Species Status Assessment Report for the Rocky Mountain monkeyflower (*Mimulus gemmiparus*)

Prepared by the Colorado Ecological Services Field Office
U.S. Fish and Wildlife Service, Grand Junction, Colorado
March 2020, **Version 1**

Photo taken by Mark Beardsley (EcoMetrics)

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Suggested Citation:

U.S. Fish and Wildlife Service. 2020. Species status assessment report for Rocky Mountain monkeyflower (*Mimulus gemmiparus*). Lakewood, Colorado.

Definitions:

Patches –groups of Rocky Mountain monkeyflower plants that are closely associated with each other but separated from other groups of plants by about three meters or more (Beardsley 2017, p. 2).
Ramets – a physiologically distinct organism that is part of a group of genetically identical individuals derived from one progenitor.
Element Occurrences –a location at which a plant, animal, or insect is, or was, present.
Metapopulation – For the purposes of this analysis, a metapopulation is considered to be a population in which patches and ramets are spatially distributed into two or more populations. We are aware that there is no known genetic exchange occurring between the populations.
Population – A group of patches that are closely associated with each other but that are geographically separated from other groups of patches.
Bulbils – A small bulb-shaped bud that has all the components needed to develop into a new ramet, including a shoot axis and rudimentary leaves and roots. The bulbil is technically not an embryo, but it is morphologically and functionally analogous to one.

Executive Summary

This species status assessment reports the results of the comprehensive review of the biological status for the Rocky Mountain monkeyflower (*Mimulus gemmiparus*), also known as the budding monkeyflower, a small plant found in north-central Colorado. This species status assessment (SSA) report summarizes a thorough analysis of the species' overall viability, or ability to maintain a population in the wild, and thus extinction risk, using the SSA framework (Smith et al. 2018, entire). This SSA report is intended to provide the best available biological information to inform the U.S. Fish and Wildlife Service's (Service's) decision on whether or not the Rocky Mountain monkeyflower is warranted for listing under the Endangered Species Act (Act) and, if so, whether and where to propose critical habitat. Rocky Mountain monkeyflower (hereafter, monkeyflower) is a small, narrow endemic plant that inhabits montane to subapline habitats at elevations of 2,400 - 3,400 m (7,874 - 11,154 ft) and is found under overhangs of south-facing cliffs or boulders (Beardsley 1997, p.6). The areas where the plant grows are typically occupied by few plants of other species (Beardsley 1997, p. 6).

Species Needs

To evaluate the biological status of the monkeyflower both currently and into the future, we assess a range of conditions that allows us to consider the species' resiliency, redundancy, and representation. The monkeyflower needs multiple resilient populations and analysis units distributed across its range to maintain its persistence into the future and to avoid extinction. Populations with good resiliency have at least 300,000 ramets and at least six patches with a dependable water supply and moist soil for most of the growing season. Resilient populations should be distributed across the three analysis units where the species currently occurs; this distributional pattern will provide for the needed redundancy and representation to increase the probability that the species will withstand future catastrophic events and maintain future adaptive capacity in terms of genetic and ecological diversity. The likelihood of the monkeyflower's persistence depends upon the number of populations, its resilience to stressors, and its distribution. As we consider the current and future conditions of the species, the more resilient populations distributed across the known range of the species within each analysis unit, the greater the viability of the species.

Current Condition

The distribution of the monkeyflower is highly discontinuous at a regional scale, but extremely clustered and dense at local scales (Beatty 2003, p. 23). For the purposes of our analysis, we divided the range of the monkeyflower into three analysis units (Units 1, 2, and 3) based on the geographic distance between each unit.

Currently there are 19 known populations; patches are found near Saint Vrain, Peaceful Valley, Guanella Pass, Geneva Basin, Burning Bear, Threemile, Black Mountain, Elk Creek, Mason Creek, Lost Park, Lost Creek, Hankins Gulch, Rainy Day Rocky, Corral Creek, Corral Dome, Old Fall River Road (historical), Horseshoe Park, Cascade Falls, and Devil's Staircase (see Figure 4). The Rocky Mountain monkeyflower occupies approximately 60 acres (ac) (24.28 hectares (ha)) on public lands managed by the United States Forest Service (USFS), National Park Service (NPS), and Colorado Parks and Wildlife (CPW) and is considered to be a metapopulation (e.g., a population in which patches and ramets are spatially distributed in two or more populations). The monkeyflower occupies approximately 7 ac in Staunton State Park, approximately 25 ac in Rocky Mountain National Park, and approximately 28 ac in Pike-San Isabel National Forest and Arapahoe-Roosevelt National Forest (See Figure 4). We analyzed each population and subsequently each analysis unit by looking at the number of patches, the number of ramets, and the hydrological regime within each population. These categories were selected as metrics because they are considered to be some of the most important habitat and demographic factors that contribute to the resilience of the monkeyflower at the population level, and that we have sufficient data to analyze. We describe the current condition for the monkeyflower in terms of demographic, habitat, and environmental conditions for each analysis unit. See the summary table below for the resiliency of each population and analysis unit.

