods for water conservation in nursery production, watering with up to 4 dS/m salinity reduced plant size but not visual plant quality. Growth medias tested did not impact growth, although growth of plants grown in pure perlite were small (Niu and Rodriguez 2006).

Wildland Seeding And Planting

First year flowering, attractiveness to pollinators, moderate growth rate and lifespan, and prolific reseeding make blanketflower a good addition to restoration seed mixes (USDA NRCS n.d.; Dorn and Dorn 2007; Ogle et al. 2011).

Wildland seeding in spring in medium to coarse well-drained soils at less than 0.5 in (1.3 cm) deep is recommended. The full seeding rate is 5 to 7 PLS lbs/ac (6-8 kg/ha) (USDA NRCS n.d.; Swingle 1939; Dorn and Dorn 2007; Ogle et al. 2011, 2012; Winslow 2011b). In Montana, blanketflower is drill seeded at a rate of 6 PLS lbs/ac (6.7 kg/ha) and broadcast seeded at 12 PLS lbs/ac (13.5 kg/ha). The rate is increased for seeding operations at critical restoration sites to 12 PLS/ac drilled and 24 PLS lbs/ac (26.9 kg/ha) broadcast (J. Scianna, USDA-NRCS retired, personal communication, January 2025).

Drill seeding into a firm, weed-free seedbed or broadcast seeding followed by rolling or dragging to improve seed-soil contact are recommended (USDA NRCS n.d.; Winslow 2011b). Blanketflower should make up 0.5 to 1 lb/ac (0.6-1 kg/ha) of seed mixes (USDA NRCS n.d.) and seeding in rows (12-in [30 cm] spacings) separate from grasses may improve establishment (Winslow 2011b). In a wildflower seed mix, amounts of blanketflower included should be low to prevent it from becoming dominant (Winslow 2011b).

Increasing the seeding rate of blanketflower can improve establishment (Scheinost et al. 2010). In cases where seed costs or availability prohibit a high seeding rate, consider

concentrating forb seed in several small areas. These islands of establishment should provide a seed source to allow blanketflower to spread into adjacent areas (Scheinost et al. 2010).

Wildland seeding. Some field studies reported good establishment and survival of blanketflower (Scheinost et al. 2010; Tilley and Pickett 2018). In studies comparing spring and fall timing of seeding, blanketflower establishment and survival density were sometimes better with spring than fall seeding (Scheinost et al. 2010; Arychuk et al. 2024).

Blanketflower survival to year 5 was high when 16 forb species were seeded at the Pullman PMC (MLRA 9) where annual precipitation averages 20 in (510 mm) (Scheinost et al. 2010). Forbs were seeded into existing grain stubble after it was chiseled, disked, then cultivated with a Glencoe cultivator (AGCO, Duluth, GA), and packed with a Brillion roller (Landoll Co., Marysville, KS). Blanketflower seed collected from nearby wild populations was seeded 0.25 to 0.5 in (0.6-1.3 cm) deep in 20 ft (6 m) long rows at 40 seeds/linear ft (131/linear m) using a Hege 1000 plot seeder (Hege Applications, Steinseltz, France). Seeding occurred in early fall (mid-September) 2002, late fall (late October) 2002, and early spring (mid- to late April). Blanketflower had one of the highest rates of initial year establishment, which did not differ significantly by timing of seeding. Blanketflower survival was also good, and its density generally increased over time. By the end of the study (5 yrs), blanketflower produced the highest percent stand cover of all species. The 5-year average seedling density of blanketflower was 5.7/linear ft (18.7/linear m) for early fall-, 5.6/linear ft (18.3/linear m) for late fall-, and 6.1/linear ft (20/linear m) for spring-seeded plots (no significant differences) (Scheinost et al. 2010).

In a field study that qualitatively compared species performance in wildflower seed mixes, blanketflower persisted and generally increased in cover over time (Tilley and Pickett 2018). Blanketflower was a component of all six wildflower seed mixes evaluated, which in total included 62 species. They were seeded side-by-side at a rate of 10 lbs/ac (11 kg/ha) on May 23, 2013 in silt loam soils at Aberdeen PMC. Seeded plots were irrigated twice every 10 days until August 1 and monitored for 4 years. Blanketflower cover increased over time, and these increases were sometimes associated with decreases in broadleaf weed cover. Blanketflower often flowered in its first growing season, had a long flowering season, was highly attractive to small native bees, and was visited by butterflies (Tilley and Pickett 2018).

Establishment and growth of potential pollinator plants were evaluated in field studies at the Bridger PMC (Majerus et al. 2017). Blanketflower density was greatest when seeded in single-species plots and in average precipitation years. The Bridger PMC field sites occur where annual precipitation averages 10 in (250 mm) and soils are silty clay loams with moderate alkalinity. Sites were glyphosate-treated before seeding and hand weeded after that. Seeding occurred on May 9, 2012, using a four-row cone planter (Kincaid Equipment Manufacturing, Haven, KS) with double disk furrow openers, depth bands, and double packer wheels. Rows were spaced 14 in (36 cm) apart and seed was planted 0.25 in (0.6 cm) deep. Plots were seeded

as individual species (25 seeds/ft² [269/m²] in 20 ft [6 m] rows), mixed species (75% various forbs and 25% grass [Sandberg bluegrass]), and alternating rows of grasses (20 seeds/ft² [215/m²] and forbs (5 seeds/ft² [54/m²]). Plants were allowed to mature, and shatter seed each fall and then mowed each spring before green up. Flowering of blanketflower started in late May. Height of blanketflower was low in 2012 (mean: 8 in [20 cm]) but increased (mean: 14-24 in [36-61 cm]) in the following years (2013 to 2016). Average density of blanketflower when seeded alone was 4.1 plants/ft² (44/m²) in 2015. In mixed and alternate row plots blanketflower density averaged 1.8 plants/ft² (19/m²) in 2015 and 0.7 plant/ft² (7.5/m²) in 2016. Precipitation was near normal in 2015 and dry in 2016 (Majerus et al. 2017).

