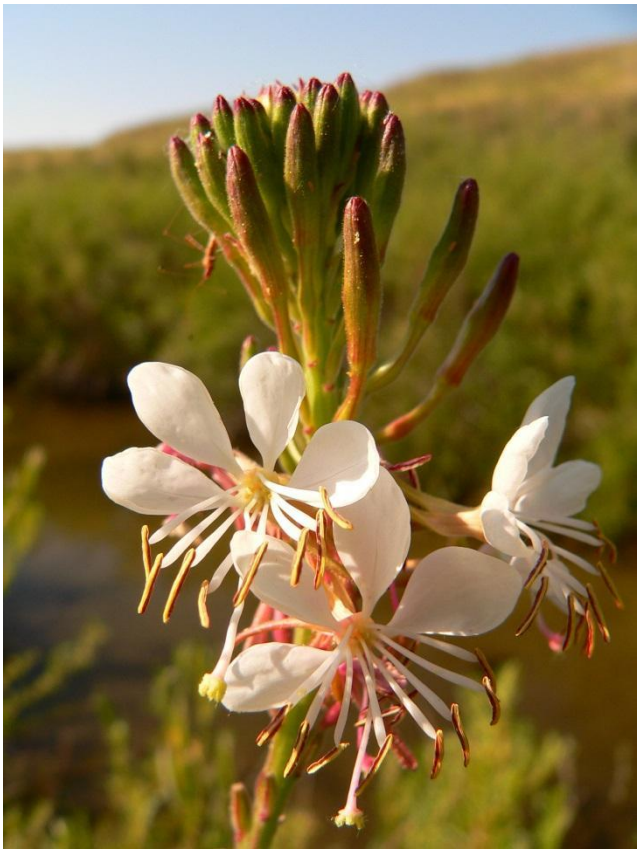
Species Biological Report for

Colorado butterfly plant

(*Oenothera coloradensis*;
formerly *Gaura neomexicana* subsp. *coloradensis*)



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This Species Biological Report is a comprehensive biological status review by the U.S. Fish and Wildlife Service (Service) for the Colorado butterfly plant (*Oenothera coloradensis* formerly *Gaura neomexicana* subsp. *coloradensis*) and provides an account of the species' overall viability. Future Service documents will use information presented in this Biological Report to provide the best available scientific information on which to base recovery and delisting decisions.

Executive Summary

Colorado butterfly plant, an herbaceous monocarpic or semelparous perennial, occurs in in southeastern Wyoming, north-central Colorado, and extreme western Nebraska between elevations of 5,000 and 6,400 feet in moist soils in wet meadows of floodplains. To evaluate both the current and future status of the Colorado butterfly plant, we consider the species' viability as characterized by resiliency, redundancy, and representation (i.e. the 3Rs). The Colorado butterfly plant needs resilient populations spanning all ecological settings throughout its range to maintain its persistence into the future and to avoid extinction.

When the Colorado butterfly plant was listed as threatened in 2000 (65 FR 62302; October 18, 2000) under the Endangered Species Act of 1973, as amended, 16 U.S.C. 1531 *et seq.* (Act), threats to the species included non-selective herbicide spraying, haying and mowing schedules that inhibit the setting of seed, land conversion for cultivation and subdivision, and competition from noxious weeds. Low numbers and limited distribution contributed to the species' vulnerability. Since that time, oil and gas activities have grown. Critical habitat was established for the Colorado butterfly plant in specific wet meadows and riparian areas within Laramie and Platte Counties in Wyoming (70 FR 1940; January 11, 2005). Four additional populations have been discovered and voluntary agreements with private landowners in much of the species' range have allowed the Service to monitor annual population trends to better understand threats affecting the 3Rs of species viability.

To summarize the species in terms of the 3Rs, the Colorado butterfly plant appears to be comprised of numerous populations that appear to be fluctuating yet resilient, with some connectivity among subpopulations and populations via pollinators and likely water-borne seed dispersal. These populations are spread within much of the historic range of the species and have common as well as unique alleles. Several populations on federal and local public lands are managed to maintain the species. The populations occurring on private lands appear to be stable through management for cattle and/or hay production. Given the current distribution of the species across much of its historic range and the resiliency of individuals and populations, the species is likely to withstand and recover from stochastic and catastrophic events. For example, we have documented declining populations that rebounded two orders of magnitude, indicating that population numbers at any one time are not necessarily a true representation of the population's resiliency. Regarding redundancy, over 20 populations are spread along and among

multiple 12-digit hydrologic unit code (HUC) watersheds in various ecological settings in all three states within the range of the species, and at least 12 are highly viable. Regarding representation, individuals and populations are found in three ecological settings, namely (1) streamside, (2) outside of the stream channel, but in the floodplain, and (3) within spring-fed wet meadows. The following analysis provides a detailed assessment of the current status of the Colorado butterfly plant, which we think indicates that the species is viable.

Introduction

The Species Biological Report is intended to be an in-depth but not exhaustive review of the species' biology and threats, an evaluation of its biological status, and an assessment of the resources and conditions needed to maintain long-term viability. The Species Biological Report is intended to be an interim approach as we transition to using a species status assessment (SSA) as the standard format that the Service utilizes to analyze species as we make decisions under the Act. The intent is for the species biological report to be easily updated as new information becomes available and to support all functions of the Endangered Species Program. Many species will have a Species Biological Report or SSA developed during the listing process. However, for species that are currently listed, such as the Colorado butterfly plant, a Species Biological Report or an SSA may be first developed during the recovery process. It is the intent that the Species Biological Report or SSA be a living document. In this Species Biological Report, we consider what the species needs to maintain viability by characterizing the status of the species in terms of its resiliency, redundancy, and representation (Wolf *et al.* 2015).

- **Resiliency** is the ability of populations, or the species as a whole, to persist in the face of environmental variation and stochastic events (i.e., events arising from random factors). Resiliency is measured by demographics, such as population abundance and growth rate, and indirectly by ecological factors such as habitat quantity and quality.
- **Redundancy** is the ability of a species to withstand catastrophic events (such as a rare destructive natural event or episode involving many populations); spreading risk among multiple populations to minimize the potential loss of the species. Redundancy is characterized by having multiple, resilient populations distributed within the species' ecological settings and across the species range. Redundancy is measured by population number, resiliency, spatial extent, and degree of connectivity.
- **Representation** is the ability of a species to adapt to changing environmental conditions over time. It is characterized by the breadth of genetic and environmental diversity within and among populations. Representation is measured by the number of varied niches occupied, genetic diversity, heterozygosity, or alleles per locus.

Status of the Species

The Colorado butterfly plant (*Oenothera coloradensis* formerly *Gaura neomexicana* subsp. *coloradensis*) was federally listed as threatened on October 18, 2000 (65 FR 62302). Prior to

that, the Colorado butterfly plant was a "Category 1" Candidate for listing between 1980 and 1998. Populations of Colorado butterfly plant occur along creeks, springs, and wet meadows between the Rocky Mountains and the Great Plains in north-central Colorado, southeastern Wyoming, and western Nebraska. Critical habitat for Colorado butterfly plant was established in 2005 in seven 12-digit HUC watersheds in Wyoming (70 FR 1940; January 11, 2005).

This plant requires periodic disturbance either through flooding, mowing, burning, or grazing to maintain open to semi-open streamside and meadow habitat it occupies. At the time of listing the Colorado butterfly plant was listed as a subspecies, with a recovery priority number of 9C, indicating the subspecies faced a moderate degree of threats with a high recovery potential, though may have conflict with development or economic activities (see striped rows in Table 1). In this biological report, we now recommend changing this recovery priority number to 14, because (1) the Colorado butterfly plant is a unique species, (2) the degree of threats are now considered as low, (3)the species has a high potential for recovery and (4) is no longer considered to be in substantial conflict with construction, development, or economic activity (see shaded rows in Table 1).

Table 1. Ranking system for determining recovery priority numbers was established in 1983 (48 FR 43098; September 21, 1983, as corrected in 48 FR 51985; November 15, 1983). The subspecies was formerly classified as 9C (hashed rows), and we recommend moving to 14 (grey rows) based on new information (see Taxonomy section below).

Degree of Threat	Recovery Potential	Taxonomy	Priority	Conflict
High	High	Monotypic Genus	1	1C
		Species	2	2C
		Subspecies/DPS	3	3C
	Low	Monotypic Genus	4	4C
		Species	5	5C
		Subspecies/DPS	6	6C
Moderate	**High**	Monotypic Genus	7	7C
		Species	8	8C
		Subspecies/DPS	**9**	**9C**
	Low	Monotypic Genus	10	10C
		Species	11	11C
		Subspecies/DPS	12	12C
Low	High	Monotypic Genus	13	13C
		Species	14	14C
		Subspecies/DPS	15	15C
	Low	Monotypic Genus	16	16C
		Species	17	17C
		Subspecies/DPS	18	18C

Taxonomy and Species Description

The Colorado butterfly plant, a member of the evening primrose family (Onagraceae), was listed as *Gaura neomexicana* subsp. c*oloradensis* in 2000 (65 FR 62302; October 18, 2000). This taxon was originally described at the species rank as *Gaura coloradensis* Rydb. based on material collected in 1895 by J.H. Cowan near Fort Collins, Colorado (Rydberg 1904, p. 572). In a revision of the genus *Gaura*, Munz (1938, p.114) treated it as a variety *G. neomexicana* var. *coloradensis* (Rydb.) Munz. In a subsequent revision of the genus *Gaura*, the infraspecific rank of subspecies was adopted. Accordingly, *Gaura neomexicana* subsp. *coloradensis* (Rydb.) P.H. Raven & D.P. Greg. (Raven and Gregory 1972, p. 63) was the accepted nomenclature at the time of listing.

Molecular studies by Hoggard *et al*. (2004, p. 143) and Levin *et al*. (2004, pp. 151–152) showed that the genus *Gaura* is deeply nested within the genus *Oenothera*. This necessitated renaming all *Gaura* taxa as species of *Oenothera*. In recognition of this and other work on the family Onagraceae, Wagner *et al*. (2007, entire) published a revised classification of the family Onagraceae. *Gaura neomexicana* subsp. *coloradensis* was transferred to *Oenothera* and elevated to species rank as *O. coloradensis* (Rydb.) W.L. Wagner & Hoch (Wagner *et al*. 2007, p. 211). The name *Oenothera neomexicana* had been previously published for a different species and hence was unavailable. There can only be one species in a genus with a particular species name. Wagner et al. (2007, p. 211) transferred the taxon previously known as *Gaura neomexicana* Wooton to *Oenothera* as *Oenothera coloradensis* subsp. *neomexicana* (Wooton) W.L. Wagner & Hoch.

More recent analyses showed that *Oenothera coloradensis* was not monophyletic. The two subspecies previously included in *O. coloradensis* are not related to each other closely enough to be considered the same species but rather each warrant separate species status (Wagner et al. 2013, p. 62). Consequently *O. coloradensis* subsp. *neomexicana* (Wooten) W.L. Wagner & Hoch as a species is now *Oenothera dodgeniana* Krakos & W.L. Wagner (Wagner et al. 2013, p. 66). Because no infraspecific entities are now recognized the listed entity is *Oenothera coloradensis,* the currently accepted name and rank of the listed entity (Wagner et al. 2013, p. 67).

The taxonomic and nomenclatural changes do not alter the description, range, or threat status of the listed entity. Its elevation to the rank of species does however alter the Recovery Priority Number (RPN).

Following provisions of the Federal Code of Regulations at 50 CFR 17.12 (b) that state: The Services shall use the most recently accepted scientific name. We will use the correct name and rank for the Colorado butterfly plant as *Oenothera coloradensis* throughout this document and subsequent documents. It was elevated to the rank of species 4 years ago, and it was published as included in *Oenothera* 10 years ago. Neither of these changes has yet to be included in the CFR even though the 50 e-CFR 17 posts in red text "e-CFR data is current as of March 9, 2017". ITIS, a database referred to on the ECOS site refers to the taxon by the correct genus and species

even though it is not reflected on the ECOS species profile page. We will use the correct name and rank for the Colorado butterfly plant but realize that the listing of the species *Oenothera coloradensis* (Colorado butterfly plant) may for the foreseeable future be incorrectly identified by name and rank in the CFR as *Gaura neomexicana* subsp. *coloradensis* until such time as a correction is published in the **Federal Register**.

The Colorado butterfly plant is a short-lived perennial monocarpic or semelparous herb. First year plants consist of a ground-level basal rosette of oblong, 3 to 18 centimeter (cm; 1 to 7 inch) long hairless leaves clustered at ground level that persists for one to several years. In the flowering stage, this plant has one to a few reddish, hairy stems that are 0.6 to 1.3 meters (2 to 4 feet) tall with sparse small leaves. Flowers are arranged in a branched elongate inflorescence above the leaves. Flowers are located below the rounded buds and above the mature fruits. Individual flowers are 5 to 14 millimeters (0.25 to 0.5 inch) long with four reddish sepals and four white petals that turn pink or red with age. The hard, nutlike fruits are four-angled capsules and have no stalk (Marriott 1987; Fertig 1994; Fertig *et al.* 1994; Fertig 2000b, Heidel *et al.* 2008).