Future Scenarios and Future Condition

The viability of the monkeyflower depends on maintaining multiple redundant and resilient populations over time, within each analysis unit (representation). Climate change models forecast warmer temperatures and a decrease in precipitation, and/or change in the timing and type of precipitation by the year 2050. Given our uncertainty regarding the future effects of climate change, as well as other stressors, we predict resiliency, redundancy, and representation of the monkeyflower under four plausible future scenarios (See Table 1 below). We selected four future scenarios to describe a range of plausible risk to the species that could occur within this biologically meaningful timeframe. These scenarios are:

- Scenario 1 – continuation of the current land management activities under the "Warm and Wet" climate change model;
- Scenario 2 – an increase in land management activities that protect the monkeyflower under the "Very Hot and Wet" climate change model;
- Scenario 3 – a decrease in land management activities that protect the monkeyflower under the "Very Hot and Dry" climate change model; and
- Scenario 4 – continuation of the current land management activities and increased herbivory under the "Hot" climate change model.

Table 1. Summary table showing the current overall resiliency and the overall resiliency for each future scenario.

Land Ownership	Analysis Units	Current Condition	Scenario 1	Scenario 2	Scenario 3	Scenario 4
NPS **USFS-ROOS**	1	Good	Good	Good	Moderate	Moderate
USFS-PIKE **CPW-Staunton**	2	Moderate	Moderate	Moderate	Poor	Poor
USFS-PIKE	3	Moderate	Good	Moderate	Moderate	Moderate