Wildland planting. Blanketflower should be transplanted after the last killing frost in the spring and before the weather becomes hot and dry. Alternatively, it can be planted no later than 30 to 45 days before the first killing frost in fall (Winslow 2011a). It may also be possible based on field experiments in North Carolina, to grow blanketflower as a native wildflower sod for restoration (Johnson and Whitwell 1997).

Fall and spring seeding and blanketflower transplants were compared at several sites within the quaking aspen parkland ecoregion of central Alberta (Arychuk et al. 2024). Sites were tilled twice and glyphosate-treated before blanketflower was drill seeded (rate: 23.66 mg/m²). Establishment was low in seeded plots (< 4% live plants/PLS sown) but density was significantly greater on spring- than fall-seeded plots ($P = 0.1$) in year 1 and 2. Spring planting resulted in significantly higher survival than fall planting ($P = 0.1$), with survival of about 80% in spring-planted plots in year 1 and 2 and a little less than 30% survival in fall-planted plots in year 1 and 2. Average spread was significantly greater in spring- than fall-planted plots ($P = 0.01$), but seed set was significantly greater in fall- than spring-planted plots in both years ($P = 0.10$). Mowing treatments that cut plants to 4 to 6 in (10-15 cm) tall occurred twice (June 21, August 5) in the first growing season to prevent seed set of weeds. Mowing treatments did not significantly affect the density of blanketflower in either year (Arychuk et al. 2024).

Unlike the results presented above by Majerus et al. (2017), Aschehoug (2011) found better blanketflower survival when it was grown with other native species than when grown alone at the Fort Missoula Biological Field Station in Missoula, Montana. Plots were established from transplants in July 2007. Plots were watered the first growing season and hand weeded. Ninety percent of plots with just blanketflower died or failed to resprout by the third growing season. Fewer plots (68%) died or failed to resprout when blanketflower was grown with other native species (needle and thread [*Hesperostipa comata*], bluebunch wheatgrass, Idaho fescue, and Lewis flax) (Aschehoug 2011).

Wildland restoration management. Several studies suggest blanketflower may be useful to restore weedy sites (Carpenter 1986; Prasser and Hild 2016). In a greenhouse study, dry weight of spotted knapweed was 75% less when grown in a pot with blanketflower than when grown alone. Blanketflower was grown for 30 days when a single knapweed seed was added to the container (Broz et al.

2008). Several herbicides were used to treat spotted knapweed rangelands in western Montana. Density of blanketflower 15 months after herbicide treatments was not significantly impacted by picloram, picloram + clopyralid, or clopyralid but was reduced by metsulfuron methyl treatments (Carpenter 1986).

In a greenhouse study, blanketflower grew well in the presence of competition from halogeton (*Halogeton glomeratus*) (Prasser and Hild 2016). Blanketflower from a commercial seed source was grown in pots (6 in [15 cm] diameter) filled with sandy clay loam as four conspecific seedlings or as two blanketflower seedlings and two halogeton seedlings. Pots were kept in a greenhouse (12-hr light/dark, 68/50 °F [20/10 °C] cycles). After 14 weeks of growth, blanketflower was taller and aboveground biomass was greater although root:shoot ratios were lower ($P < 0.05$) when grown with halogeton than in a monoculture. Halogeton survival fell below 30% when grown with blanketflower than with conspecifics (Prasser and Hild 2016).

Emergence of blanketflower in the greenhouse was not significantly different in containers filled with soils collected from Russian knapweed (*Rhaponticum repens*)-invaded and noninvaded sites (Tyrer et al. 2007). Invaded and non-invaded soils were collected from rangelands in Greybull and Riverton, Wyoming and pastureland in Greeley, Colorado. Emergence of blanketflower ranged from 45 to 79% with no significant difference with respect to invasion (Tyrer et al. 2007).

In a study that evaluated blanketflower's resistance to catechin, a potent phytotoxin exuded from roots of spotted knapweed, germination, root and shoot growth, and seedling mortality of blanketflower were not severely impacted at catechin concentrations of 0 to 4.0 mg/mL. Researchers rated blanketflower moderately resistant to catechin (Perry et al. 2005). Yet, in a study of invaded vegetation along the Going-to-the-Sun highway in Glacier National Park, blanketflower cover was <0.1% in spotted knapweed, 1.8% in timothy (*Phleum pratense*), and 0.6% in native fescue dominated vegetation (Tyser 1992).

Love et al. (2016) found good blanketflower emergence and noted it was competitive with weeds and other meadow species. This study was a stepwise approach to establishing a native meadow in an area dominated by weeds and lacking native grasses and forbs. It occurred at the University of Idaho Aberdeen Research and Extension Center in Aberdeen, Idaho, a semi-arid high desert region with average annual precipitation of 9.2 in (234 mm), July temperatures of 87 °F (31 °C), and January temperatures of 12 °F (-11 °C). The study included a variety of initial weed control methods, both seeding and planting of forbs, and additional later weed control methods. Ultimately, the best restoration included spring seeding of grasses, weed control by mowing or turf-appropriate herbicide treatments, and fall overseeding of forbs into established grasses. Blanketflower made up 27% of established forb stands by October 2015 in this project that began in June 2013 (Love et al. 2016).

Remediation. Studies suggest blanketflower may be useful in remediation of saline (Blanchard et al. 2023) and petroleum-contaminated soils (Liu et al. 2012). Blanketflower transplants were planted on croplands in the

northern Great Plains where an accumulation of salts in the soil were reducing production yields of corn and soybean (Blanchard et al. 2023). A portion of blanketflower outplants (< 20%) survived to the end of the first growing season, from May to October in medium salinity (3.2 dS/m) and more survived (< 40%) in low salinity (0.3 dS/m) soils. Transplants did not survive in high salinity soils (7.9 dS/m). Researchers recommended blanketflower for use in the restoration of minimally salt-impacted soils (Blanchard et al. 2023). Pot-culture experiments showed that blanketflower reduced the total petroleum hydrocarbons when grown in petroleum-contaminated soil collected from China's Sheguli Oil Field (Liu et al. 2012). Petroleum hydrocarbons were reduced 37% after 30 days, which was significantly more than the reductions in soils lacking plants that were watered on the same schedule (13%). Researchers concluded that blanketflower may be potentially useful in the phytoremediation of oil-contaminated soil (Liu et al. 2012).