Life History

Seeds of the Colorado butterfly plant germinate in spring and produce single basal rosettes that persist for one to a few years. After a rosette has reached sufficient above and/or below-ground resources, the plant grows one to several central stems which flower and produce fruit once and then the plant dies. In the flowering stage, flowers sequentially open up the stem so that only a few flowers are open on any stem at a given point in time (Marriott 1987; Fertig 1994; Fertig *et al.* 1994; Fertig 2000a, 2000b, 2001).

Pollinators for related species of *Gaura* and *Colyphus* (Onagraceae, tribe Onagreae) consist of noctuid moths (Noctuidae) and halictid bees (Lasioglossum; Clinebell *et al.* 2004), and both moths and bees have been identified visiting Colorado butterfly plant flowers during annual censusing (USFWS 2016). Additionally, one study found that Colorado butterfly plant does not exhibit a bimodal pollination system that is seen in other *Gaura* species since the majority of pollination occurs at night by noctuid moths (Krakos *et al.* 2013).

Research on reproductive ecology of this species found that Colorado butterfly plant is self-compatible, but does not appear to be pollen-limited, meaning pollination events do not fertilize all ovules (Krakos *et al.* 2014, p. 528). Self-compatibility has been suggested as a mechanism to overcome pollen limitation in other related species (Krakos *et al*. 2014, p. 523). The hard, four-angle nutlike fruits produced from each flower contain three to five seeds (Burgess *et al*. 2005). There are no apparent adaptations for dispersal; many seeds fall to the ground around parent plants (Floyd and Ranker 1998), and, because the seed floats, others may be dispersed downstream. Livestock and native ungulates could provide an important dispersal mechanism as well through ingestion of the seeds (USFWS 2012, p. 27). We are unsure how long seeds persist

in the soil, though a population presumed extirpated by dewatering in Nebraska was rediscovered during an occasional monitoring event over 10 years later after water was reintroduced to the drainage (Wooten 2008). Additionally, seeds that were stored for five years in cold storage had more viable seeds per capsule than more recent seed collections at 16, 4, 3, and 2 months (Burgess *et al.* 2005). This provides evidence of a seedbank, an adaptation that enables species to take advantage of favorable growing seasons, particularly in flood-prone areas (Holzel and Otte 2004).

Population growth rates in Colorado butterfly plant appear to be influenced by rates of seedling establishment and survival of vegetative rosettes to reproductive maturity. These factors may be influenced by summer precipitation (Marriott and Jones 1988; Floyd 1995a; Fertig 1996, 1997, 1998a, 1998b; Floyd and Ranker 1998). More recent evaluation suggests that the combination of cool and moist spring months, is important in germination, and that germination levels shaped the outcome of flowering plant population census in subsequent years. Additionally, summer conditions, and temperature in particular, appears to be an important mortality factor rather than a major influence on germination (Heidel 2004a, 2005a, Laursen and Heidel 2003). During the drought of 1994, Floyd measured 47% less seedling recruitment at sample plots on Francis Emroy (F.E.) Warren Air Force Base (Warren AFB) than in the preceding year (Floyd and Ranker 1998). Differences in soil moisture and vegetation cover may also influence recruitment success (Munk *et al.* 2002).

The vegetative rosettes within a population may provide an important and particularly resilient stage of the life history of this species. Individual vegetative rosettes appear to be capable of surviving adverse stochastic events such as fire (Mountain West Environmental Services 1985) and adverse climatic years when new seedling establishment is low. Therefore, episodic establishment of large seedling recruitment classes may be important for the long-term growth, replenishment, and survival of populations (Floyd and Ranker 1998).

Distribution and Habitat

Colorado butterfly plant is a regional endemic riparian species known from 29 12-digit HUC watersheds, historically found from Boulder, Douglas, Larimer, and Weld Counties in Colorado, Laramie County in Wyoming, and western Kimball County in Nebraska (see Figure 1). Prior to 1984, no extensive searches for the plant had been conducted and herbarium specimens were the primary basis of understanding Colorado butterfly plant's historical distribution. At that time, the plant was known from a few historical and presumably extirpated locations in southeastern Wyoming and several locations in northern Colorado, as well as from three extant populations in Laramie County in Wyoming and Weld County in Colorado. Prior to listing, extensive surveys were conducted in 1998 to document the status of the known populations, and all still supported populations of Colorado butterfly plant (Fertig 1998b).

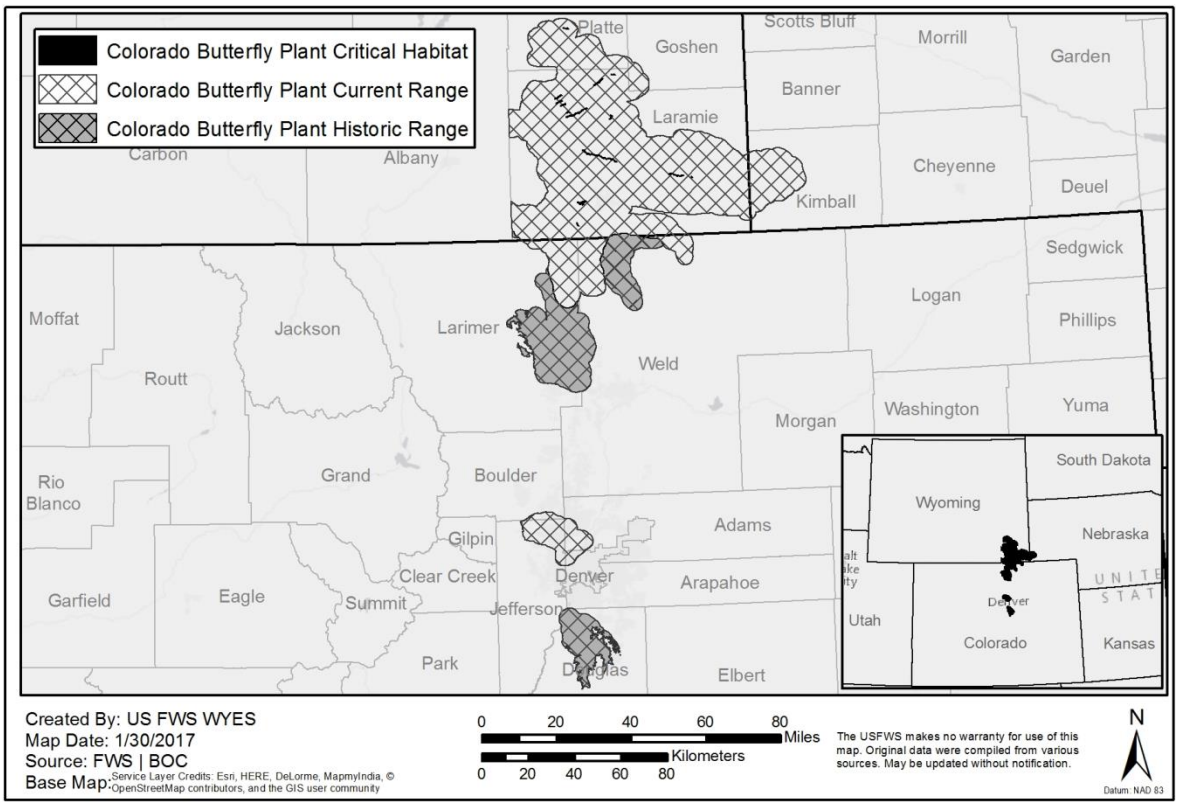


Figure 1. Historical and current range of Colorado butterfly plant (O. *coloradensis*) in Colorado, Wyoming, and Nebraska. Known populations generalized to 12-digit HUC watersheds and buffered by two miles.

Colorado butterfly plant occurs on subirrigated, alluvial soils derived from conglomerates, sandstones, and tuffaceous mudstones and siltstones of the Tertiary White River, Arikaree, and Oglalla Formations (Love and Christiansen 1985 in Fertig 2000) on level or slightly sloping floodplains and drainage bottoms at elevations of 1,478 to 1,951 meters (4,850 to 6,400 feet). Populations are typically found in habitats created and maintained by streams active within their floodplains, with vegetation that is relatively open and not overly dense or overgrown (65 FR 62302; October 18, 2000). Populations are often found in a variety of ecological settings, including low depressions or along bends in wide, active, meandering stream channels slightly upslope of the channel, though at least one population also occurs in a spring-fed wet meadow (see Figure 2). The Wyoming Ecological Services Field Office developed an area of influence map focused on buffering drainages where this species occurs (see Figure 3).

Figure 2. Images of example Colorado butterfly plant habitats or ecological settings ((1) streamside, 2) within spring-fed wet meadows, and (3) outside of the stream channel, but in the floodplain. Photo credit Julie Reeves, USFWS.

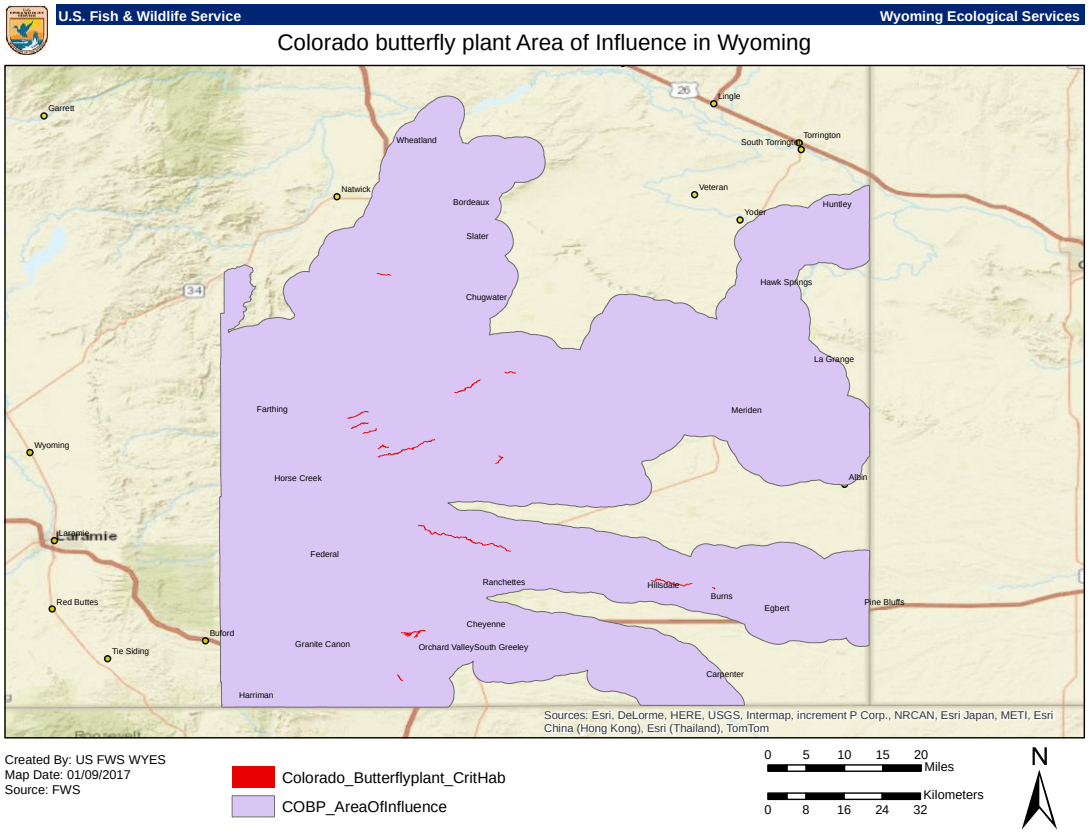


Figure 3. Area of influence for the Colorado butterfly plant in Wyoming. Description of how this area of influence was developed is available at https://www.fws.gov/mountain-prairie/es/wyoming/Species/COButterfly.php.

The plant is often found in but not restricted to early- to mid-succession riparian habitat. Historically, flooding was probably the main cause of disturbances in the plant's habitat, although wildfire and grazing by native herbivores also may have been important. Although flowering and fruiting stems may exhibit increased mortality because of these events, vegetative rosettes appear to be little affected (Mountain West Environmental Services 1985). It commonly occurs in communities dominated by non-native and disturbance-tolerant native species including: *Agrostis stolonifera* (creeping bentgrass), *Poa pratensis* (Kentucky bluegrass), *Glycyrrhiza lepidota* (American licorice), *Cirsium flodmanii* (Flodman's thistle), *Grindelia squarrosa* (curlytop gumweed), and *Equisetum laevigatum* (smooth scouring rush). Its habitat on Warren AFB includes wet meadow zones dominated by *Panicum virgatum* (switchgrass), *Muhlenbergia richarsonis* (mat muhly), *Schizachyrium scoparium* (little bluestem), and other native grasses. All of these habitat types are usually intermediate in moisture ranging from wet, streamside communities dominated by sedges, rushes, and cattails to and dry, upland prairie habitat.