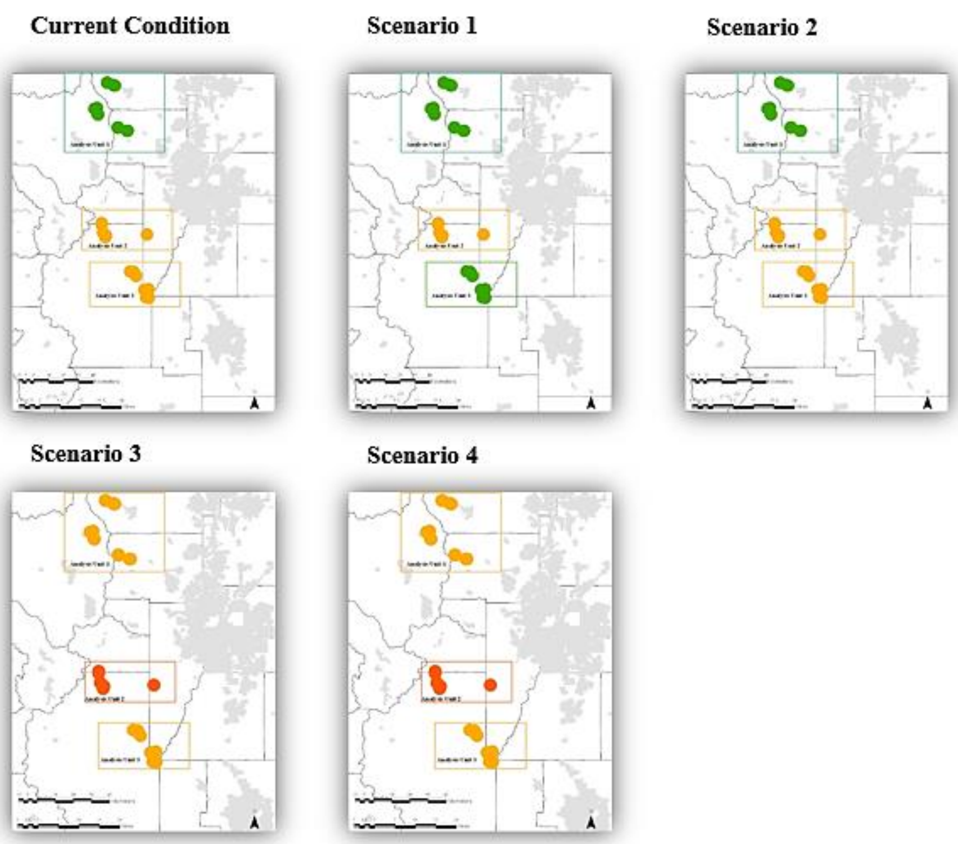

Figure 1. Current and future conditions for the monkeyflower. Green represents a population in good condition, orange represents moderate condition, and red represents poor condition. Refer to Sections 3.3-3.5 and Chapter 4 for more detail on these categories and how they were used to evaluate current and future conditions.

Uncertainties and Assumptions

The historical range of the monkeyflower, prior to being discovered in 1950, is unknown. We do not know how many populations are needed to provide sufficient redundancy and representation to the species. We do not know if there are any additional populations on either public or private lands. It is possible that there are additional populations that have not been discovered yet; however, we are unable to rely on the existence of such populations for the purposes of our analysis. We do not have information on the populations that are located within Rocky Mountain National Park. Thus, these populations were not included in our “ranking” process for current and future condition and are not included in Table 2 (the Population Summary for the Monkeyflower).

We do not fully understand the factors that define and constrain this species to its relatively small range. There is some uncertainty regarding what factors are influencing the population dynamics of the monkeyflower. Uncertainties remain regarding how the monkeyflower will respond to a changing climate, how the climate may change, and how future management activities may change within this species’ habitat. In addition, we are uncertain of which environmental factors will affect the monkeyflower more; for example, an increase in evaporative demand may lead to further reductions in resiliency, even when sufficient levels of precipitation are available.

Additionally, the presence of clonality, when the extent of it is unknown, may lead to an overestimation of the level of genetic diversity, leading to an underestimation of perceived threats to persistence (Bradbury 2016, pg. 194); therefore, this unknown extent of clonality can lead to an overestimation of resiliency and representation. However, although there are numerous studies that indicate that asexually reproducing species exhibit low levels of genetic diversity, a 2004 study found that the monkeyflower exhibits a considerable amount of genetic diversity (Beardsley *et al* 2004, pg. 34). Because the monkeyflower primarily reproduces asexually, it would be logical to assume that the populations have low levels of genetic diversity within them and that it is more genetically diverse between populations (Beardsley *et al* 2004, pg. 35). However, the majority of the genetic diversity was found within populations and less so between the populations (Beardsley *et al* 2004, pg. 35). Because the 2004 study was only conducted on the East Inlet, Guanella Pass, Hankins Gulch, North Inlet, Staunton Park, and Saint Vrain populations, some uncertainty still remains as to the overall amount of genetic diversity for this species.

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Chapter 1: Introduction

Rocky Mountain monkeyflower (*Mimulus gemmiparus*, hereafter, monkeyflower) is a species that is endemic to Colorado occurring at elevations of approximately 2,400 - 3,400 meters (m) (7,874 - 11,154 feet (ft)) in Boulder, Clear Creek, Grand, Jefferson, and Larimer Counties. The monkeyflower is a unique annual species because it reproduces predominantly with asexual propagules (bulbils; which function analogously to seeds) (Beatty 2003, p. 3). The monkeyflower was included in the 1985 Review of Plant Taxa for Listing as Endangered or Threatened Species as a Category 2 Candidate under the Endangered Species Act of 1973, as amended (Act). In 1996, the U.S. Fish and Wildlife Service (Service) proposed removing all Category 2 species, including the monkeyflower, in the candidate species notice of review; this action resulted in the removal of the monkeyflower from the candidate list. In July 2007, the Service received a petition from Forest Guardians (now WildEarth Guardians) requesting that the Service list 206 species, including the monkeyflower (74 FR 6122, February, 5, 2009). In 2009, in response to this petition, the Service published a 90-day finding for the monkeyflower; the Service concluded that the petition did not represent substantial scientific or commercial information indicating that the listing of the monkeyflower may be warranted. The information that was reviewed from the petition described one or more threats for the general area in which the species exists, but did not link the threats to the species or the habitat the species occupies. WildEarth Guardians again petitioned to list the species on October 4, 2011. We published a 90-day finding in the Federal Register in response to this petition on August 29, 2012; it found that the petition presented substantial information and that listing may be warranted.