Acknowledgements

Funding for Western Forbs: Biology, Ecology, and Use in Restoration was provided by the USDI BLM Great Basin Native Plant Materials Ecoregional Program through the Great Basin Fire Science Exchange. Great thanks to the chapter reviewers: Monica Pokorny, USDA NRCS Bridger PMC and Joe Scianna, USDA NRCS Bridger PMC (retired).

This research was supported in part by the USDA Forest Service, Rocky Mountain Research Station. The findings and conclusions in this publication are those of the authors and should not be construed to represent any official USDA or U.S. Government determination or policy.

Literature Cited

- Airhart, D.L.; Falls, K.M. 1988. Experiments with seed-grown sod as plant introduction technique described (Massachusetts). Restoration and Management Notes. 6(1): 51.
- Andersen, B.A.; Holmgren, A.H. 1996. Mountain plants of northeastern Utah, revised. HG 506. Logan, UT: Utah State University Extension. 132 p.
- Antos, J.A.; McCune, B.; Bara, C. 1983. The effect of fire on an ungrazed western Montana grassland. The American Midland Naturalist. 110(2): 354-364.
- Arychuk, C.E.; Dhar, A.; Wilkinson, S.R.; Naeth, M.A. 2024. Seeding and transplanting native forbs on reclamation sites in Alberta, Canada. Restoration Ecology. 23(4): e14122.
- Aschehoug, E. 2011. Indirect interactions and plant community structure. Missoula, MT: University of Montana. Thesis. 144 p.
- Association of Official Seed Analysts [AOSA]. 2010. AOSA/SCST tetrazolium testing handbook. Contribution No. 29. Lincoln, NE: Association of Official Seed Analysts.
- Association of Official Seed Analysts [AOSA]. 2023. AOSA rules for testing seeds. Vol. 1. Principles and procedures. Washington, DC: Association of Official Seed Analysts.
- Ayyad, M.A.G.; Dix, R.L. 1964. An analysis of a vegetation-microenvironmental complex on prairie slopes in Saskatchewan. Ecological Monographs. 34(4): 421-442.
- Barner, J. 2008. Propagation protocol for production of *Gaillardia aristata* Pursh seed. Native Plant Network. U.S. Department of Agriculture, Forest Service, National Center for Reforestation, Nurseries, and Genetic Resources. <http://nnp.rngr.net/propagation/protocols> [Accessed 2024 May 5].
- Basey, A.C.; Fant, J.B.; Kramer, A.T. 2015. Producing native plant materials for restoration: 10 rules to collect and maintain genetic diversity. Native Plants Journal. 16(1): 37-53.
- Beran, D.D.; Gaussoin, R.E.; Masters, R.A. 1999. Native wildflower establishment with imidazolinone herbicides. Hortscience. 34(2): 283-286.
- Blanchard, A.P.; Clay, S.A.; Perkins, L.B. 2023. The good, the bad, the salty: Investigation of native plants for revegetation of salt-impacted soil in the northern Great Plains, United States. Journal of Soil and Water Conservation. 78(6): 479-485.
- Bosco, A.; Molina, L.; Kernéis, S.M.; Hatzopoulos, G.; Favez, T.; Gönczy, P.; Tantapakul, C.; Maneerat, W.; Jeremy, B.; Williams, D.E.; Andersen, R.J.; Golsteyn, R.M. 2021. Pulchelloid A, a sesquiterpene lactone from the Canadian prairie plant *Gaillardia aristata* inhibits mitosis in human cells. Molecular Biology Reports. 48(7): 5459-5471.
- Bower, A.D.; St. Clair, J.B.; Erickson, V. 2014. Generalized provisional seed zones for native plants. Ecological Applications. 24(5): 913-919.
- Brower, L.P.; Brower, J.V. 1956. Cryptic coloration in the anthophilous moth *Rhododipsa masoni*. The American Naturalist. 90(852): 177-182.