Typically, Colorado butterfly plant habitat is open, without dense or woody vegetation. The establishment and survival of seedlings appears to be enhanced at sites where tall and dense vegetation has been removed by some form of disturbance. In the absence of occasional disturbance, the plant's habitat can become choked by dense growth of willows, grasses, and exotic plants (Floyd 1995a; Fertig 1996). This prevents new seedlings from becoming established and replacing plants that have died (Floyd 1995a; Fertig 1996).

In areas of suitable habitat for Colorado butterfly plant, *Salix exigua* (coyote willow), *Cirsium arvense* (Canada thistle), and *Euphorbia esula* (leafy spurge) may become dominant; the willow in particular increases in the absence of grazing or mowing. These species can outcompete and displace Colorado butterfly plant, presumably until another disturbance removes competing vegetation and creates openings for Colorado butterfly plant seedlings to germinate.

For the purposes of this analysis, we consider all occurrences of Colorado butterfly plant within the same 12-digit HUC to be one population. Populations defined this way typically consist of numerous subpopulations, each with dozens to hundreds of flowering stems and rosettes. These subpopulations are often widely scattered and may be isolated by gaps of seemingly suitable habitat, which contributes to resiliency of this species. There are no detailed genetics data for defining populations and though distance of 1 km or greater may exceed the distance traveled by pollinators, it is possible that fruits may disperse over much greater distances. Therefore, because these gaps are probably too small to prevent the dispersal of pollinators and/or fruits between subpopulations, colonies along the same stream reach should be considered part of the same population (Heidel pers. comm. 2016b). This varies from the characterization of populations in both the listing decision (65 FR 62302; October 18, 2000) and critical habitat designation (70 FR 1940; January 11, 2005), where populations were defined by landowner and/or proximity within a drainage. We find organizing populations based on 12-digit HUCs to more accurately describe components of population ecology (genetic exchange within a

geographic area) and stressors affecting the species tend to vary by watershed. Because of this new organization of population structure, some populations considered distinct and separate during the listing decision are now combined and vice versa, though many populations are retained between the two documents.

Critical Habitat

On January 11, 2005, seven units in Wyoming were designated as critical habitat for Colorado butterfly plant (70 FR 1940). The units are: (1) Tepee Ring Creek; (2) Bear Creek East; (3) Bear Creek West; (4) Little Bear Creek/Horse Creek; (5) Lodgepole Creek West; (6) Lodgepole Creek East; and (7) Borie (see Figure 4). At the time of the designation, only one naturally occurring population was known in Colorado. This site was excluded from the final critical habitat designation under section 4(b)(2) of the Act, because this area was covered by a Wildlife Extension Agreement (WEA) that provided for the conservation of the Colorado butterfly plant. Other historical locations in Boulder, Douglas, and Larimer Counties in Colorado were also not included in the designation, because those areas did not contain the Primary Constituent Elements. The critical habitat designation did not include any portions of Nebraska; we knew of no areas in the State containing subpopulations or suitable habitat at the time of the designation (USFWS 2005: 70 FR 1940, January 11, 2005).

The final designation of critical habitat (70 FR 1940, January 11, 2005) for Colorado butterfly plant included the following critical habitat primary constituent elements:

1) Subirrigated, alluvial soils on level or low-gradient floodplains and drainage bottoms at elevations of 1,524 to 1,951 meters (5,000 to 6,400 feet);
2) A mesic moisture regime, intermediate in moisture between wet and dry, streamside communities dominated by sedges, rushes, cattails, and dry upland shortgrass prairie;
3) Early- to mid-succession riparian (streambank or riverbank) plant communities that are open and without dense or overgrown vegetation (including hayed fields that are disced every 5 to 10 years at a depth of 20 to 30 centimeters (8 to 12 inches), grazed pasture, other agricultural lands that are not plowed or disced regularly, areas that have been restored after past aggregate extraction, areas supporting recreation trails, and urban/wildland interfaces); and
4) Hydrological and geological conditions that maintain stream channels, floodplains, floodplain benches, and wet meadows that support patterns of plant communities associated with Colorado butterfly plant.

Over the past 12 years since the time of designation, the Service has not consulted on projects that may adversely affect designated critical habitat in any of the seven units. This may be because all designated critical habitat occurs on private lands, and due to the requirement that only federal agencies or those seeking federal permits or funding must consult on projects that may affect designated critical habitat under the Act, no such projects have been proposed. This

may also be because no private landowners have sought the development of their property or sought to consult with the Service under a habitat conservation plan.

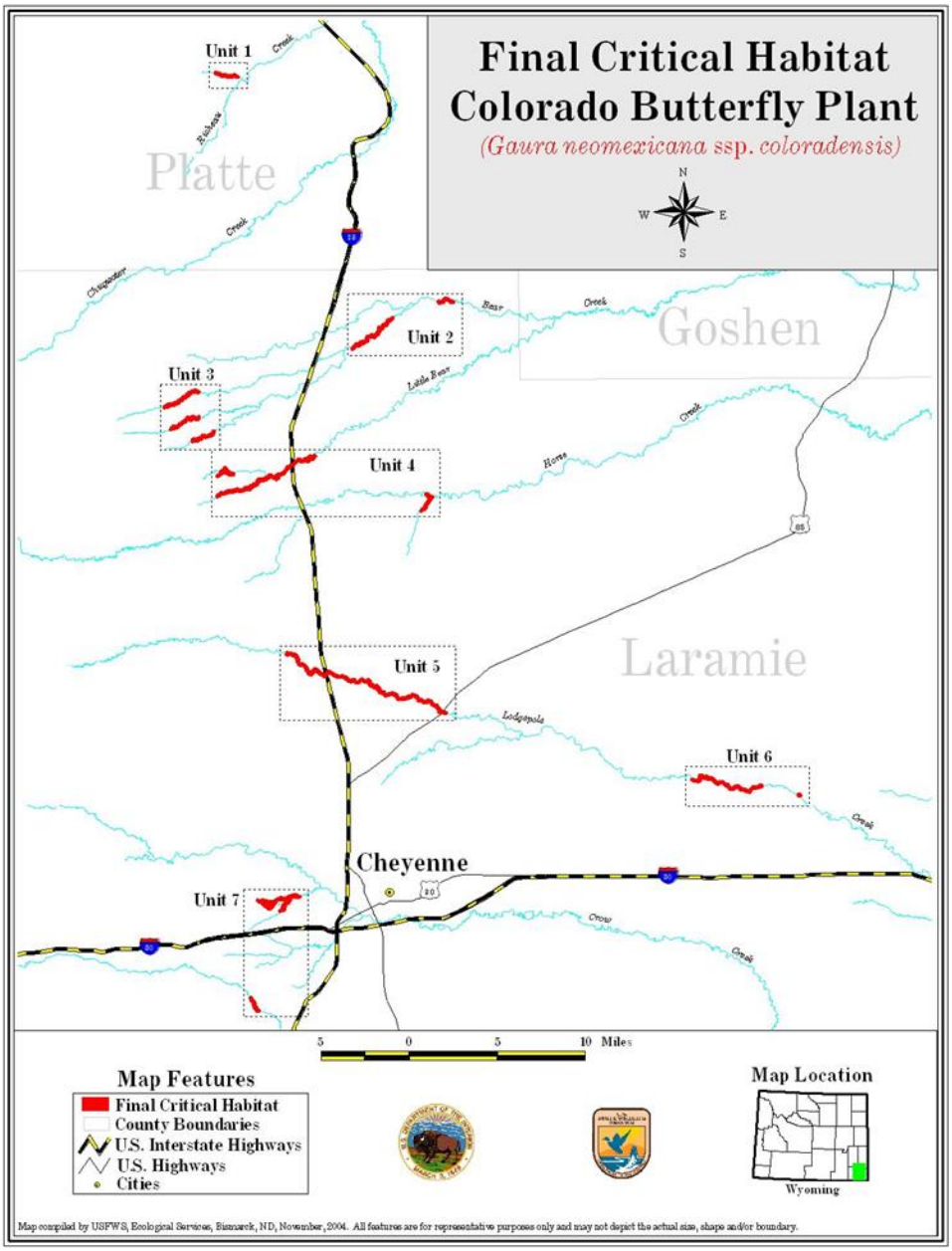


Figure 4. Designated critical habitat for the Colorado butterfly plant (USFWS 2005: 70 FR 1940, January 11, 2005).

Population Abundance and Trends

Colorado butterfly plant occurred historically and continues to occur in various ecological settings, as described above under Habitat and Distribution, including streamside habitats, outside of the stream channel, but in the floodplain, and spring-fed wet meadows. In 1979, the total known species size of Colorado butterfly plants was estimated in the low hundreds when very few Wyoming populations were known (Clark and Dorn 1979). Extensive range-wide surveys between 1984 and 1986 resulted in the detection of more than 20 populations distributed among sites in Wyoming, Colorado, and Nebraska, supporting approximately 20,000 flowering individuals (Marriott 1987). Additional surveys since 1992 resulted in the discovery of several additional populations in Wyoming and Colorado (Fertig 1994; 2000; Floyd 1995b; USFWS 2016). However, after intensive searches, other historically known populations or subpopulations in Wyoming, Colorado, and Nebraska have not been rediscovered in the past few years and may no longer be extant (Fertig 1994, Handwerk pers. comm. 2016, Heidel pers. comm. 2016a, Rabbe pers. comm. 2016; see Table 2).

In 1998-1999, in preparation for listing the species, the rangewide census of flowering individuals was estimated at 47,300 to 50,300, with the majority of these occurring in Wyoming (Fertig 1998b, 2000). However, a population was located in Colorado in 2005 that had a peak census of 26,000 plants in 2011 appearing to represent roughly 33 percent of the total species' numbers, bringing the total rangewide population to approximately 73,300 to 76,000 plants over time. Another population was discovered upstream of known populations on Horse Creek in Laramie County, Wyoming in 2016 with only 17 individuals, although the area had just been hayed and so was likely an incomplete representation of the total number of plants in this population (USFWS 2016).

Average numbers may be a more appropriate way to represent populations than the minimum and maximum values, though all provide insight into the population's resiliency. The number of reproductive individuals in a population is somewhat driven by environmental factors and are shown to vary considerably, and so understanding the variability in the number of individuals present in any given year is meaningful in assessing population resiliency. Population numbers in unmanaged population have fluctuated by a factor of five in the longest-running Colorado butterfly plant monitoring study conducted on Warren AFB. There, the population has peaked at over 11,000 plants in 1999 and 2011, as one of the largest populations rangewide, and dropped to 1,916 in 2008 (Heidel *et al.* 2016). While the Warren AFB population numbers provide some indication of how population numbers can vary under idle conditions, it is likely that numbers vary even more dramatically on managed landscapes. If this were applied to the rangewide population estimates above, then total numbers on average years might be less than 50 percent of rangewide population estimates in favorable years (Handwerk pers. comm. 2016, Heidel pers. comm. 2016).

Table 2 presents information on the 28 known populations representing 12-digit HUCs throughout the species' range. Information on minimum, maximum, and mean number of reproductive individuals is provided, where available. Resiliency for each population is determined based on population numbers, trends, and threats, and is classified in the table as being high, moderate, or low. Populations that are highly resilient tend to contain more than 100 flowering individuals in any given year, moderately resilient contain 50 to 100 flowering individuals, and low resiliency populations tend to have fewer than 50 individuals during most censuses. It is important to note that population resiliency in this Species Biological Report varies from the classification of populations used in the 2000 final listing rule (65 FR 62308; October 18, 2000) for the species, where populations were defined as being large (3,000 or more flowering individuals), moderate (500 to 2,500 flowering individuals), or small (less than 200 flowering individuals), particularly because the number of flowering individuals in any given year does not provide an adequate representation of the resiliency of that population. Comparing the current status of populations to the resiliency of populations as described at the time of listing, we now have 15 highly resilient populations and two moderately resilient populations compared to 10 that were stable or increasing at the time of listing; six low resiliency populations compared to four that were extant but declining at the time of listing; two populations with unknown resiliency compared to three that were probably small but had not been surveyed recently at the time of listing; three introduced populations compared to zero at the time of listing; and records of six extirpated populations compared to the nine described as potentially extirpated at the time of listing (see Table 2). Appendix A. includes specific information on populations for which we have multiple years of census data, which further supports our assertion that most populations appear stable, but with dramatic changes in the number of flowering individuals between years.

Table 2. All historical and currently known occurrences of Colorado butterfly plant arranged by 12-digit HUC watershed. Extant occurrences are based on survey and monitoring data from 2004 to present. A population is presumed extirpated when no individuals have been counted there since 1984; over 30 years. Resiliency is based on average number of reproductive individuals within the survey area (generally having more than 100 reproductive individuals most years indicates high resiliency, between 50 and 100 is moderate, and under 50 is low), trends in population numbers where available, and response to stochastic events. Note that minimum, maximum, and mean census may not provide a count of all flowering plants in a population due to access constraints, and that none of these measurements provide an accurate assessment of resiliency when taken alone due to the natural fluctuations in numbers of reproductive individuals in any given year. Specific values for all populations with more than two years of monitoring are provided in Appendix A.