This Species Status Assessment (SSA) is intended to be an in-depth review of the species' biology and threats, an evaluation of its biological status, and an assessment of the resources and conditions needed to maintain populations over time (i.e., viability). This SSA report for the monkeyflower is intended to provide the biological support for the decision on whether or not to propose to list the species as threatened or endangered under the Act and, if so, where to propose critical habitat. The SSA report does not represent a decision by the Service on whether this species should be proposed for listing as a threatened or endangered species under the Act. Instead, this SSA report provides a review of the best available scientific and commercial information regarding the biological status of the monkeyflower. The listing decision will be made by the Service after reviewing this document and all relevant laws, regulations, and policies. The results of a proposed decision will be announced in the *Federal Register*, with opportunities for public input, if appropriate. The intent is for the SSA report to be easily updated as new information becomes available and to support all functions of the Endangered Species program, from candidate assessment to listing to recovery. As such, the SSA report will be a living document upon which other documents such as listing rules, recovery plans, and 5-year status reviews would be based, if the species warrants listing under the Act.

For the purpose of this assessment, we generally define viability as the ability of the monkeyflower to sustain a population in the wild over time. Using the SSA framework, we consider what the species needs to maintain viability by characterizing the status of the species in terms of the three conservation biology principles of resiliency, redundancy, and representation (Service 2016, entire).

- **Resiliency** describes the ability of a species to withstand stochastic disturbance. Resiliency is positively related to population size and growth rate and may be influenced by connectivity among populations. Generally speaking, populations need abundant ramets within habitat patches of adequate area and quality to maintain survival and reproduction in spite of disturbance. Our analysis explores the number of patches and ramets within each population, in addition to each population's hydrological conditions.

- **Redundancy** describes the ability of a species to withstand catastrophic events; it is about spreading the risk among multiple populations to minimize the potential loss of the species from catastrophic events. Redundancy is characterized by the presence of multiple, resilient populations distributed within the species' ecological settings and across the species' range. It can be measured by population number, resiliency, spatial extent, and degree of connectivity. Our analysis explores the influence of the number, distribution, and connectivity of populations on the species' ability to withstand catastrophic events (e.g., rescue effect).

- **Representation** is characterized by the breadth of genetic and environmental diversity within and among populations and describes the ability of a species to adapt to changing environmental conditions over time. Measures may include the number of varied niches occupied, the genetic diversity, heterozygosity, or alleles per locus. Our analysis explores the relationship between the species' life history, the influence of environmental factors on monkeyflower phenology (the study of the timing of life cycle events at the population level, most often in relation to climate), and the species' ability to adapt to changing environmental conditions over time.

Our approach for assessing the viability of the monkeyflower involved three stages. In Stage 1, we described the species' ecological requirements for survival and reproduction at the individual, population, and species levels using the 3Rs (resiliency, redundancy, and representation). In Stage 2, we assessed the species' current condition in relation to the 3Rs and ongoing factors (risk and beneficial factors) that led to the species' current condition. In Stage 3, using the baseline conditions established in Stage 2 and the prediction for future risk and beneficial factors, we projected the future conditions of monkeyflower populations.

The species' ecological needs (Stage 1) are summarized in Chapter 2; the current condition of the species and habitat (Stage 2) is summarized in Chapter 3; and the species future condition and status (Stage 3) are summarized in Chapter 4.

Chapter 2: Species Ecology

In this Chapter, we provide basic biological information about the monkeyflower, including physical environment, taxonomic history and relationships, morphological descriptions, and reproductive and other life history traits. We then outline the resource needs of ramets, populations, and the species as a whole. Here we report those aspects of the life history of the monkeyflower that are important to our analysis. Data on this species was provided by the Colorado Natural Areas Program, U.S. Forest Service, and the Colorado Natural Heritage Program.

2.1 Biology and Life History

Taxonomy

The original, 1972 classification of the monkeyflower placed it in the Scrophulariaceae (Figwort) family and *Mimulus* genus (Weber 1972). However, the taxonomy of the monkeyflower is currently under debate. Recent phylogenetic studies suggest that this species is a member of the Phrymaceae (Lopseed) family, not the Scrophulariaceae (Figwort) family, and belongs in the *Erythranthe* genus and not *Mimulus,* as previously recorded. This recent research would thus suggest that the scientific name should be *Erythranthe gemmipara*. Researchers also found that *Mimulus gemmiparus* (the monkeyflower) is genetically distinct from all other members of the genus *Mimulus* (Beardsley *et al* 2004, pp 474-489; Bradbury 2016, pp. 193-205). Until modern genetic data can help to resolve the considerable taxonomic uncertainties (Lowry *et al* 2019, p. 5), we will continue to use the original classification below (Weber 1972).