- Broz, A.K.; Manter, D.K.; Callaway, R.M.; Paschke, M.W.; Vivanco, J.M. 2008. A molecular approach to understanding plant-plant interactions in the context of invasion biology. *Functional Plant Biology*. 35(11): 1123-1134.
- Budd, A.C.; Campbell, J.B. 1959. Flowering sequence of a local flora. *Journal of Range Management*. 12(3): 127-132.
- Byers, B.A. 2017. Colorado fires and firemoths. *Frontiers in Ecology*. 15(1): 51-52.
- Cane, J.H. 2008. Pollinating bees crucial to farming wildflower seed for U.S. habitat restoration. In: James, R.; Pitts-Singer, T., eds. *Bees in agricultural ecosystems*. Oxford, UK: Oxford University Press: 48-64.
- Cane, J.H.; Love, B.; Swoboda, K. 2012. Breeding biology and bee guild of Douglas' dustymaiden, *Chaenactis douglasii* (Asteraceae, Helenieae). *Western North American Naturalist*. 72(4): 563-568.
- Carpenter, J.L. 1986. Responses of three plant communities to herbicide spraying and burning of spotted knapweed (*Centaurea maculosa*) in western Montana. Missoula, MT: University of Montana. Thesis. 110 p.
- Carter, S.; Goeckner, N.; Julian, C.; Langelo, L.; Shonle, I.; Dennis, C. 2023. Low-flammability landscape plants. 6.305 Fact Sheet. Fort Collins, CO: Colorado State University Extension. 8 p.
- Chambers, K.L. 2020. *Gaillardia* (Blanketflower). In: Meyers, S.C.; Jaster, T.; Mitchell, K.E.; Harvey, T.; Hardison, L.K., eds. *Flora of Oregon*, Vol. 2: Dicots A-F. Fort Worth, TX: Botanical Research Institute of Texas (BRIT) Press: 152-370.
- Clements, D.R.; Krannitz, P.G.; Gillespie, S.M. 2007. Seed bank responses to grazing history by invasive and native plant species in a semi-desert shrub-steppe environment. *Northwest Science*. 81(1): 37-49.
- Consortium of Pacific Northwest Herbaria [CPNWH]. 2020. Seattle, WA: University of Washington Herbarium, Burke Museum of Natural History and Culture. pnwherbaria.org/
- Coupland, R.T.; Johnson, R.E. 1965. Rooting characteristics of native grassland species in Saskatchewan. *Journal of Ecology*. 53(2): 475-507.
- Cronquist, A. 1994. Volume five: Asterales. In: Cronquist, A.; Holmgren, A.H.; Holmgren, N.H.; Reveal, J.L.; Holmgren, P.K., eds. *Intermountain flora: Vascular plants of the Intermountain West, U.S.A.* Bronx, NY: The New York Botanic Garden. 496 p.
- Currah, R.; Smrecin, A.; Van Dyk, M. 1983. *Prairie wildflowers*. Edmonton: University of Alberta, Friends of the Devonian Botanic Garden. 300 p.
- Daubenmire, R.F. 1942. An ecological study of the vegetation of southeastern Washington and adjacent Idaho. *Ecological Monographs*. 12(1): 53-79.
- De Santo, J. 1989. *Alpine wildflowers of Glacier National Park, Montana and Waterton Lakes National Park, Alberta*. Missoula, MT: University of Montana. 124 p.
- Debnam, S.; Liao, H.X.; Callaway, R.M. 2021. Indirect facilitation mediated by pollinators in intermountain prairie. *Community Ecology*. 22(3): 309-317.
- deCalesta, D.S. 1979. Spring and summer foods of Audubon's cottontail rabbit (*Sylvilagus audubonii*) in north-central Colorado. *Southwestern Naturalist*. 24(3): 549-553.
- Derr, J.F. 1993. Wildflower tolerance to metolachlor and metolachlor combined with other broadleaf herbicides. *Hortscience*. 28(10): 1023-1026.
- Discover Life. 2024. Sam Houston State University. Available: <https://www.discoverlife.org/>
- Dorn, R.D.; Dorn, J.L. 2007. *Growing native plants of the Rocky Mountain area*. Morrisville, NC: Lulu.com. 260 p.
- European Native Seed Conservation Network [ENSCONET]. 2009. ENSCONET seed collecting manual for wild species. Edition 1: 32 p.
- Farr, D.F.; Rossman, A.Y. 2024. Fungal databases, U.S. National Fungus Collections. U.S. Department of Agriculture, Agricultural Research Service. <https://fungi.ars.usda.gov/>
- Ferner, J.W.; Rosenthal, M. 1981. A cryptic moth, *Schinia masoni* (Noctuidae), on *Gaillardia aristata* (Compositae) in Colorado. *Southwestern Association of Naturalists*. 26(1): 88-90.
- Frankie, G.W.; Pawelek, J.C.; Guerrero, S.S.L.; Thorp, R.W.; Rizzardi, M.A.; Chase, M.H.; Jadallah, C.C.; Smith-Pardo, A.; Lyons, A.; Feng, I.C.; Witt, S.L. 2018. Survey of native and honey bees from agricultural Brentwood and their constructed bee gardens in northern California, 2010-2018. *Journal of the Kansas Entomological Society*. 91(4): 310-349.
- Goodrich, S.; Neese, E. 1986. *Uinta Basin flora*. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Region. 320 p.
- Hammond, H.E.; Schoellhorn, R.K.; Wilson, S.B.; Norcini, J.G. 2007. Differing blanketflower cultivar and ecotype responses to plant growth regulators. *HortTechnology*. 17(4): 552-556.
- Hansen, R.M.; Ueckert, D.N. 1970. Dietary similarity of some primary consumers. *Ecology*. 51(4): 640-648.