12 Digit HUC	State – ID No.	Watershed	County	Known at time of listing?	Most recent data	Min. Census	Max. Census	Mean census	Extant/ Historical	WEA	CH	Resiliency
101900080105	CO-11	Spring Creek (Meadow Springs Ranch)	Weld	Y	2015	46	1432	324	E			High
101900070903	CO-12	HQ and Meadow Pastures at Soapstone Prairie	Larimer		2015	77	26189	8867	E			High
101800120301	WY-1 & WY-4	South Fork Bear Creek	Laramie	Y	2004	?	805	?	E		Unit 3	High
101800120302	WY-2	North Fork Bear Creek	Laramie	Y	2004	?	3952	?	E		Unit 3	High
101800120304	WY-1	South Fork Bear Creek	Laramie	Y	2004	?	601	?	E		Unit 2	High
101800120401	WY-3 & WY-5	Little Bear Creek	Laramie	Y	2004	?	1156	?	E		Unit 4	High
101800120402	WY-5	Middle Little Bear Creek	Laramie	Y	2004	?	1323	?	E		Unit 5	High

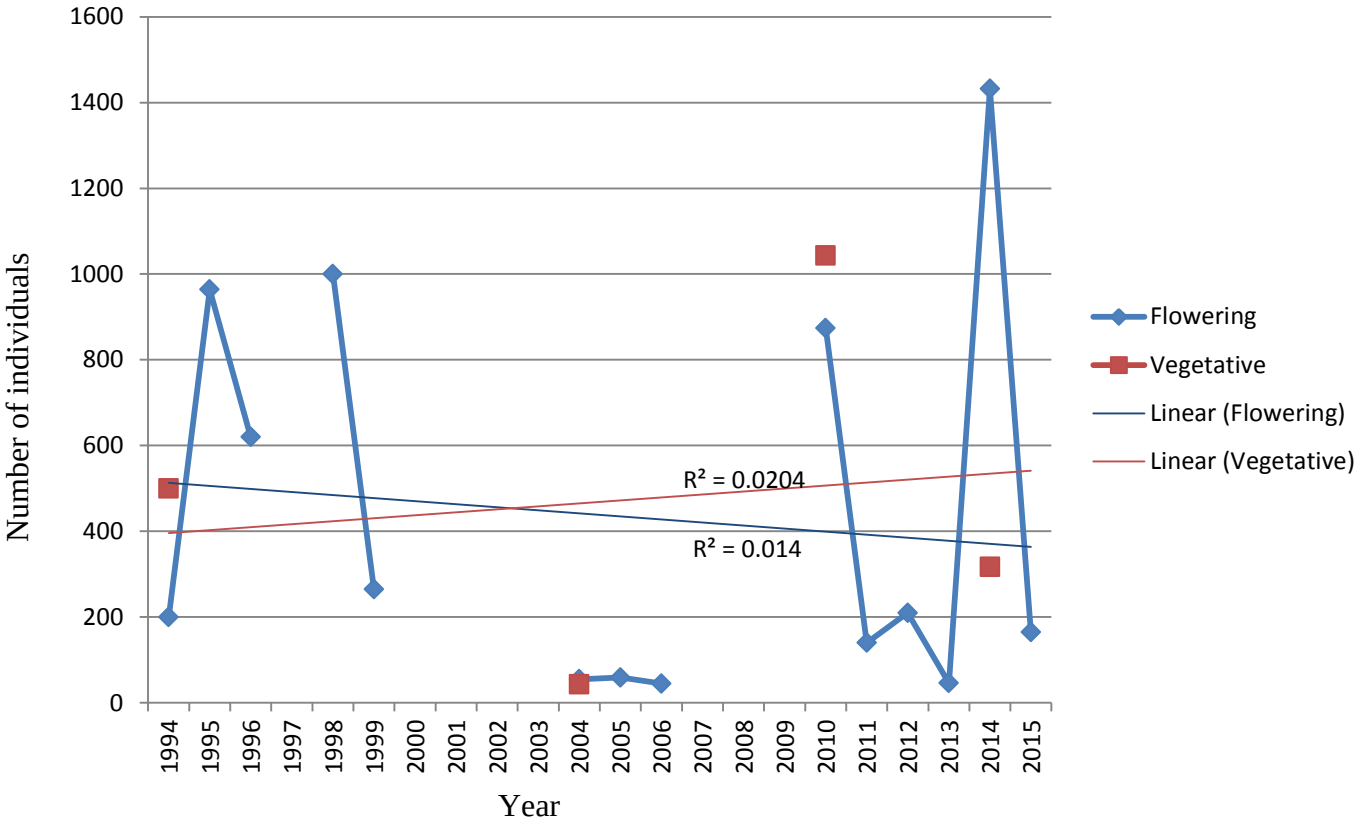
101900150104	WY-14	Lodgepole Creek	Laramie	Y	2004	?	1262	?	E		Unit 5	High
101800120106	WY-8	Upper Horse Creek	Laramie	Y	2016	156	7472	884	E	Y	Unit 4	High
101900090107	WY-15	Crow, Diamond, Unnamed Creeks (FE Warren)	Laramie	Y	2016	2230	11975	6613	E			High
101900090107	WY-17	Diamond Creek	Laramie	Y	2016	2	11742	2357	E	Y	Unit 7	High
101900090108	WY-18	Spring Creek	Laramie	Y	2016	0	5193	1565	E	Y		High
101900150103	WY-14	Lodgepole Creek	Laramie	Y	2016	0	936	128	E	Y	Unit 5	High
101900150201	WY-10	Lower Lodgepole Creek	Laramie	Y	2016	1	1347	476	E	Y	Unit 6	High
101900150204	WY-10	Lodgepole Creek - Thomas Reservoir	Laramie	Y	2016	22	2101	692	E		Unit 6	High
101800120107	WY-8	Horse Creek	Laramie	Y	2016	10	485	96	E		Unit 4	Moderate
101900080101	WY-19	Lone Tree Creek	Laramie	Y	2016	0	215	49	E	Y	Unit 7	Moderate
101900070903	CO-17	Jack Springs at Soapstone Prairie	Larimer		2015	0	250	69	E			Low
101900050603	CO-16	Rock Creek (Upper Church Ditch)	Jefferson	Y	2011	1	1	1	E			Low
101900080204	CO-3, 5, 14	Lone Tree Creek (Natural Fort , CO-WY border)	Weld	Y	1984 & 2008	3	280	142	E			Low
101900150206	NE-1 , 5, 9, WY-9	Lower Lodgepole Creek - Pine Bluffs	Laramie	Y	1985 & 2008	0	2065	?	E			Low
101900150208	NE-2, 3, 6, 7	Lower Lodgepole Creek - Bucknell	Laramie	Y	2008	0	?	?	E			Low

101900160101	NE-4, 8	Lower Lodgepole Creek - Oliver Reservoir	Laramie	Y	2008	0	27	?	E			Low
101800110901	WY-22	Teepee Ring Creek	Platte		2001	?	?	?	E		Unit 1	Unknown
101800120102	WY-23	Horse Creek	Laramie		2016	17	17	17	E			Unknown
101900030406	CO-13	Walnut Creek (Chambers Preserve)	Jefferson	Y	2011	?	100	?	E			Introduced
101900030407	CO-X	Private Residence (not on creek)	Adams		2016	?	150	?	E			Introduced
101900040404	CO-15	Clear Creek (at Broadway Bridge)	Adams	Y	2011	?	11	?	E			Introduced
101900020703	CO-9	Plum Creek (Sedalia)	Douglas		1942	?	?	?	H			Extirpated
101900050406	CO-7	Not on named creek (Lee Hill Rd)	Boulder		1984	?	1	?	H			Extirpated
101900071002	CO-2	Cache La Poudre R. (East of Poudre)	Larimer		1897	?	?	?	H			Extirpated
101900080201	CO-6	Township record: drainages w/ extant records (NE Larimer Co.)	Larimer		1944	?	?	?	H			Extirpated
101900080303	CO-1	Lone Tree Creek (vicinity of Carr)	Weld		1979	?	1	?	H			Extirpated
101900080104	WY-20	Duck Creek	Laramie		1984	?	42	?	H			Extirpated

Colorado: Colorado butterfly plant is known to occur in Adams, Boulder, Douglas, Jefferson, Larimer, and Weld Counties in northern Colorado, spanning 12 12-digit HUC watersheds (see Figure 1 and Table 1). Six historical occurrences in four of the six counties (Boulder, Larimer, Douglas, and Weld) have not been documented since 1984 and are presumed extirpated. Three of the eight records in Colorado do not represent indigenous populations, and are either seeded into the wild or into a garden setting (see CO-ID numbers 13, X, and 15 in Table 2). These three populations consist of: (1) a captive population at a residence in Thornton (Adams Co.) introduced in 2005 from seeds collected at Warren AFB and apparently thriving under atypical conditions for this species (Smith per. comm. 2016); (2) a population of seedlings and transplants from the University of Wyoming introduced in the mid-1980s at a special management area at Chambers Preserve in Jefferson County (Handwerk pers. comm. 2016); and (3) an occurrence in Adams County where plants are growing within 30 m (100 ft) of a bike trail along an inundated floodplain of an urban riparian area with a high percentage (50–100 percent) of nonnative invasive weed species that is also thought to be introduced (Smith and Strouse 2011, entire). These introduced sites were not designed specifically for species' conservation, and therefore are not the focus of species status evaluation in Colorado.

The majority of Colorado butterfly plants in Colorado are located on lands managed by the City of Fort Collins Natural Areas Department (CFCNAD) in Weld and Larimer Counties. The plants are distributed among three distinct habitats on either side of Interstate 25 and have numbered between zero to over 26,000 reproductive individuals (see CO-ID numbers 11, 12, and 17 in Table 2). These areas are being managed to maintain suitable habitat for the species (CFCNAD 2008, p. 1; CFCNAD 2010, p. 1; CFCNAD 2011a, entire; CFCNAD 2011b, entire; CFCNAD 2014, entire). Annual census information on flowering individuals at the Meadow Springs Ranch in Weld County has been monitored both by CFCNAD and the Wyoming Ecological Services Field Office since 1994. Our records indicate that the large fluctuations in population numbers are actually around a stable mean (325 flowering plant average, range of 55 –1,400 flowering plants). Other populations in Colorado have not been routinely monitored; consequently, no trend information is available (USFWS 2016, entire). In summary, the species is represented in Colorado by two highly viable, three low viability, three introduced, and five extirpated populations.

Figure 5. Number of flowering and vegetative individuals the Meadow Springs Ranch, in Weld County, Colorado population. Linear fit lines for flowering and vegetative individuals show no distinct trends in number of individuals in each life stage.



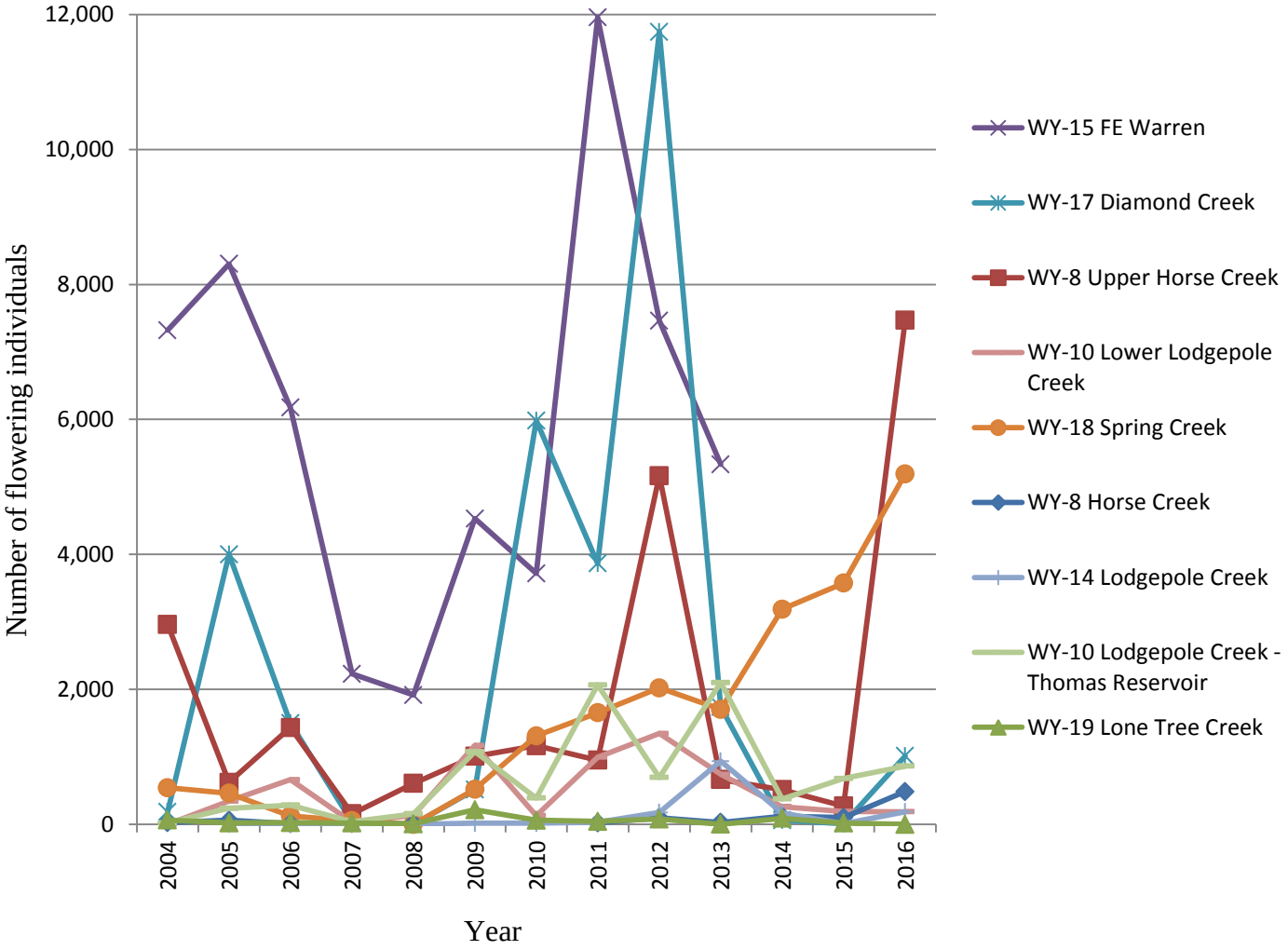
Nebraska: In 1985, monitoring along Lodgepole Creek in extreme eastern Wyoming and Kimball County, Nebraska found 2065 individual plants in six subpopulations (see NE-ID numbers 1 , 5, 9, and WY-9 in Table 2). A survey in 1992 found two populations of Colorado butterfly plant: one population (547 plants) along Lodgepole Creek in Kimball County and one population (43 plants) at Oliver Reservoir state recreation area (SRA) in the southwest panhandle of Nebraska in Kimball County west of the city of Kimball, Nebraska (Fertig 2000a). Survey results from 2004 suggested the species was extirpated from the State. However, a 2008 Colorado butterfly plant survey within three 12-digit HUC watersheds, along eight miles of historically occupied habitat and the Oliver Reservoir SRA, located 12 plants in four locations on private lands along Lodgepole Creek: five plants in areas where the species had been located before and seven plants in areas newly watered by a landowner piping water into Lodgepole Creek from a cattle stock tank (see Table 2). No plants were located at the Oliver Reservoir SRA (Wooten 2008), and these areas have not been surveyed since 2008. Outside of these occurrences, no other populations of Colorado butterfly plant are known to occur in Nebraska