Class: Magnoliopsida
- Subclass: Asteridae
  - Order: Scrophulariales
    - Family: Scrophulariaceae (Figwort family)
      - Genus: *Mimulus*
        - Species: *Mimulus gemmiparus*

General Description

Ruth Ashton Nelson discovered the monkeyflower in 1950 but it was not officially described until 1972, when William Weber published its taxonomy (Weber 1972). It is a small, annual herb from 1 to 10 centimeters (cm) tall with glabrous usually unbranched stems (please refer to Figure 2 and Figure 3) (Beatty 2003, p. 13-14). The leaves are opposite, entire, ovate, glabrous, and up to 10 millimeters (mm) long and 7 mm wide. The petioles (the stalk that connects the leaf blade to the stem) are 2 to 3 mm long and are laterally compressed with a small pouch that contains a lens-shaped propagule function in asexual reproduction (Beatty 2003, p. 14). All of the leaves produce bulbils except the first (lowermost) pair because these leaves were pre-formed in the originating bulbil (Weber 1972, pp. 423-425). The leaves at the top of the plant produce the largest propagules and the most reduced leaves (Weber 1972, pp. 423-425). The yellow, solitary, bilabate flowers are terminal or axillary, 4 to 5 mm long, with spreading lobes and an open throat (Beatty 2003, p. 14).

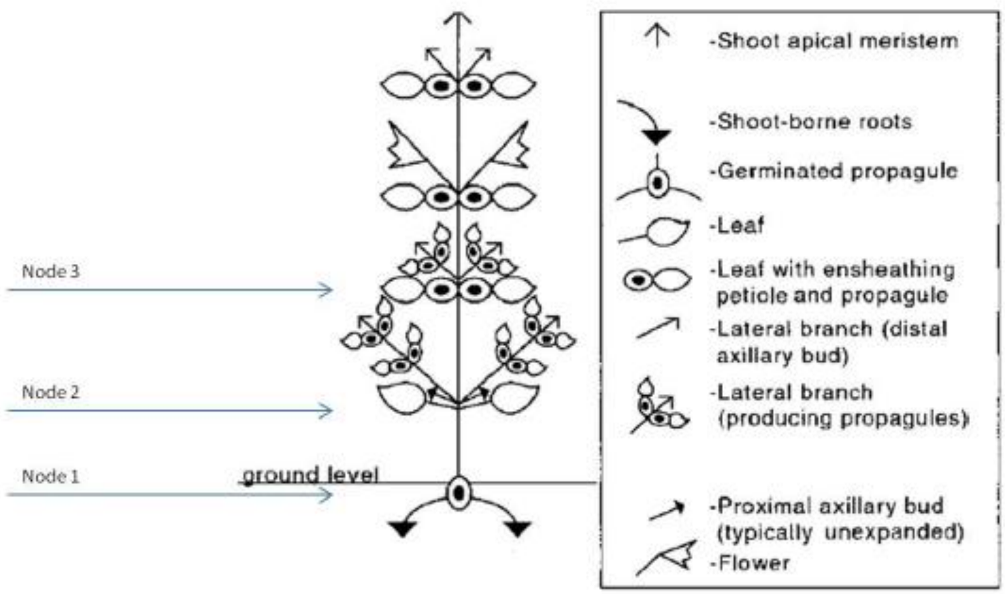

Figure 2. Diagram of Mimulus gemmiparus from Moody et al. (1999) depicting the general pattern of growth. Node 1 represents the germinated propagule.