- Hegstad, R.J.; Maron, J.L. 2019. Productivity and related soil properties mediate the population-level consequences of rodent seed predation on blanketflower, *Gaillardia aristata*. *Journal of Ecology*. 107(1): 34-44.
- Hermann, F. 1966. Notes on western range forbs: Cruciferae through Compositae. Agric. Handb. 293. Washington, DC: U.S. Department of Agriculture, Forest Service. 365 p.
- Hickman, J.C., ed. 1993. The Jepson manual: Higher plants of California. Berkeley, CA: University of California Press. 1400 p.
- Hitchcock, C.L.; Cronquist, A. 2018. Flora of the Pacific Northwest: An illustrated manual. Second Ed. Giblin, D.E.; Legler, B.S.; Zika, P.F.; Olmstead, R.G., eds. Seattle, WA: University of Washington Press. 882 p.
- Holch, A.E.; Hertel, E.W.; Oakes, W.O.; Whitwell, H.H. 1941. Root habits of certain plants of the foothill and alpine belts of Rocky Mountain National Park. *Ecological Monographs*. 11(3): 327-345.
- Jacobs, J.S.; Winslow, S.R.; Pokorny, M.L. 2007. The effect of five pre-emergence herbicides on emergence and establishment of four native wildflowers. *Native Plants Journal*. 8(3): 224-231.
- Johnson, A.M.; Whitwell, T. 1997. Selecting species to develop a field-grown wildflower sod. *HortTechnology*. 7(4): 411-414.
- Kalaman, H.; Wilson, S.B.; Mallinger, R.E.; Knox, G.W.; van Santen, E. 2022. Evaluation of native and nonnative ornamentals as pollinator plants in Florida: I. Floral abundance and insect visitation. *HortScience*. 57(1): 126-136.
- Keil, D.J. 2012. *Gaillardia aristata*. In: Jepson Flora Project (eds.) Jepson eFlora, https://ucjeps.berkeley.edu/eflora/eflora_display.php?tid=3006 [Accessed on 2024 September 27].
- Kim, M. 2016. Inhibition of melanogenesis by *Gaillardia aristata* flower extract. *Journal of Dermatological Science*. 84(1): e179.
- Krock, S.; Smith, S.; Elliott, C.; Kennedy, A.; Hamman, S.T. 2016. Using smoke-water and cold-moist stratification to improve germination of native prairie species. *Native Plants Journal*. 17(1): 19-27.
- Lady Bird Johnson Wildflower Center [LBJWC]. 2022. *Gaillardia aristata* Pursh. Native Plant Database. Austin, TX: Lady Bird Johnson Wildflower Center. https://www.wildflower.org/plants/result.php?id_plant=gaar [Accessed 2024 September 13]
- Leach, M.; Dibble, A.C.; Stack, L.B.; Perkins, L.B.; Drummond, F.A. 2021. The effect of plant nutrition on bee flower visitation. *Journal of the Kansas Entomological Society* 94(4): 277-300.
- Lesica, P. 2012. Manual of Montana vascular plants. Fort Worth, TX: Botanical Research Institute of Texas (BRIT) Press. 779 p.
- Levang-Brilz, N.; Biondini, M.E. 2003. Growth rate, root development and nutrient uptake of 55 plant species from the Great Plains grasslands, USA. *Plant Ecology*. 165(1): 117-144.
- Ley, E.L.; Buchmann, S.; Stritch, L.; Soltz, G. 2007. Selecting plants for pollinators: A regional guide for farmers, land managers, and gardeners in the southern Rocky Mountain steppe. San Francisco, CA: The Pollinator Partnership/North American Pollinator Protection Campaign. 24 p.
- Link, E., ed. 1993. Native plant propagation techniques for national parks interim guide: A cooperative program between the U.S. Department of Agriculture, Soil Conservation Service and U.S. Department of the Interior, National Park Service. East Lansing, MI: U.S. Department of Agriculture, Natural Resources Conservation Service, Rose Lake Plant Materials Center.
- Liu, R.; Jadeja, R.N.; Zhou, Q.X.; Liu, Z. 2012. Treatment and remediation of petroleum-contaminated soils using selective ornamental plants. *Environmental Engineering Science*. 29(6): 494-501.
- Looman, J. 1963. Preliminary classification of grasslands in Saskatchewan. *Ecology*. 44(1): 15-29.
- Looman, J. 1969. The fescue grasslands of western Canada. *Vegetatio*. 19(1/6): 128-145.
- Love, S. 2014. Blanketflower in the landscape. In: Native plants for the Intermountain West. Laramie, WY: University of Wyoming Extension. Available: <https://cwelwnp.usu.edu/westernnativeplants/plantlist.php> [Accessed 2024 May 5].
- Love, S.L.; Akins, C.J. 2019. Third summary of the native seed germination studies of Norman C Deno: species with names beginning with letters F through K. *Native Plants Journal*. 20(2): 123-144.
- Love, S.L.; Hutchinson, P.J.; Price, W.J. 2016. Managing weeds during wildflower meadow establishment in the arid Intermountain West: Efficacy of a grass-first strategy for sites with heavy annual weed pressure. *Native Plants Journal*. 17(3): 216-229.
- Luna, T.; Evans, J.; Wick, D; Hosokawa, J. 2008. Propagation protocol for production of container (plug) *Gaillardia aristata* Pursh. 160 ml containers. Native Plant Network. U.S. Department of Agriculture, Forest Service, National Center for Reforestation, Nurseries, and Genetic Resources. <http://npn.rngr.net/propagation/protocols> [Accessed 2024 May 5].
- Lyseng, M.P.; Bork, E.W.; Hewins, D.B.; Alexander, M.J.; Carlyle, C.N.; Chang, S.X.; Willms, W.D. 2018. Long-term grazing impacts on vegetation diversity, composition, and exotic species presence across an aridity gradient in northern temperate grasslands. *Plant Ecology*. 219(6): 649-663.