(Rabbe pers. comm. 2016). In summary, the species is represented in Nebraska by three populations with low viability.

Wyoming: Extant populations of Colorado butterfly plant in Wyoming span most of Laramie County and extend northward into Platte County (USFWS 2005), spanning 17 12-digit HUC watersheds (see Table 2). Over 90% of known occurrences in Wyoming are on private lands, with parts of two occurrences on State lands and all of a third occurrence on State lands, and one occurrence is on Federal lands. Those populations in Wyoming that are found partly or fully on state school trust lands are managed for agricultural uses. The population on federal lands occurs on Warren AFB located adjacent to Cheyenne (see WY-15 in Table 2), providing information on species trends under idle conditions and representing the level of hydrological complexity of three different stream orders. The highest census numbers at Warren AFB have totaled over 11,000 plants twice (in 1998 and 2011) and the mean has remained over half of the peak (based on 1988-2016; Heidel *et al.* 2016). Additionally, regarding genetic representation, a study conducted solely on Colorado butterfly plants occupying three drainages at Warren AFB found one unique allele in the population (Floyd 1995a), while another study also at Warren AFB found that one of the drainages was unique from the other two (Tuthill and Brown 2003) indicating genetic divergence on a local scale in the species. This genetic information, however, does not provide sufficient strength in discerning populations from each other.

The Wyoming Ecological Services Field Office has agreements with 11 private landowners within six 12-digit HUC watersheds in Laramie County, Wyoming and one in Weld County, Colorado (see Table 2, occurrences in the WEA column) since 2004 to conduct annual monitoring of the Colorado butterfly plant and to provide management recommendations to help landowners use their land in a way that maintains habitat for the Colorado butterfly plant. Many of the landowners graze cattle or horses where the Colorado butterfly plant occurs, while others use the areas for haying operations. Many of the individual populations that are part of these agreements have fluctuated in population size from tens of plants, to zero plants, and back to tens or hundreds of plants over the span of a few years (USFWS 2012, USFWS 2016). For example, one population was heavily grazed for over a decade, leading to counts of less than 30 reproductive individuals for several years, but when the grazing pressure was relieved, the population rebounded within one year to over 600 reproductive individuals (see Population A in Figure 6B; USFWS 2016), which may indicate that either a robust seedbank was present or vegetative rosettes avoided the intense grazing pressure and bolted upon release. The total number of plants counted in Wyoming under these agreements has varied from approximately 1,000 to over 21,000 reproductive individuals since 2004 (see Figure 6A; USFWS 2016). Combining annual census numbers from all monitored populations in Wyoming, we have observed small to extreme population fluctuations (note individual population census numbers over years depicted in Figure 6A and 6B). Wyoming is represented by 13 highly resilient populations, two moderately resilient populations, two populations with unknown resiliency due to lack of information, and one extirpated population.

Figure 6. Number of censused flowering plants in nine 12-digit HUCs for which we have multiple years of monitoring data. Note that these values do not necessarily present a complete population census due to access issues and occurrences spanning multiple property owners.



The listing decision stated that "In order for a population to sustain itself, there must be enough reproducing individuals and sufficient habitat to ensure survival of the population. It is not known if the scattered populations of *Gaura neomexicana* ssp. *coloradensis* contain sufficient individuals and diversity to ensure their continued existence over the long term." (65 FR 62302; October 18, 2000). Today, we understand that, regarding ecological representation, the species is characterized by having at least one population within each ecological setting and within all but the southern-most portions of the historic range. Furthermore, most populations contain individuals in more than one ecological setting, such as individuals along the creek bank and

individuals outside of the creek bank and in the floodplain of the creek. While surveyors typically census the number of flowering individuals during surveys due to relative ease in counting, the number of flowering plants in a survey location any given year does not represent the resiliency of the population. Resiliency, as in Table 2, is determined through a combination of number of flowering individuals, trends in this number, and response of the population to stochastic events.

Reasons for listing/Threats assessment

The Colorado butterfly plant is currently federally listed as threatened. Below, we present a summary of threats affecting the species and its habitats. A detailed evaluation of factors affecting the species at the time of listing can be found in the listing determination (65 FR 62302; October 18, 2000) and designation of critical habitat (70 FR 1940; January 11, 2005). These primary threats to the species identified at the time of listing include agricultural practices such as mowing and haying at inappropriate times of the year and habitat conversion to row-crop agriculture, water development, residential and urban development, natural succession, overgrazing by cattle or horses, application of broadleaf herbicides, and competition with exotic plants (Marriott 1987; USFWS 1987; Fertig 1994, 2000). Since the time of listing, oil and gas development and climate change have become potential threats to this species and are analyzed under Factor A and Factor E, respectively.

Factor A. The present or threatened destruction, modification, or curtailment of its habitat or range

Agricultural Practices

At the time of listing, conversion of grassland to farmlands, mowing grasslands, and grazing were considered threats to the Colorado butterfly plant. Prior to listing, the conversion of moist, native grasslands to commercial croplands was widespread throughout much of southeastern Wyoming and northeastern Colorado (Compton and Hugie 1993, p. 22). However, conversion from native grassland to cropland has slowed throughout the species' range since the time of listing, with no lands converted in Laramie County and just 12 ha (30 ac) converted in Platte County between 2011 and 2012 (FSA 2013).

Mowing areas for hay production that are occupied by the Colorado butterfly plant was identified as a threat, if conducted at an inappropriate time of year (prior to seed maturation) (Fertig 1994, p. 40; USFWS 1997, p. 8). However, monitoring by the Service over the past 12 years indicates that this occurs infrequently. Even in areas where early season mowing has occurred, annual monitoring has shown high numbers of reproductive plants present in subsequent years, suggesting that mowing for hay production is not a threat to the species (USFWS 2016b, entire).

The agricultural practices of grazing and herbicide application threatened the Colorado butterfly plant at the time of listing. However, since then, the Service has made and continues to make recommendations to cooperating landowners on agricultural management that fosters resiliency in populations of the species. We believe that these measures have decreased the severity of these stressors. Consequently, we conclude, based on the available information, that land conversion, mowing, grazing, and herbicide application are not threats to the Colorado butterfly plant currently or within the foreseeable future. Grazing is further explored under Factor C and herbicide spraying is further explored under Factor E.

Water Management

At the time of listing, water management (actions that moved water to croplands, such as irrigation canals, diversions, and center pivot irrigation development) was considered a threat that would remove moisture from Colorado butterfly plant habitat. The management of water resources for livestock production and domestic and commercial human consumption, coupled with increasing conversion of lands for agricultural production, often led to channelization and isolation of water resources, changes in seasonality of flow, and fragmentation, realignment, and reduction of riparian and moist lowland habitat (Compton and Hugie 1993, p. 22). All of these actions could negatively impact suitable habitat for the species.

Dewatering portions of Lodgepole Creek in Kimball County, Nebraska has led to the extirpation of some of the species' known historical populations, and low likelihood of long-term resiliency for the two extant populations last monitored in 2008 (Rabbe pers. comm. 2016). Extant populations in Nebraska continue to be threatened by dewatering and overgrazing on private land. However, when water was reintroduced to formerly occupied habitat after being absent for more than 10 years, a population was rediscovered (Wooten 2008, p. 4). While rediscovery of this population indicates persistence of a viable seedbank for at least 10 years, numbers of plants within the population declined from over 600 plants (Fertig 2000, p. 12) to 12 plants (Wooten 2008, p. 4), and the application of water that allowed plants to grow was temporary, which suggests the population has a low likelihood of long-term resiliency.

The Colorado Water Conservation Board on behalf of CFCNAD filed an instream flow right on Graves Creek in 2015, which is the stream that runs through the meadow in which the population of Colorado butterfly plants occurs on Soapstone Prairie Natural Area (CFCNAD 2016b). This instream flow right may help maintain subirrigation of this large and important population into the future.

Throughout the range of the Colorado butterfly plant, water usage is managed under a partnership with the states of Colorado, Wyoming, and Nebraska and the Department of Interior, which is called the Platte River Recovery Implementation Program (PRRIP). This PRRIP allows existing and most or all new water uses and water-development activities in the Platte River in these three states to operate in regulatory compliance with the Act for the four Platte River

"target species" in Nebraska, namely *Grus americana* (Whooping crane), *Sterna (Sternula) antillarum* (Interior least tern), *Charadrius melodus* (northern Great Plains population of piping plover), *Scaphirhynchus albus* (pallid sturgeon), and *Platanthera praeclara* (Western prairie fringed orchid). Compliance with the PRRIP ensures that shortages to the target flows in the central Platte River will be substantially reduced (PRRIP 2006, p. 1). Because Colorado butterfly plant occurs within the Platte River watershed, this is a high likelihood that measures implemented under the PRRIP will also benefit the Colorado butterfly plant.

Residential, Urban, and Energy Development

At the time of listing, residential and urban development around the cities of Cheyenne and Fort Collins were identified as past causes of habitat conversion and habitat loss to Colorado butterfly plant. Although difficult to quantify, many acres of formerly suitable habitat were converted to residential and urban sites, contributing to loss of habitat (Fertig 1994, p. 38; Fertig 2000a, pp. 16–17). Much of the range of Colorado butterfly plant occurs along the northern Front Range of the Rocky Mountains in Colorado and Wyoming, which has experienced dramatic growth in the recent past and is predicted to grow considerably in the future (America 2050, visited on January 23, 2016), particularly in Larimer and Weld Counties in Colorado (University of Colorado Boulder 2015, pp. 119–120). The demand that urban development places on water resources also has the ability to dewater the streams and lower groundwater levels required by Colorado butterfly plant to maintain self-sustaining populations, was explored above in Water Development.

Despite projected outlooks for increased human density and urban development along the northern Front Range, the two large populations of Colorado butterfly plant in Larimer and Weld Counties, Colorado occur on lands managed as open space by the City of Fort Collins Natural Areas Department, and are not directly subject to residential or urban development. These lands are managed to allow for the persistence of these populations, either with managed grazing or burning (CFCNAD 2016). However, the CFCNAD does not own all mineral rights on these lands and therefore sensitive areas within these boundaries may be impacted by mineral development. In light of this potential threat, the City of Fort Collins Natural Areas Department completed a planning process in which they highlighted these areas to be avoided by development (The Nature Conservancy 2013, entire). While oil and gas development has increased in northern Colorado and southeastern Wyoming since the time of listing, no oil or gas wells have yet been proposed in areas that will directly or indirectly impact populations of Colorado butterfly plant in Colorado or in Wyoming.