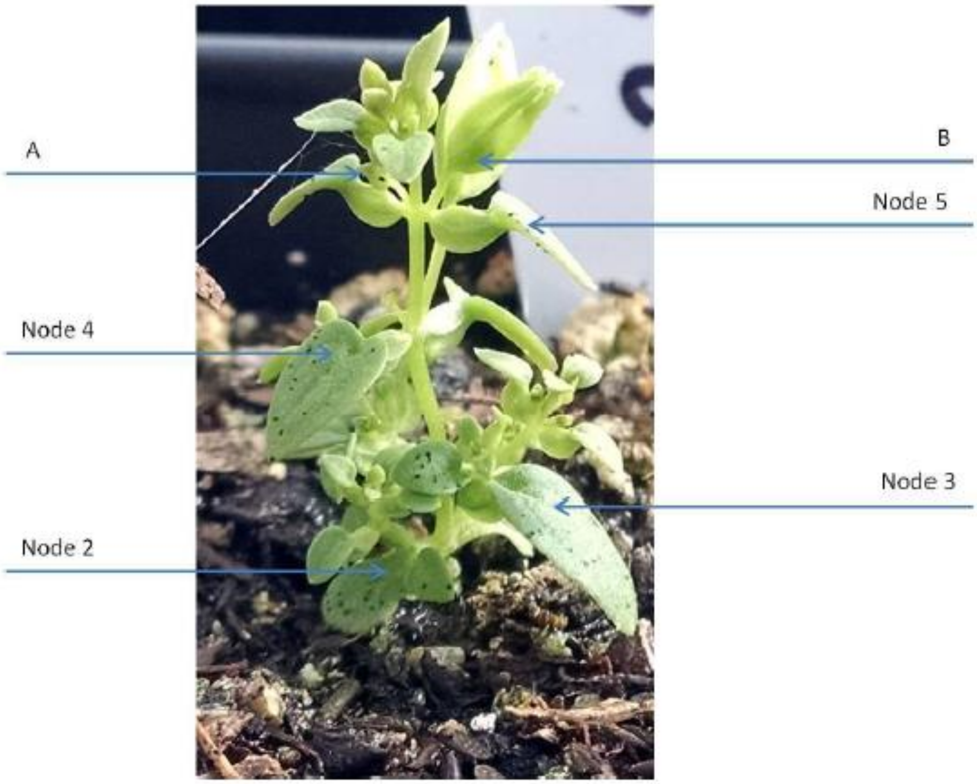

Figure 3. Mimulus gemmiparus showing above ground nodes. Node 5 shows axillary buds becoming a flower on the right (B) and a branch on the left (A). Node 5 shows an example of a propagule where the petiole of the leaf encases a bulbil (Chu 2016).

2.1.2 Species Distribution

The historical range of the monkeyflower, prior to being discovered in 1950, is unknown. The monkeyflower is found in Boulder, Clear Creek, Grand, Jefferson, and Larimer Counties in Colorado and occurs on lands managed by the U.S. Forest Service (USFS), Colorado Parks and Wildlife (CPW), and the National Park Service (NPS). The distribution of the monkeyflower is highly discontinuous at a regional scale, but extremely clustered and dense at local scales (Beatty 2003, p. 23). In 1972, this species was only known from three element occurrences in Rocky Mountain National Park near Estes Park, Colorado (Beatty 2003, p. 13). Between 1992 and 2005, five more element occurrences were located, both inside and outside the park (CNHP 2003 in Beatty 2003, p. 13). Thus, in 2005, eight element occurrences were known range-wide (Steingraeber and Beardsley 2005, p. 2). The type locality, found near Fall River Road in Rocky Mountain National Park, is presumed to be extirpated (Beardsley and Steingraeber 2013, p. 3). In 2007, Paul Beardsley discovered a new element occurrence in Staunton State Park (Beardsley and Steingraeber 2013, p. 3). Three of the known element occurrences are found on USFS lands; Saint Vrain, Guanella Pass, and Hankins Gulch (Beardsley and Steingraeber 2013, p. 3). According to 2005 estimates, these three element occurrences accounted for approximately 93 percent of the total number of ramets and approximately 54 percent of the geographical extent of the species (Steingraeber and Beardsley 2005, p. 7). In 2013, the estimated number of ramets on USFS land was 52 percent less than the 2005 estimate (Beardsley and Steingraeber 2013, p. 9). In 2015, there were approximately 41 known patches (patches are groups of plants closely associated with each other but separated from other patches by approximately three meters or more) of monkeyflowers on USFS and CPW lands (Beardsley 2017, p. 11). Until we began an assisted migration project in 2016, we only knew of nine element occurrences (those described above). In 2016, approximately 126 native patches were discovered during an assisted migration project that was funded by Colorado Natural Areas Program (CNAP) and the Service, with support from the USFS (Beardsley 2017, p. 11). In 2017, 46 patches were "established" by planting bulbils that were collected from native patches and grown in a greenhouse (Beardsley 2017, pp. 1, 11). These additional discoveries and plantings in 2016 and 2017 added 15 new known element occurrences.