- Maguire, A.D.; Overland, A. 1959. Laboratory germination of seeds of weedy and native plants. Washington State Agricultural Experiment Station Circular 349. Pullman, WA: Washington State University. 15 p.
- Majerus, M.; Pokorny, M.; Winslow, S. 2017. Spring seeded native plants for enhancing pollinator habitat. Final report demonstration planting. Bridger, MT: U.S. Department of Agriculture, Natural Resources Conservation Service. 8 p. Available: <https://www.nrcs.usda.gov/plantmaterials/mtpmcsr13298.pdf>
- Maron, J.L.; Hajek, K.L.; Hahn, P.G.; Pearson, D.E. 2018. Rodent seed predators and a dominant grass competitor affect coexistence of co-occurring forb species that vary in seed size. *Journal of Ecology*. 106(5): 1795-1805.
- Maron, J.L.; Hajek, K.L.; Hahn, P.G.; Pearson, D.E. 2019. Seedling recruitment correlates with seed input across seed sizes. *Ecology*. 100(12): 1-11.
- Maron, J.L.; Pearson, D.E.; Potter, T.; Ortega, Y.K. 2012. Seed size and provenance mediate the joint effects of disturbance and seed predation on community assembly. *Journal of Ecology*. 100(6): 1492-1500.
- Masin, E.; Nelson, C.R.; Valliant, M.T. 2018. Can sheep control invasive forbs without compromising efforts to restore native plants? *Rangeland Ecology and Management*. 71(2): 185-188.
- Matt, C.P.; Keyes, C.R.; Dumroese, R.K. 2018. Biochar effects on the nursery propagation of four northern Rocky Mountain native plant species. *Native Plants Journal*. 19(1): 14-26.
- Mawdsley, J.R. 1999. Redescription and notes on the biology of *Amecocerus senilis* (Leconte) (Coleoptera: Melyridae: Dasytinae). *Journal of the New York Entomological Society*. 107(1): 68-72.
- McLean, A.; Holland, W.D. 1958. Vegetation zones and their relationship to the soils and climate of the Upper Columbia Valley. *Canadian Journal of Plant Science*. 1: 328-345.
- McManamen, C.; Nelson, C.R.; Wagner, V. 2018. Timing of seeding after herbicide application influences rate of germination and seedling biomass of native plants used for grassland restoration. *Restoration Ecology*. 26(6): 1137-1148.
- Mee, W.; Barnes, J.; Kjelgren, R.; Sutton, R.; Cerny, T.; Johnson, C. 2003. *Water wise: Native plants for Intermountain landscapes*. Logan, UT: Utah State University Press. 220 p.
- Mikkelsen, J.R.; Lym, R.G. 2013. Effect of aminopyralid on desirable forb species. *Invasive plant science and management*. 6(1): 30-35.
- Moerman, D. 2003. *Native American ethnobotany: A database of foods, drugs, dyes, and fibers of Native American peoples, derived from plants*. Dearborn, MI: University of Michigan. <http://naeb.brit.org>
- Moore, R.P. 1985. *Handbook on tetrazolium testing*. Zurich, Switzerland: International Seed Testing Association. 99 p.
- Moss, E.H. 1955. The vegetation of Alberta. *Botanical Review*. 21(9): 493-567.
- Mueggler, W.F. 1983. Variation in production and seasonal development of mountain grasslands in western Montana. Res. Pap. INT-316. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 16 p.
- Mueggler, W.F.; Stewart, W.L. 1980. Grassland and shrubland habitat types of western Montana. Gen. Tech. Rep. INT-66. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 154 p.
- Niu, G.H.; Rodriguez, D.S. 2006. Salinity and growing medium affected growth and morphology of *Gaillardia aristata*. *Hortscience*. 41(4): 1071-1071.
- Ogle, D.; Pavék, P.; Fleenor, R.; Stannard, M.; Dring, T.; Cane, J.; Fullen, K.; St. John, L.; Tilley, D. 2011. Plants for pollinators in the Inland Northwest. Tech. Note 2B. Boise, ID: U.S. Department of Agriculture, Natural Resources Conservation Service. 65 p.
- Ogle, D.; St. John, L.; Stannard, M.; Holzworth, L. 2012. Conservation plant species for the Intermountain West. Plant Material Technical Note 24. Boise, ID: U.S. Department of Agriculture, Natural Resources Conservation Service. 57 p.
- Ogle, D.; Tilley, D.; Cane, J.; St. John, L.; Fullen, K.; Stannard, M.; Pavék, P. 2011. Plants for pollinators in the Intermountain West. Plant Materials Tech. Note 2A. Boise, ID: U.S. Department of Agriculture, Natural Resources Conservation Service. 40 p.
- Ogle, D.; Tilley, D.; Cane, J.; St. John, L.; Fullen, K.; Stannard, M.; Pavék, P. 2019. Plants for pollinators in the Intermountain West. Plant Materials Tech. Note 2A. Boise, ID: U.S. Department of Agriculture, Natural Resources Conservation Service. 40 p.
- Omernik, J.M. 1987. Ecoregions of the conterminous United States. Map (scale 1:7,500,000). *Annals of the Association of American Geographers*. 77(1): 118-125.
- Palmer, J.B.; Hahn, P.G.; Metcalf, E.C.; Maron, J.L. 2021. Seed size of co-occurring forb species predicts rates of predispersal seed loss from insects. *Ecosphere*. 13(4): e4032.
- Parkinson, H. 2003. Landscaping with native plants of the Intermountain Region. Tech. Ref. 1730-3. Boise, ID: U.S. Department of the Interior, Bureau of Land Management. 46 p.
- Pavék, P.; Erhardt, B.; Heekin, T.; Old, R. 2012. Forb seedling identification guide for the Inland Northwest: Native, introduced, invasive, and noxious species. Pullman, WA: U.S. Department of Agriculture, Natural Resources Conservation Service, Pullman Plant Materials Center. 144

p.

Pearson, D.E.; Callaway, R.M.; Maron, J.L. 2011. Biotic resistance via granivory: Establishment by invasive, naturalized, and native asters reflects generalist preference. *Ecology*. 92(9): 1748-1757.

Perry, L.G.; Johnson, C.; Alford, E.R.; Vivanco, J.M.; Paschke, M.W. 2005. Screening of grassland plants for restoration after spotted knapweed invasion. *Restoration Ecology*. 13(4): 725-735.

Pitt, M.; Wikeem, B.M. 1990. Phenological patterns and adaptations in an *Artemisia/Agropyron* plant community. *Journal of Range Management*. 43(4): 350-358.

Plant Conservation Alliance [PCA]. 2015. National seed strategy for rehabilitation and restoration 2015-2020. Washington, DC: U.S. Department of the Interior, Bureau of Land Management. 52 p.

Plants for a Future [PFAF]. 2019. *Gaillardia* × *grandiflora* – Hort. ex Van Houtte. <https://pfaf.org/user/Plant.aspx?LatinName=Gaillardia+x+grandiflora> [Accessed 2024 September 23].

Prasser, N.P.; Hild, A.L. 2016. Competitive interactions between an exotic annual, *Halogeton glomeratus*, and 10 North American native species. *Native Plants Journal*. 17(3): 244-254.

Pratt, M.; Banner, R.; Bowns, J.; Rasmussen, A. 2024. Range plants of Utah: Blanketflower. Logan, UT: Utah State University Extension. <https://extension.usu.edu/rangeplants/> [Accessed 2024 September 23].

Ramaley, F. 1919a. Some mountain plant communities of sandy soil. *The Plant World*. 22(11): 313-328.

Ramaley, R. 1919b. Xerophytic grasslands at different altitudes in Colorado. *Bulletin of the Torrey Botanical Club*. 46(2): 37-52.

Redente, E.F.; Ogle, P.R.; Hargis, N.E. 1982. Growing Colorado plants from seed: A state of the art. Vol. III, forbs. FWS/OBS-82/30. Washington, D.C.: U.S. Department of the Interior, Fish and Wildlife Service. 141 p.