According to publically available information, there are no current proposals to urbanize or develop lands containing populations of Colorado butterfly plant within Wyoming for residential purposes. Monitoring data over the past 28 years have shown that populations at WAFB and other areas currently occupied in Wyoming remain stable, although numbers of reproductive individuals fluctuates during any given year. Monitoring has also shown that neither

urbanization nor conversion to intensive agricultural has occurred as predicted in the listing document (Heidel *et al.* 2016; USFWS 2012, pp. 11–22; USFWS 2016, entire). Since the time of listing, the Service has received few requests for consultation under section 7 of the Act for projects that may adversely affect this species; projects for which request have been made were limited to grazing, power lines, pipelines, road development, and drainage crossings for which avoidance and minimization of potential impacts has readily been achieved (USFWS 2017, entire). Furthermore, Chapters 3 and 4 of the Laramie County Land Use Regulations address floodplain management and call for specific provisions and permits required for construction within floodplains (Laramie County 2011, pp. 165–185), which encompass the entirety of Colorado butterfly plant habitat within the county and therefore extends some level of protection to Colorado butterfly plant and its habitat. These Regulations are in place to "promote public health, safety, and general welfare and to minimize public and private losses due to flood conditions" (Laramie County 2011, p. 165), which is a common-sense approach to protect many resources, including the Colorado butterfly plant and its habitat, by limiting development in the floodplains.

The threats of residential and urban development, once considered significant threats to the Colorado butterfly plant, have been largely avoided because almost all such development has occurred outside of the habitat in which this species occurs. Annual monitoring since 2004 indicates that populations are stable and unaffected by any development that has occurred within the species' range. While human population growth and development are predicted for the Front Range of the Rocky Mountains in Colorado into the future, these areas, particularly the City of Fort Collins and the Town of Wellington in Larimer County, Colorado, are outside of the species' currently occupied habitat, and we anticipate no development in the protected areas under management of CFCNAD. Furthermore, while the City of Cheyenne in Laramie County, Wyoming is wholly encompassed by the range of the Colorado butterfly plant, the City has developed the Greater Cheyenne Greenway to provide a recreational corridor along Crow Creek and other riparian areas through the City (City of Cheyenne 2017, entire). Additionally, increases in oil and gas development in northern Colorado and southeastern Wyoming have not directly or indirectly impacted populations of Colorado butterfly plant. Consequently, residential, urban, and energy development are no longer considered significant threats to this species.

Natural succession and competition with non-native invasive species

In the absence of periodic disturbance, natural succession of the plant community in areas of Colorado butterfly plant moves from open habitats, to dense coverage of grasses and forbs, and then to willows and other woody species. The semi-open habitats preferred by this species can become choked by tall and dense growth of willows, grasses, and nonnative invasive species (Fertig 1994, p. 19; Fertig 2000a, p. 17). Natural disturbances such as flooding, fire, and native ungulate grazing were sufficient in the past to create favorable habitat conditions for the species. However, the natural flooding regime within the species' floodplain habitat has been altered by

construction of flood control structures and by irrigation and channelization practices (Compton and Hugie 1993, p. 23; Fertig 1994, pp. 39–40). Consequently, the species relies on an altered flood regime and other sources of disturbance to maintain its habitat.

In the absence of natural disturbances today, managed disturbance may be necessary to maintain and create areas of suitable habitat (Fertig 1994, p. 22; Fertig 1996, pp. 12–14, Fertig 2000a, p. 15). However, monitoring of the population at Warren AFB indicates that populations can persist without natural disturbances such as fire and flooding through natural dieback of woody vegetation and native ungulate grazing (Heidel *et al*. 2016, pp. 2–5). Additionally, some Federal programs, such as those administered by the USDA Natural Resources Conservation Service, focus on enhancing or protecting riparian areas by removing the types of disturbance the Colorado butterfly plant needs—increasing vegetation cover and pushing the habitat into later successional stages (65 FR 62302; October 18, 2000, p. 62307). However, these programs are implemented in only a small portion of the species' range. The 11 WEA properties are typically managed for livestock grazing, coupled with an altered flood regime, which appears to provide the correct timing and intensity of disturbance to maintain suitable habitat for the species (USFWS, 2012 pp. 9–21; USFWS 2016b, entire). Therefore, it appears that natural succession is not occurring at the level previously considered to threaten this species.

The final listing rule included competition with exotic plants and noxious weeds as a threat to Colorado butterfly plant (65 FR 62302; October 18, 2000). Competition with exotic plants and noxious weeds, here referred to as nonnative invasive species, may pose a threat to the Colorado butterfly plant, particularly given the species' adaptation to more open habitats. In areas of suitable habitat for Colorado butterfly plant, the native *Salix exigua* (coyote willow), nonnative invasive *Cirsium arvense* (Canada thistle), and nonnative invasive *Euphorbia esula* (leafy spurge) may become dominant; *Salix* in particular increases in the absence of grazing or mowing. These species can outcompete and displace Colorado butterfly plant, presumably until another disturbance removes competing vegetation and creates openings for Colorado butterfly plant seedlings to germinate (Fertig 1998b, p. 17). We have monitored populations of Colorado butterfly plant that have slowly decreased in numbers or disappeared following the invasion and establishment of these other plant species, only to see Colorado butterfly plants return to the area following disturbance (USFWS 2016b, entire). Additionally, at least one population has moved to an uninvaded area downstream of its former invaded habitat (J. Handwerk, pers. comm. 2016), suggesting that populations can move to find more suitable habitat nearby.

Prior to listing, biological control agents were used to control nonnative invasive species at Warren AFB and may have depressed numbers and extent of Canada thistle and leafy spurge. Introduced gall-forming flies have slowly become established on Warren AFB and have reduced the vigor, height, and reproductive ability of small patches of Canada thistle (Fertig 1997, p. 15), at least in some years (Heidel *et al.* 2016, p. 16). Also on the Warren AFB, a biocontrol agent for leafy spurge, a different flea beetle than infests Colorado butterfly plant, was observed in

1997 (Fertig 1998a, p. 18). While the effects of biocontrol agents on nonnative invasive species appear promising, we do not have current information on the status of biocontrol of these agents.

Natural succession was considered a threat to the Colorado butterfly plant at the time of listing. However, we now understand that the altered flood regime of today, coupled with disturbance from fire and grazing, is sufficient to maintain suitable habitat throughout much of the species' range. Competition with nonnative invasive species is an ongoing stressor for portions of populations, although these invasive species tend not to survive the regular disturbances that create habitat for Colorado butterfly plant. Therefore, while individuals or populations may be out-competed by native or nonnative invasive species at higher succession levels, periodic disturbance maintains or creates new habitats for Colorado butterfly plant. Consequently, we conclude, based on the available information, natural succession and competition with nonnative invasive species are not threats to Colorado butterfly plant currently or within the foreseeable future.

Summary of Factor A

The following stressors warranted consideration as possible current or future threats to the Colorado butterfly plant habitat under Factor A: (1) agricultural practices; (2) water management; (3) residential, urban, and energy development; and (4) natural succession and competition with nonnative invasive species. However, these stressors are either being adequately managed, have not occurred to the extent anticipated at the time of listing, or the species is tolerant of the stressor as described above. While these stressors may be responsible for loss of historical populations (they have negatively affected population redundancy), and are currently negatively affecting the populations in Nebraska, we do not anticipate a rangewide increase in these stressors in the future, although they will continue at some level. Additionally, the displacement of individuals through competition with natural succession or non-native invasive species may adversely affect the resiliency of those individuals, we understand that populations are comprised of individuals in microhabitats within the area and are generally resilient when any type of disturbance is introduced or re-introduced to the system.

Factor B. Overutilization for commercial, recreational, scientific, or educational purposes

Factor B was not considered a threat to the species at the time of listing. We are aware of three collections of seeds of Colorado butterfly plant for scientific and/or commercial purposes since the final listing rule. These collections are described as follows.

- At some time prior to 2001, seeds were collected from Warren AFB and sent to Bridger Plant Materials Center (Carbon Co., MT). It was a source of seed used in later research (Burgess 2003, p. 1, Burgess *et al*. 2005, p. 9) and was discontinued (Heidel pers. comm. 2017).
- In 2004, a private individual, without a permit, collected an unknown number of seeds from one of the populations at Warren AFB to conduct personal research

and establish a source population at his home in Longmont, Colorado (Smith, pers. comm. 2016a).

- This same individual also collected seeds from the introduced planting in Westminster, Colorado. He now has sufficient seeds from the self-sustaining planting to conduct research and no longer anticipates collecting further seed from wild populations (Smith, pers. comm. 2016b).

Other than these collections, we are not aware of any attempts to use Colorado butterfly plant for commercial, recreational, scientific, or educational purposes. In the future, we do not anticipate this species will be collected due to its lack of showiness for much of the year and because it occurs in generally inaccessible areas.

Summary of Factor B

At the time of listing, Factor B was not considered a threat to the Colorado butterfly plant. We are aware of only three collections of the species since listing. These collection events had no apparent effect on the number and distribution of plants from which they were taken. Based on available information, we do not consider there to be threats in the future related to overutilization for commercial, recreational, scientific, or educational purposes.

Factor C. Disease or predation

The original listing of Colorado butterfly plant did not include threats from disease or predation, though livestock grazing was described as a potential threat if grazing pressures were high (65 FR 62302; October 18, 2000). However, in 2007, a precipitous decline in plant numbers was observed in many populations of Colorado butterfly plant monitored in Colorado and Wyoming. The exact cause of the decline was not positively identified, but weather and insect herbivory are two major factors that may have contributed to the decline. Weather-related impacts include: lower than normal spring precipitation levels (which were magnitudes lower than in all previous years); and higher mean temperatures in late summer. Insect herbivory was suspected as many Colorado butterfly plant were riddled with holes, flowering/fruit production was curtailed or greatly reduced on all plants, and some flowering plants were dead (Heidel *et al*. 2011). Flowering plant numbers remained low or declined further in 2008. Surveyors identified one or more flea beetle species that may have been responsible for the herbivory. The likely flea beetle species (*Altica foliaceae*) is a native species, and its numbers are not known to be affected by human causes (Heidel *et al.* 2011).

While it may not be a severe or immediate threat to Colorado or Wyoming populations as the impacted populations rebounded to pre-infestation numbers in 2009 and 2010 (Heidel *et al.* 2011), the full impact of outbreaks and their frequency may warrant further consideration (Heidel *et al*. 2011). This incident of insect herbivory may be episodic and preliminary tests have been run on its potential impact on population viability (Heidel *et al*. 2010). For example, in 2014, intense herbivory from flea beetles at Soapstone Prairie and Meadow Springs Ranch

resulted in high mortality and a reduction in bolting of vegetative rosettes (Strouse, pers. comm. 2017), and numbers of reproductive individuals in those populations were low in 2015 and 2016. We anticipate that these populations will rebound in 2017 or 2018, in the same way populations rebounded after the 2007 flea-beetle-caused decline. This herbivory has not been reported for the Nebraska populations though it is possible that similar insect herbivory influenced 2008 survey results in Nebraska.

Colorado butterfly plant is highly palatable to a variety of insect and mammalian herbivores (e.g., *Schinia gaura* (Gaura moth; Fertig 1994, p. 6; Heidel *et al*. 2011; Heidel and Tuthill 2015), cattle, horses, and pronghorn (*Antilocapra americana*)), but it appears to have some capacity to compensate for herbivory by increasing branch and fruit production (Fertig 2000a, p. 17). Livestock grazing can be a threat at some sites if grazing pressures are high due to animals not being rotated among pastures or if use is concentrated during the summer flowering period. Additionally, plants may be occasionally uprooted or trampled by livestock and wildlife. In at least one location where a population of Colorado butterfly plant was divided by a fence, the heavily grazed side of the fence had few or no Colorado butterfly plant plants, while the ungrazed side had many (USFWS 2016). While heavy grazing at inappropriate times of the year may be detrimental to Colorado butterfly plant populations, moderate grazing acts as a disturbance that keeps the habitat in an open or semi-open state suitable for this species. Light to medium grazing can provide benefits by reducing the competing vegetative cover and allowing Colorado butterfly plant seedlings to become established. Extremely high intensity grazing at the wrong time of year can remove all reproductive individuals from a population and remove seed production for that year; however, even after many years of intensive grazing, populations have rebounded upon relief (USFWS 2012, USFWS 2016) likely due to survival of non-reproductive individuals and recruitment from the seedbank.

Summary of Factor C

In general, while Factor C, disease or predation, has had an occasional negative impact on individuals and localities, these impacts do not appear to affect entire populations, nor do these impacts persist for any extended period of time. Individuals are resilient to damage: vegetative plants (i.e., basal rosettes) appear to be resistant to damage from grazing activities and are capable of withstanding stochastic events, and reproductive plants send out additional flowering branches upon injury. Also, given the lack of any known diseases affecting the species and because of the species' redundancy of many populations distributed across most of the historic range, this would likely provide a buffer to any type of catastrophic disease outbreak. Therefore, we do not consider Factor C, disease or predation, to be a threat to the Colorado butterfly plant.