Currently, there are 19 populations that contain all of the known element occurrences and patches; patches are found near Saint Vrain, Peaceful Valley, Guanella Pass, Geneva Basin, Burning Bear, Threemile, Black Mountain, Elk Creek, Mason Creek, Lost Park, Lost Creek, Hankins Gulch, Rainy Day Rocky, Corral Creek, Corral Dome, Old Fall River Road (historical), Horseshoe Park, Cascade Falls, and Devil's Staircase (see Figure 4). The monkeyflower occupies approximately 60 acres (ac) (24.28 hectares (ha)) on public lands managed by the USFS, NPS, and CPW, and is considered to be a metapopulation (e.g., a population in which ramets are spatially distributed in two or more populations). The monkeyflower occupies approximately 7 ac in Staunton State Park, approximately 25 ac in Rocky Mountain National Park, and approximately 28 ac in Pike-San Isabel National Forest and Arapahoe-Roosevelt National Forest (See Figure 4).

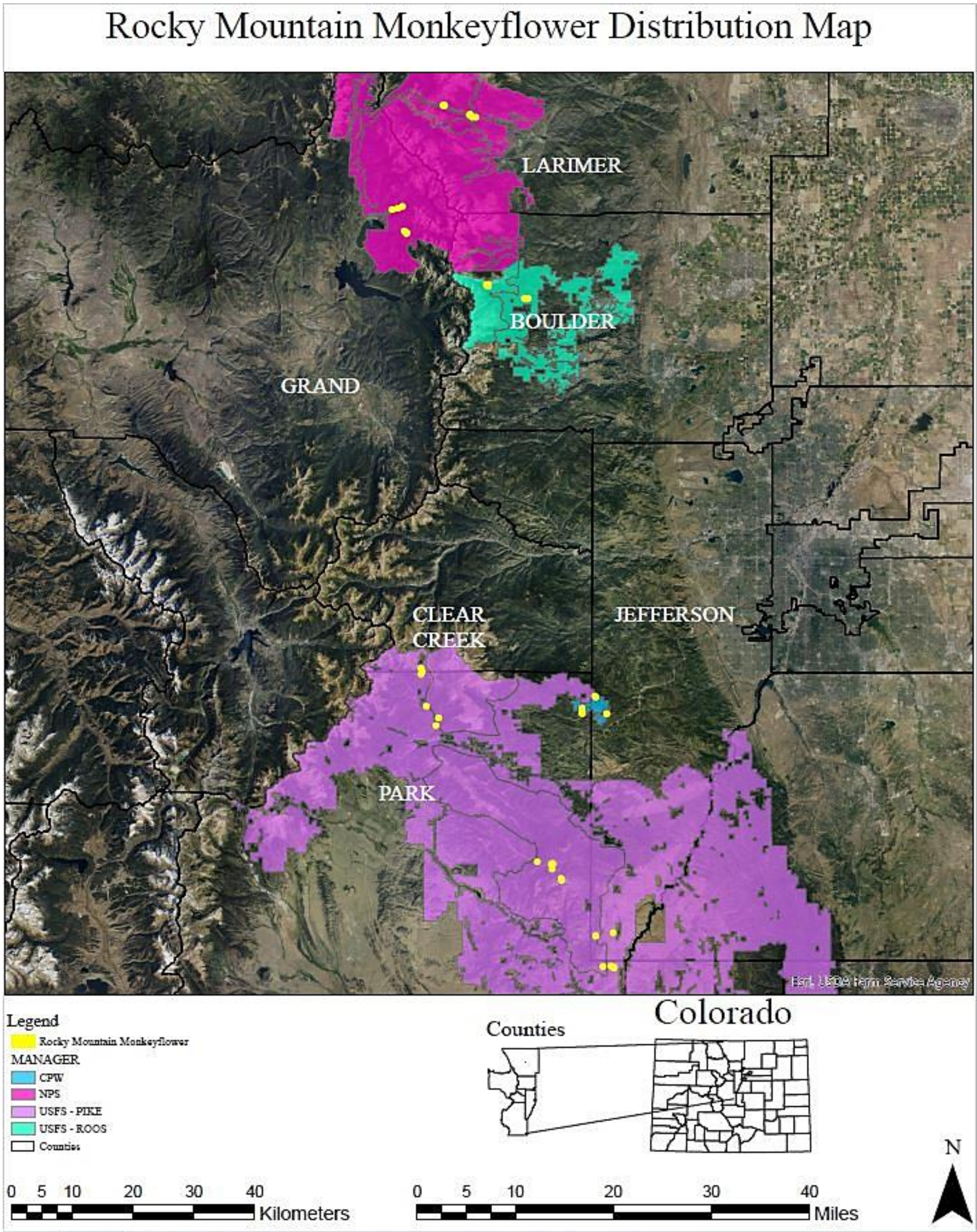

Figure 4. Overall range of the monkeyflower with land ownership. The overall range of the species is shown as yellow dots which represent each population.