Reed, E.L. 1917. Meadow vegetation in the montane region of northern Colorado. *Bulletin of the Torrey Botanical Club*. 44(2): 97-109.

Reveal, J.L.; Moulton, G.E.; Schuyler, A.E. 1999. The Lewis and Clark collections of vascular plants: Names, types, and comments. *Proceedings of the Academy of Natural Sciences of Philadelphia*. 149: 1-64.

Richardson, B.; Kilkenny, F.; St. Clair, B.; Stevenson-Molnar, N. 2020. Climate Smart Restoration Tool. <https://climaterestorationtool.org/csrt/>

Robbins, W.W. 1908. Variation in flower-heads of *Gaillardia aristata*. *Biometrika*. 6(1): 106-108.

Robinson, G.S.; Ackery, P.R.; Kitching, I.; Beccaloni, G.W.; Hernández, L.M. 2023. HOSTS: A Database of the World's Lepidopteran Hostplants [Data set]. Natural History Museum. <https://doi.org/10.5519/havt50xw>

Robson, S.; Kingery, J. 2006. Native plants for Idaho roadside restoration and revegetation programs. Moscow, ID: University of Idaho and Idaho Transportation Department. 83 p.

Roemmich, A.R. 2011. Germination characteristics of prairie dropseed, blanketflower, and hairy goldaster in response to prechill and temperature treatments. Brookings, SD: South Dakota State University. Thesis. 58 p.

Scheinost, P.L.; Skinner, D.M.; Stannard, M.E. 2010. Evaluation of planting time and survivability of 16 forb and 2 grass species native to the Inland Northwest. Plant Materials Tech Note Note 20. Pullman, WA: U.S. Department of Agriculture, Natural Resources Conservation Service. 20 p.

SEINet – Regional Networks of North American Herbaria Steering Committee [SEINet]. 2020. SEINet Regional Networks of North American Herbaria. <https://Symbiota.org/docs/seinet>

Shiflet, T.N. 1994. Rangeland cover types of the United States. Denver, CO: Society for Range Management. 152 p.

Skinner, D.M. 2006. Propagation protocol for production of propagules (container plug) *Gaillardia aristata* Pursh plants. Native Plant Network. U.S. Department of Agriculture, Forest Service, National Center for Reforestation, Nurseries, and Genetic Resources. <http://npn.rngr.net/propagation/protocols> [Accessed 2024 May 10].

Society for Ecological Restoration; International Network for Seed Based Restoration; Royal Botanic Gardens [SER, INSR, RBGK]. 2024. Seed Information Database (SID). Available from: <https://ser-sid.org/>

Stegmaier, C.E. 1968. A review of recent literature on the host plant range of the genus *Liriomyza mik* (Diptera: Agromyzidae) in the continental United States and Hawaii, excluding Alaska. *The Florida Entomologist*. 51(3): 167-182.

Stoutamire, W. 1977. Chromosome races of *Gaillardia pulchella* (Asteraceae). *Brittonia*. 29(3): 297-309.

Strother, J. L. 2006. 384. *Gaillardia*. In: Flora of North America Editorial Committee, ed. Flora of North America North of Mexico. Volume 21 Magnoliophyta: Asteridae, part 8: Asteraceae, part 3 Asterales, part 3 (Aster order). New York, NY: Oxford University Press: 421-426.