Factor D. The inadequacy of existing regulatory mechanisms

When the Colorado butterfly plant was listed in 2000, the majority of known populations occurred on private lands managed primarily for agriculture, with one population at Warren

AFB, and a few other populations throughout the species' range under various local jurisdictions. The listing decision described the species' status as Sensitive by the U.S. Forest Service, though no populations occurred on Forest Service lands at the time. The listing decision also described the lack of protection extended to the Colorado butterfly plant through the federal threatened status of the *Zapus hudsonius preblei* (Preble's meadow jumping mouse) that occurs in the same range of habitats due to the two species' use of differing successional stages of riparian habitats (65 FR 62302; October 18, 2000).

The population on Warren AFB represents one of the largest and most highly resilient populations of the species, is protected under the Act, and is managed under an Integrated Natural Resource Management Plan (Warren AFB 2014, entire) and a Conservation and Management Plan under Air Force Information 32-7064 (Warren AFB 2004, entire). These Plans call for annual monitoring, protection and maintenance, and research on threats and genetic variability of the population located there. Additionally, a Service employee is stationed at Warren AFB to manage its natural resources and guide management of the Colorado butterfly plant and its habitat, including directing herbicide application in the vicinity of the species' habitat. The population of Colorado butterfly plant at Warren AFB has been monitored since before listing to determine population trends, detect any changes in its habitat, pursue viability assessment, and assess population response to different hydrological conditions. The results indicate that plant numbers fluctuate depending on climate and hydrology, and seem to be capable of rebounding after extreme stochastic events such as the flea beetle infestation of 2007 (Heidel *et al.* 2016, pp. 15–17). Should the protections of the Act be removed from this species upon delisting, we anticipate that the Plans would stay in place at least until the next Plan revisions and that the species would continue to be managed and monitored as part of the post-delisting monitoring plan.

Discovery and subsequent protection of large populations of Colorado butterfly plant on lands owned and managed by the CFCNAD is an important addition to conservation of the species after it was listed. The regulatory protections that these two populations receive from occurring on municipal natural areas lands include indefinite protections of land and water and restoring and rehabilitating land and natural systems to build ecological diversity and permanence (City of Fort Collins 2014, pp. 1–2). As discussed under Factor A, populations managed by CFCNAD are afforded some level of protection from oil and gas development (The Nature Conservancy 2013, entire) and from water withdrawals (CFCNAD 2016b, entire). These include a set of recommendations made to the State Land Board to protect the species' habitat from oil and gas development (The Nature Conservancy 2013, entire) and an instream flow right on Graves Creek (CFCNAD 2016b, entire). These recommendations are not necessarily permanent or regulatory. However, populations owned and managed by CFCNAD are currently, and will continue to be into the foreseeable future, specifically managed and monitored for the persistence of Colorado butterfly plant, including managed cattle grazing, prescribed burns, and fencing (CFCNAD 2008, p. 1; CFCNAD 2010 pp. 1–2; CFCNAD 2011a, entire; CFCNAD 2011b pp. 2–3; CFCNAD 2014, p. 1).

On private lands in Wyoming without any regulatory mechanism, over a decade of monitoring a dozen populations has documented similar fluctuations in population size. The populations occurring within designated critical habitat have not been surveyed since the critical habitat determination surveying in 2004 and so their viability is uncertain. However, the Wyoming Ecological Services Field Office has not consulted under the Act with private landowners managing these parcels on any projects that may adversely affect the critical habitat for this species. Additionally, we reviewed aerial imagery of the critical habitat units and found only two minimal changes between 2004 and 2015 (reflecting habitat conditions at the time of designation and the most recent aerial imagery available) throughout all critical habitat units affecting only a few acres of designated critical habitat (USFWS 2017). Consequently, we determine that activities occurring on critical habitat are likely the same as they were at the time of designation. Furthermore, because many of the private lands included in the critical habitat designation are adjacent to lands under WEAs, we determine that the populations occurring within designated critical habitat are likely stable, and fluctuating similarly to populations on lands that we monitor under WEAs. We have no reason to believe that populations occurring on designated critical habitat are responding to stressors in a way different than those populations we monitor. Therefore, populations throughout the species' range on private, local, and Federal lands either have been observed to be or are highly likely to be fluctuating around a stable population size, regardless of the existence of any regulatory mechanism beyond the species being listed under the Act.

While no populations occur within lands managed by the Bureau of Land Management (BLM) in Wyoming, the BLM entered into a programmatic consultation under section 7 of the Act on potential impacts to the species and its critical habitat. This consultation included specific conservation measures to be implemented in grazing areas managed by the BLM and that overlap potential Colorado butterfly plant habitats (BLM 2005, pp. 4-2 –4.4). These conservation measures are incorporated into the BLM's Resource Management Plan (RMP), which regulates and guides how BLM lands are managed (BLM 2008, pp. 2-47–2-48). The newly discovered population on Wild Horse Creek (WY-23) falls within the agreement area that BLM has with the landowners there, and the conservation measures in the Rawlins RMP are applied to this population.

Finally, water use is managed under the PRRIP, as described under Factor A, which ensures that water use in the Platte River is conducted in a way to maintain volume at certain times of the year in the central and lower reaches of the Platte River in Nebraska. Because all of the watersheds in which the Colorado butterfly plant is found occur within the PRRIP, the water on which the species depends is managed under this program (PRRIP 2006).

Summary of Factor D

In summary, Factor D, the inadequacy of existing regulatory mechanisms, appeared to be a threat to the species at the time of listing because the majority of known populations occurred on private lands that were managed for agriculture. Today, we understand that two of the three largest populations of the species occur on Warren AFB and a ranch owned and managed for the species by CFCNAD. We also understand, based on 12 years of annual monitoring of 11 survey areas on private lands under WEAs, that private land-use for agricultural purposes can be compatible with the persistence of the species, even without any regulatory mechanism in place. Finally, the Colorado butterfly plant is a Tier 1 species in the Plants of Greatest Conservation Need in Colorado (Colorado SWAP 2015) and is listed on the State endangered species list for Nebraska and will continue to afford that designation due to the species' extreme rarity in the State (Wooten 2008, p. 1). We conclude, based on the available information, that inadequate regulatory mechanisms are not a threat to the Colorado butterfly plant currently or within the foreseeable future inasmuch as we are not aware of any threats requiring regulatory mechanisms to protect the species and because many of the existing regulatory mechanisms would remain in place even after the species is delisted.

Factor E. Other natural or manmade factors affecting its continued existence

Herbicide spraying

At the time of listing, the non-selective use of broadleaf herbicides to control *Cirsium arvense* (Canada thistle), *Euphorbia esula* (leafy spurge), and other non-native invasive plants was considered a threat to Colorado butterfly plant (Marriott 1987; Fertig 2000; 65 FR 62302, October 18, 2000). For example in 1983, prior to listing, nearly one-half of the mapped populations on Warren AFB were inadvertently destroyed when sprayed with Tordon, a persistent herbicide. The status of that portion of the population is unknown due to lack of clear record-keeping over 30 years. Furthermore, herbicide use along road crossings in and adjacent to Colorado butterfly plant populations was also noted (65 FR 62302; October 18, 2000, p. 62307).

After the listing of Colorado butterfly plant, the Service has worked with Warren AFB and private landowners to develop best management practices for applying herbicides within the vicinity of known occurrences of Colorado butterfly plant in such a way to remove non-native invasive species while minimizing harm to individual Colorado butterfly plants. For example, the agreements in place call for a buffer of 30.5 meters (100 feet) from known subpopulations of Colorado butterfly plant. At one property, however, the landowner inadvertently sprayed individual Colorado butterfly plants in early 2016. While there monitoring, Service staff observed reddened plants with shriveled leaves, which likely reduced the vigor of those individuals. We anticipate recording whether these effects persisted into the future in our monitoring of the site in 2017 and future years. While herbicide application may continue to inadvertently remove sprayed individuals from populations in which herbicide is applied, we know that unsprayed individuals persist in the population and can repopulate Colorado butterfly

plants in areas where plants were killed. The seedbank can play an additional role in restoring Colorado butterfly plant to areas that have been sprayed. Based on our records, herbicide application is a management tool used in conjunction with non-native invasive species removal in only four of the known occurrences of the species (CO-11, CO-12, WY-15, and WY-18 in Table 2), and these are among our largest and most resilient populations of the species. Our records indicate that, in general, the application of buffers has been successful at reducing invasive species presence and competition near individual Colorado butterfly plants without causing harm to the population (USFWS 2012, pp. 24–25; USFWS 2016b, entire) and when conducted appropriately, herbicide application can help improve habitat for Colorado butterfly plant by eliminating competition. Therefore, based on education and agreements in place, we do not consider application of herbicides to be a threat to this species currently, and anticipate that landowners would continue to buffer Colorado butterfly plants from herbicide spraying into the future.

Additionally, prior to listing, biological control agents were used to control non-native invasive species at Warren AFB and may have depressed numbers and extent of Canada thistle and leafy spurge. Introduced gall-forming flies have slowly become established on Warren AFB and have reduced the vigor, height, and reproductive ability of small patches of Canada thistle (Fertig 1997), at least in some years (Heidel *et al.* 2016). Also on the Warren AFB, a biocontrol agent for leafy spurge, a different flea beetle than infests Colorado butterfly plant, was observed in 1997 (Fertig 1998a). We do not have current information on the status of biocontrol for non-native invasive species within the habitats of Colorado butterfly plant.

Small Population Size and Restricted Range

The final listing decision included the limited range and the small population size of many populations to be a threat to the species (65 FR 62302; October 18, 2000). Historically, Colorado butterfly plant populations ranged from Castle Rock, Colorado, north to Chugwater, Wyoming, and east into a small portion of southwest Nebraska. The extent of its range was approximately 6,880 ha (17,000 ac). Most of this range is still occupied, although some small and/or peripheral populations in Nebraska and Colorado have been extirpated since intensive survey efforts began. Despite the loss of these populations, the species continues to maintain multiple resilient, representative, and redundant populations throughout nearly all of its range known at the time of listing (see Figure 1).

We have evidence that populations throughout the range have persisted despite stochastic events that may have caused short-term declines in number of individuals. For example, a 100-year flood in August 1985 along Crow Creek on the Warren AFB inundated the Crow Creek portion of the population, knocking down some plants and surrounding vegetation, and depositing sediments (Rocky Mountain Heritage Task Force 1987 as cited in Heidel *et al*. 2016, p. 2). Instead of being extirpated, these populations rebounded in 1986 and continue to persist, as shown by annual monitoring since 1988 (summarized in Heidel *et al.* 2016 pp. 2–18).

Additionally, based on annual monitoring of populations on private property in Wyoming, stochastic events such as floods and hail storms have reduced population numbers during the event year, then populations rebounded in following years (USFWS 2012, pp. 11–22; USFWS 2016b, entire). Individual plants may be vulnerable to random events such as fires, insect or disease outbreaks, or other unpredictable events. However, this species is adapted to disturbance, and rather than being extirpated, the seedbank can provide opportunity for populations to rebound after such events.

The historic range included populations farther south into Larimer and Weld Counties in Colorado that were lost prior to the listing of the species. No populations in Larimer and Weld Counties in Colorado have been extirpated since the species was listed and we do not think that further range restriction has occurred in this portion of the species' range. In the future, species range restriction may occur through loss of peripheral populations in the three 12-digit HUCs in Nebraska where dewatering has removed formerly suitable habitat (Wooten 2008, entire). However, these 12-digit HUCs are downstream of highly viable populations in Wyoming and do not constitute a removal of the species from this drainage entirely. The resiliency and redundancy of populations across much of the species' range indicate that further range restriction is not likely.

Climate Change

Impacts from climate change were not considered in the final rule to list the species. Our current analyses under the Act include consideration of ongoing and projected changes in climate. The terms "climate" and "climate change" are defined by the Intergovernmental Panel on Climate Change (IPCC). "Climate" refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2007, p. 78). The term "climate change" thus refers to a change in the mean or variability of one or more measures of climate (e.g., temperature or precipitation) that persists for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (IPCC 2007, p. 78). Various types of changes in climate can have direct or indirect effects on species. These effects may be positive, neutral, or negative and they may change over time, depending on the species and other relevant considerations, such as the effects of interactions of climate with other variables (e.g., habitat fragmentation) (IPCC 2007, pp. 8–14, 18–19). In our analyses, we use our expert judgment to weigh relevant information, including uncertainty, in our consideration of various aspects of climate change.

According to the Intergovernmental Panel on Climate Change (IPCC) "most plant species cannot naturally shift their geographical ranges sufficiently fast to keep up with current and high projected rates of climate change on most landscapes." (IPCC 2014, p. 13). Plant species with restricted ranges may experience population declines as a result of climate change. The concept of changing climate can be meaningfully assessed both by looking into the future and reviewing

past changes. A review of Wyoming climate since 1895 indicates that there has been a significant increase in the frequency of warmer-than-normal years, an increase in temperatures throughout all regions of the State, and a decline in the frequency of "wet" winters (Shumann 2011). Data from the Cheyenne area over the past 30 years indicate a rise in spring temperatures (Heidel *et al*. 2016). The current climate in Colorado butterfly plant habitat is quite variable with annual precipitation ranging from 25–50 cm (10–20 in) of rain and 81–275 cm (32–108 in) of snow per year near the center of the species' range at Cheyenne Municipal Airport (NOAA 2016). The years 2000 through 2006 appeared to have lower than average precipitation (NOAA 2016), which may have affected the ability of plants to withstand flea beetle outbreak in 2007 (Heidel *et al*. 2011, p. 286). The Colorado butterfly plant is semelparous (individual plants are first vegetative, then flower and fruit, and then die). Therefore, individuals are likely capable of remaining in a vegetative state under some conditions and duration until suitable flowering conditions exist, suggesting that the species is adapted to variability in the amount and timing of precipitation.

Climate change may affect the timing and amount of precipitation as well as other factors linked to habitat conditions for the Colorado butterfly plant. For example, climate models predict that by 2050, watersheds containing the species (HUC 4: South Platte, 1019 and North Platte, 1018) will become warmer for all four seasons, precipitation will increase in the winter, and remain about the same in spring, summer, and fall (USGS 2016, pp. 1–3). Snow water equivalent will decrease in winter and spring and soil water storage will decrease in all four seasons (USGS 2016, pp. 4–5). Modeling predicts an increase in winter precipitation, but decreases in soil water storage will mean less water for subirrigation of the species' habitat. This may mean a shorter window for seed germination, lower seed production, and potentially increased years at the rosette stage to obtain sufficient resources to bolt and flower. However, we also understand that C_3 plants, plants which combine water, sugar, and carbon dioxide in carbon fixation, including this species, have a 41 percent proportional increase in growth resulting from a 100 percent increase in carbon dioxide (Poorter 1993, p. 77). This may counteract the need to spend more time in the vegetative portion of the life cycle in response to climate change. Additionally, monitoring indicates that populations are able to withstand several consecutive years of poor growing conditions, and still rebound with suitable conditions (USFWS 2012, pp. 11–22; USFWS 2016b, entire). Climate change has the potential to affect the species' habitat and the species if flea beetle outbreaks are fostered or if flowering levels are suppressed, and although we lack scientific certainty regarding what those changes may ultimately mean for the species, we expect that the species' current adaptations to cope with climate variability will mitigate the impact on population persistence. Therefore, based on the available information, we conclude that climate change is not a threat to Colorado butterfly plant currently or within the foreseeable future.

Summary of Factor E

Herbicide spraying: Individuals and populations are resilient to a single herbicide application at some level and are capable of surviving or bouncing back from such events. Education of landowners has greatly reduced the indiscriminate application of herbicides near populations of Colorado butterfly plant.

Small population size and range: when the species was listed, the stochastic extirpation of individual populations suggested that the range of the species might be declining. Despite the fact that some populations in Colorado, Wyoming, and Nebraska were extirpated prior to listing, and others in Nebraska were extirpated after listing, four additional populations have been discovered, two of which are protected or managed for the species, and there are still representative and redundant populations occurring throughout the range of the species.

Climate change: While climate change presents a largely unknown potential stressor to the species, individual plants are capable of deferring the reproductive stage until suitable conditions are available, populations are made up of individuals found in a range of microhabitats, and populations are located within various ecological settings within the species' range. This indicates that the resiliency, redundancy, and representation of populations will maintain the species in the face of climate change.

Therefore, we conclude that restricted range, herbicide spraying, and climate change are not threats now, nor are they likely to be threats in the future to Colorado butterfly plant. Therefore, we do not expect Factor E, other natural or manmade factors affecting its continued existence, to be a threat to the Colorado butterfly plant now, or in the foreseeable future.

Ongoing Conservation Efforts

The Service has worked with partners to protect existing populations. Much of this work has been accomplished through voluntary cooperative agreements. For example, beginning in 2004, the Service has entered into 11 WEAs with private landowners, representing six of the 12-digit HUCs, to manage riparian habitat for Colorado butterfly plant (70 FR 1940; January 11, 2005). These 15-year WEAs cover a total of 1,038 hectares (ha) (2,564 acres (ac)) of the species' habitat along 59 km (37 mi) of stream. These agreements represent approximately one-third of the known populations of Colorado butterfly plant in Wyoming and Colorado, including some of the largest populations on private lands. All of the landowners have agreed to the following:
1) Allow Service representatives or their designee access to the property for monitoring or fence installation;
2) Coordinate hay cutting activities in areas managed primarily for hay production to consider Colorado butterfly plant seed production needs;
3) Prevent application of herbicides closer than 30.5 m (100 ft) of known subpopulations of Colorado butterfly plant; and
4) Manage livestock grazing activities in conjunction with conservation needs of Colorado butterfly plant.

One of the landowners signed a 10-year agreement instead of a 15-year agreement that was renewed in 2015. The remaining agreements expire in late 2019. We anticipate that participating landowners will continue to support the work being performed under the WEAs and will seek renewal of these agreements. Based on the ongoing relationship that the Service has with these participating landowners, we anticipate that they would support the inclusions of their properties under the post delisting monitoring program should the Colorado butterfly plant be removed from the list of federally listed species under the Act.

The Service and the U.S. Air Force signed a Memorandum of Agreement (MOA) on January 18, 1982 (updated in 1999 and 2004) to facilitate the preservation, conservation, and management of Colorado butterfly plant (USFWS 2004, entire). In 2004, Warren AFB included a Conservation and Management Plan for the species in their Integrated Natural Resource Management Plan (CNHP 2004, entire). Through these Plans, the Service partners with the U.S. Air Force and WYNDD to monitor and protect the population of Colorado butterfly on the Warren AFB. This includes annual monitoring, non-native invasive species control and eradication, and maintenance of appropriate floodplain characteristics for the species.

Three populations in Larimer and Weld Counties, Colorado, occur on properties owned by the City of Fort Collins and two are among the largest across the species' range. The properties are managed by CFCNAD to support Colorado butterfly plant persistence on the landscape (CFCNAD 2016a, entire), including prescribed burns to eliminate competition, managed grazing, and improved security of water flow to the species' habitat.

Populations of Colorado butterfly plant are not known to occur on lands managed by the Bureau of Land Management (BLM) at this time, though there is potential for populations to be discovered on BLM lands in the future. Because of this possibility, the Service and BLM in Wyoming have developed conservation measures under a statewide programmatic consultation under section 7 of the Act for the Colorado butterfly plant. These conservation measures are incorporated into the BLM's Resource Management Plan (RMP) and include, but are not limited to, (1) buffering individuals and populations by 800 m (0.5 mi), (2) implementing Standards for Healthy Rangelands and Guidelines for Livestock Grazing Management for the Public Lands Administered by the BLM in the State of Wyoming, (3) limiting the number of grazing animals within the permit area, and (4) protecting surface water through prohibiting surface development in the following areas: within 400 m (0.25 mi) of the North Platte River; within 152 m (500 ft) of live streams, lakes, reservoirs, and canals and associated riparian habitat; and within 152 m (500 ft) of water wells, springs, or artesian and flowing wells (BLM 2005, pp. 4-2 through 4-4). The newly discovered population on Wild Horse Creek (WY-23) occurs within the agreement area that BLM developed with the landowners, and so the conservation measures included in the Rawlins RMP are applied to this population.

In summary, these agreements have provided useful data, facilitated good management of nine of the largest and most resilient populations, and resulted in stable or increasing population trends. Because of the information we obtained through these agreements, we are able to understand the resilience of individual plants and populations, the representation of the species within its ecological settings, and the redundancy of the species' population's numbers and potential for connectivity.

Summary of current resiliency, redundancy, and representation

In summary, resiliency, redundancy, and representation of the individual, population, and species appear to indicate moderate to high viability. Regarding resiliency, the species has adaptations at each life stage, including the seedbank, rosettes, and flowering individuals to circumvent or survive adverse conditions. Seeds may opportunistically germinate in years of favorable growing conditions. Newly-established plants are capable of withstanding a period of unsuitable climate conditions as basal rosettes before bolting and flowering, and reproductive individuals can survive some level of damage from grazing and hail by producing new flowering stems beneath the damaged portion of the plant. We have documented populations declining in years of poor growing conditions from a few to zero reproductive individuals. However, those populations have rebounded to hundreds of reproductive individuals following a wet spring or decreased grazing pressure, indicating that population numbers at any one time do not always provide a true representation of the population's viability.

Because this species is self-compatible, individuals can produce seeds even in years of few reproductive individuals though there is higher pollination success rate associated with outcrossing (Krakos *et al.* 2013). In either case, seeds can re-enter the seedbank or be distributed in place or downstream, potentially establishing new populations or subpopulations and contributing to genetic exchange among cohorts of any given population, and among populations or subpopulations, increasing representation. Regarding redundancy, 28 extant populations are spread along and among multiple 12-digit HUC watersheds in various ecological settings in all three states within the presumed historic range of the species, and at least 15 of the 28 are highly viable and occupying almost all of the 12-digit HUC watersheds where this species historically occurred (Figure 1 and Table 2). Because many of these populations occur within the same or neighboring drainages, there is a high probability that they are connected either through pollination or by seed dispersal.

Regarding representation, individuals and populations of Colorado butterfly plant are found in streamside habitats, over 100 meters (328 feet) upland from the stream in the floodplain, and within spring-fed wet meadows, indicating that this species can occur anywhere appropriate hydrology requirements are met and where lack of competition allows for germination, growth, and reproduction. Additionally, we understand that one unique allele occurred within sampled individuals collected at three drainages of Warren AFB (Floyd 1995a), and that the Crow Creek

subpopulation is unique from the individuals at the other two drainages (Tuthill and Brown 2003) indicating that there is likely some genetic diversity in this species.

Therefore, based on this analysis of the 3Rs for Colorado butterfly plant, the species appears to be comprised of numerous populations that appear to be fluctuating in abundance yet resilient, with some connectivity among subpopulations and populations via pollinators and water-borne seed dispersal. These populations are spread within much of the historic range of the species and have common as well as unique alleles. Several populations are managed due to their location on federal, state, or local government lands, and the populations occurring on private lands appear to be stable through management for cattle/hay production.

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Appendix A. Annual monitoring results of number of flowering Colorado butterfly plant individuals for all populations for which we have data for more than two years. Populations are organized by state and Element Occurrence number. The total number of plants, mean, median, min, max, and standard error for each population for each year at the bottom of the table. The total number of plants counted in each year is provided in the far right column.

Population	CO-11	CO-12	CO-17	WY-2	WY-3 & WY-5	WY-8	WY-8	WY-10	WY-10	WY-14	WY-15	WY-17	WY-18	WY-19	All populations
Year	Spring Creek (Meadow Springs Ranch)	HQ and Meadow Pastures at Soapstone Prairie	Jack Springs at Soapstone Prairie	North Fork Bear Creek	Little Bear Creek	Upper Horse Creek	Horse Creek	Lower Lodgepole Creek	Lodgepole Creek - Thomas Reservoir	Lodgepole Creek	Crow, Diamond, Unnamed Creeks (FE Warren)	Diamond Creek	Spring Creek	Lone Tree Creek	Total per year
1986										1262					1262
1993				3952	1320										5272
1994	200										7275				7475
1995	964										9927				10891
1996	620										5594				6214
1997											9094				9094
1998	1000			1950	187	6518		3489	1304	4891	10889	8050	6		38284
1999	265										11344				11609
2000											7676				7676
2001											7467				7467
2002											5726				5726
2003											6912				6912
2004	55			2298	827	6422	25	1	22	37	7322	182	542	234	17967

2005	59	150				622	60	343	238	2	8303	4000	460	21	14258
2006	45	11688				1435	10	661	285	0	6175	1500	125	25	21949
2007						156		30	42	0	2230	30	55	18	2561
2008		6231				607	16	132	157	0	1916	2	0	7	9068
2009						1009		1170	1076	16	4531	513	521	215	9051
2010	874		25			1164		129	390	16	3717	5984	1310	62	13671
2011	140	26189	250			950	22	994	2067	33	11957	3865	1654	43	48164
2012	210					5167	98	1347	695	175	7462	11742	2022	78	28996
2013	46					663	27	741	2101	936	5333	1740	1704	1	13292
2014	1432		0			513	118	262	376	168	10247	61	3187	90	16454
2015	165	77	0			270	101	189	680	8	3409	11	3574	19	8503
2016						7472	485	187	863	185	8385	1012	5193	0	23782
Total	6075	44335	275	8200	2334	32968	962	9675	10296	7729	162891	38692	20353	813	345598
Mean	433.9	8867.0	68.8	2733.3	778.0	2354.9	96.2	691.1	735.4	515.3	7082.2	2763.7	1453.8	62.5	13823.9
Median	205	6231	12.5	2298	827	979.5	43.5	302.5	535	33	7322	1256	926	25	9094
Min	45	77	0	1950	187	156	10	1	22	0	1916	2	0	0	1262
Max	1432	26189	250	3952	1320	7472	485	3489	2101	4891	11957	11742	5193	234	48164
Range	1387	26112	250	2002	1133	7316	475	3488	2079	4891	10041	11740	5193	234	46902
SD	439.5	9676.9	105.1	873.4	463.8	2611.9	135.0	883.8	661.2	1224.9	2734.9	3475.3	1524.8	74.3	10871.3