- Süle, G.; Miholcsa, Z.; Molnár, C.; Kovács-Hostyánszki, A.; Fenesi, A.; Bauer, N.; Szigeti, V. 2023. Escape from the garden: Spreading, effects and traits of a new risky invasive ornamental plant (*Gaillardia aristata* Pursh). *NeoBiota*. 83: 43-69.
- Swingle, C.F. 1939. Seed propagation of trees, shrubs and forbs for conservation planting. SCS-TP-27. Washington, DC: U.S. Department of Agriculture, Soil Conservation Service. 198 p.
- Taylor, R.J. 1992. Sagebrush country: A wildflower sanctuary. Missoula, MT: Mountain Press Publishing Company. 211 p.
- Tilley, D.; Spencer, J.; Cracroft, T.; Brazee, B.; Vaughan, M.; Cruz, J.K. 2019. Creation and management of Utah butterfly habitat. Tech. Note Plant Materials 73. Boise, ID: U.S. Department of Agriculture, Natural Resources Conservation Service. 20 p.
- Tilley, D.J.; Pickett, T. 2018. Commercial wildflower seed mix evaluation, 2013-2017. Final study report. Aberdeen, ID: U.S. Department of Agriculture, Natural Resources Conservation Service. 30 p.
- Turesson, G. 1914. Slope exposure as a factor in the distribution of *Pseudotsuga taxifolia* in arid parts of Washington. *Bulletin of the Torrey Botanical Club*. 41(6): 337-345.
- Turner, N.J.; Bouchard, R.; Kennedy, D.I. 1980. Ethnobotany of the Okanagan-Colville Indians of British Columbia and Washington. Victoria, BC: British Columbia Provincial Museum. 179 p.
- Turner, N.J.; Thompson, L.C.; Thompson, M.T.; York, A.Z. 1990. Thompson ethnobotany: Knowledge and usage of plants by the Thompson Indians of British Columbia. Royal British Columbia Museum Memoir No. 3. Victoria, British Columbia, Canada: Royal British Columbia Museum. 335 p.
- Tyrer, S.J.; Hild, A.L.; Meador, B. A.; Munn, L.C. 2007. Establishment of native species in soils from Russian knapweed (*Acroptilon repens*) invasions. *Rangeland Ecology and Management*. 60(6): 604-612.
- Tyser, R.W. 1992. Vegetation associated with two alien plant species in a fescue grassland in Glacier National Park, Montana. *The Great Basin Naturalist*. 52(2): 189-193.
- USDA Forest Service, Bend Seed Extractory [USDA FS BSE]. 2021. Nursery Management Information System Version 4.1.11. Local Source Report 34-Source Received. Bend, OR: U.S. Department of Agriculture, Forest Service, Bend Seed Extractory.
- USDA Forest Service, Western Wildland Environmental Threat Assessment Center [USFS WWETAC]. 2017. TRM Seed Zone Applications. Prineville, OR: U.S. Department of Agriculture, Forest Service, Western Wildland Environmental Threat Assessment Center. <https://research.fs.usda.gov/pnw/products/dataandtools/seed-zone-webmap>
- USDA Natural Resources Conservation Service [USDA NRCS]. 2024. The PLANTS Database. Greensboro, NC: U.S. Department of Agriculture, Natural Resources Conservation Service, National Plant Data Team. <https://plants.sc.egov.usda.gov/>
- USDA Natural Resources Conservation Service [USDA NRCS]. n.d. Meriwether blanketflower *Gaillardia aristata* Pursh. A conservation plant release by USDA NRCS Bridger Plant Materials Center, Bridger, Montana. 2 p.
- USDI Bureau of Land Management, Seeds of Success [USDI BLM SOS]. 2020. Seeds of Success collection data. Washington, DC: U.S. Department of the Interior, Bureau of Land Management, Plant Conservation and Restoration Program.
- USDI Bureau of Land Management, Seeds of Success [USDI BLM SOS]. 2023. Bureau of Land Management technical protocol for the collection, study, and conservation of seeds from native plant species for Seeds of Success. Washington, DC: U.S. Department of the Interior, Bureau of Land Management, Plant Conservation and Restoration Program. 45 p.
- USDI Environmental Protection Agency [USDI EPA]. 2018. Ecoregions. Washington, DC: U.S. Environmental Protection Agency. <https://www.epa.gov/eco-research/ecoregions>
- USDI Geological Survey [USDI USGS]. 2020. Biodiversity Information Serving Our Nation (BISON). U.S. Geological Survey. <https://www.gbif.us/>
- Utah Crop Improvement Association [UCIA]. 2015. How to be a seed connoisseur. Logan, UT: UCIA, Utah Department of Agriculture and Food, Utah State University and Utah State Seed Laboratory. 16 p.
- Utah State University. 2024. EcoRestore Utah. Logan, UT: Utah State University Extension. <https://extension.usu.edu/ecorestore/>
- Vestal, A.G. 1917. Foothills vegetation in the Colorado Front Range. *Botanical Gazette*. 64(5): 353-385.
- Victor, S.; Doherty, K.; DuPre, M.E.; Ramsey, P.W.; Lekberg, Y. 2023. Fine-scale trait variation of five native forbs along environmental gradients. *Native Plants Journal*. 24(3): 192-205.
- Wang, S.; Callaway, R.M.; Zhou, D.-W.; Weiner, J. 2017. Experience of inundation or drought alters the responses of plants to subsequent water conditions. *Journal of Ecology*. 105(1): 176-187.
- Weaver, J.E. 1914. Evaporation and plant succession in south-eastern Washington and adjacent Idaho. *The Plant World*. 17(10): 273-294.
- Weaver, T.; Gustafson, D.; Lichthardt, J. 1993. Plants colonizing disturbed areas in fifteen Rocky Mountain environments: Weeds and reclamation candidates. University of Wyoming National Park Service Research Center annual report. 17(4): 1-9.

Welsh, S.L.; Atwood, N.D.; Goodrich, S.; Higgins, L.C., eds. 2015. A Utah Flora. Fifth Edition, revised. Provo, UT: Brigham Young University. 990 p.

Wiese, J.L.; Keren, E.N.; Menalled, F.D. 2011. Tolerance of native wildflower species to postemergence herbicides. *Native Plants Journal*. 12(1): 31-36.

Wikeem, B.M.; Pitt, M.D. 1979. Interpreting diet preference of California bighorn sheep on native rangeland in south-central British Columbia. *Rangelands*. 1(5): 200-202.

Wilkins, B.T. 1957. Range use, food habits, and agricultural relationships of the mule deer, Bridger Mountains, Montana. *The Journal of Wildlife Management*. 21(2): 159-169.

Winslow, S.; Ayala, I.; Majeski, M.; Eckman, C.; Pokorny, M. 2023. Plant guide for blanketflower (*Gaillardia aristata*). Bridger, MT: U.S. Department of Agriculture, Natural Resources Conservation Service, Bridger Plant Materials Center. 7 p.

Winslow, S.R. 2002. Propagation protocol for production of propagules *Gaillardia aristata* Pursh seeds. Native Plant Network. U.S. Department of Agriculture, Forest Service, National Center for Reforestation, Nurseries, and Genetic Resources. <http://npn.rngr.net/propagation/protocols> [Accessed 2024 May 10].

Winslow, S.R. 2011a. Plant fact sheet for blanketflower (*Gaillardia aristata*). Bridger, MT: U.S. Department of Agriculture, Natural Resources Conservation Service. 2 p.

Winslow, S.R. 2011b. Blanketflower (*Gaillardia aristata*): A native conservation wildflower for use in the northern Great Plains and Rocky Mountains. Plant Materials Technical Note MT-71. Bridger, MT: U.S. Department of Agriculture, Natural Resources Conservation Service. 4 p.

Wolf, J.J.; Beatty, S.W.; Seastedt, T.R. 2004. Soil characteristics of Rocky Mountain National Park grasslands invaded by *Melilotus officinalis* and *M. alba*. *Journal of Biogeography*. 31(3): 415-424.

Young, S.A.; Schrupf, B.; Bouck, M.; Moore, M. 2020. How the Association of Official Seed Certifying Agencies (AOSCA) tracks wildland sourced seed and other plant propagating materials. Logan, UT: Utah State University, Utah Agricultural Experiment Station. 36 p.

How to Cite

Gucker, Corey L.; Shaw, Nancy L. 2025. Blanketflower (*Gaillardia aristata*). In: Gucker, C.L.; Shaw, N.L., eds. Western forbs: Biology, ecology, and use in restoration. Reno, NV: Great Basin Fire Science Exchange. <https://westernforbs.org>