We do not have precise data pertaining to total population size for this species; however, a summary from recent site visits indicates that, as of 2017, there are approximately 165 native patches and 43 established patches consisting of approximately 14,634,300 ramets (13,275,000 native, 1,359,300 established) within the 15 populations for which there is data (See Table 2. Population summary for the monkeyflower; this table excludes the four populations on NPS managed lands for which we have no data. Data for this summary table was taken from Beardsley (2017), pp. 14-145).) (Beardsley 2017, pp. 14-145). One researcher alerted us that in 2019, in contrast to the 2017 data in Table 2, only one patch was located in the Hankins Gulch populations (Baker 2020, Pers. Comm).

Table 2. Population summary for the monkeyflower; this table excludes the four populations on NPS managed lands for which we have no data. Data for this summary table was taken from Beardsley (2017), pp. 14-145).

Population Name	Patches			Ramets		
	Native	Planted	Total	Native	Planted	Total
Saint Vrain	20	0	20	1,000,000	0	1,000,000
Peaceful Valley	6	9	15	200,000	0	200,000
Guanella Pass	19	5	24	1,200,000	1,200,000	2,400,000
Geneva Basin	6	0	6	35,000	0	35,000
Burning Bear	0	0	0	0	0	0
Threemile Creek	0	5	5	0	4,000	4,000
Black Mountain	2	4	6	100,000	4,500	104,500
Elk Creek	1	2	3	100,000	3,200	103,200
Mason Creek	0	3	3	0	500	500
Lost Park	0	1	1	0	100	100
Lost Creek	0	7	7	0	100,000	100,000
Hankins Gulch	3	0	3	320,000	0	320,000
Rainy Day Rock	0	1	1	0	1,000	1,000
Corral Dome	100	0	100	10,000,000		10,000,000
Corral Creek	8	6	14	320,000	46,000	366,000
Total	**165**	**43**	**208**	**13,275,000**	**1,359,300**	**14,634,300**

Researchers conducting demographic monitoring of the monkeyflower currently count the number of bulbils pre-germination to estimate population size because bulbils are the persistent overwintering stage of the monkeyflower (Beardsley 2017, p. 3). In Table 2, and in this SSA, we use this pre-germination number of bulbils as a proxy for the number of ramets post-germination in a population. Since not all bulbils survive to germinate, using pre-germination numbers of bulbils is likely an overestimation of the number of ramets. However we do not have sufficient information on the survival rate of bulbils from pre-germination to post germination to correct this count.

2.1.3 Life History

The monkeyflower is an annual species (plants germinate, grow, reproduce, and die in one growing season) (Beardsley 1997, p. 4) that grows from July to September. After germination, young plants increase their biomass and produce leaves, including bulbils within the petioles. When the leaves die and abscise (to separate by abscission, as a leaf from a stem), the bulbils become separated from the adult plant and disperse (See Figure 5) (Beardsley 1997 p. 150). Since the monkeyflower exhibits asexual reproduction the species can be described as an indeterminate (iteroparous) annual where adults have the ability to produce offspring throughout their lifetime (Beardsley 1997 p. 39). Thus, the production of asexual propagules increases the species' reproductive output and radically influences its life history (Beardsley 1997, p. 168). An adult ramet can start producing offspring from a young age/stage and can continue to produce offspring throughout its life (Beatty 2003, p. 20). Based on the vegetation strategies described by Grime (1979), the monkeyflower may be considered a ruderal, or r-selected, species (Beatty 2003, p. 20). Ruderal species can exploit low stress, high disturbance environments by minimizing vegetative growth and maximizing reproductive output (Grime 1979, Barbour et al. 1987 in Beatty 2003, p. 20). The monkeyflower has the potential to maximize reproductive output by developing bulbils concurrent with leaf development (Beatty 2003, p. 20).

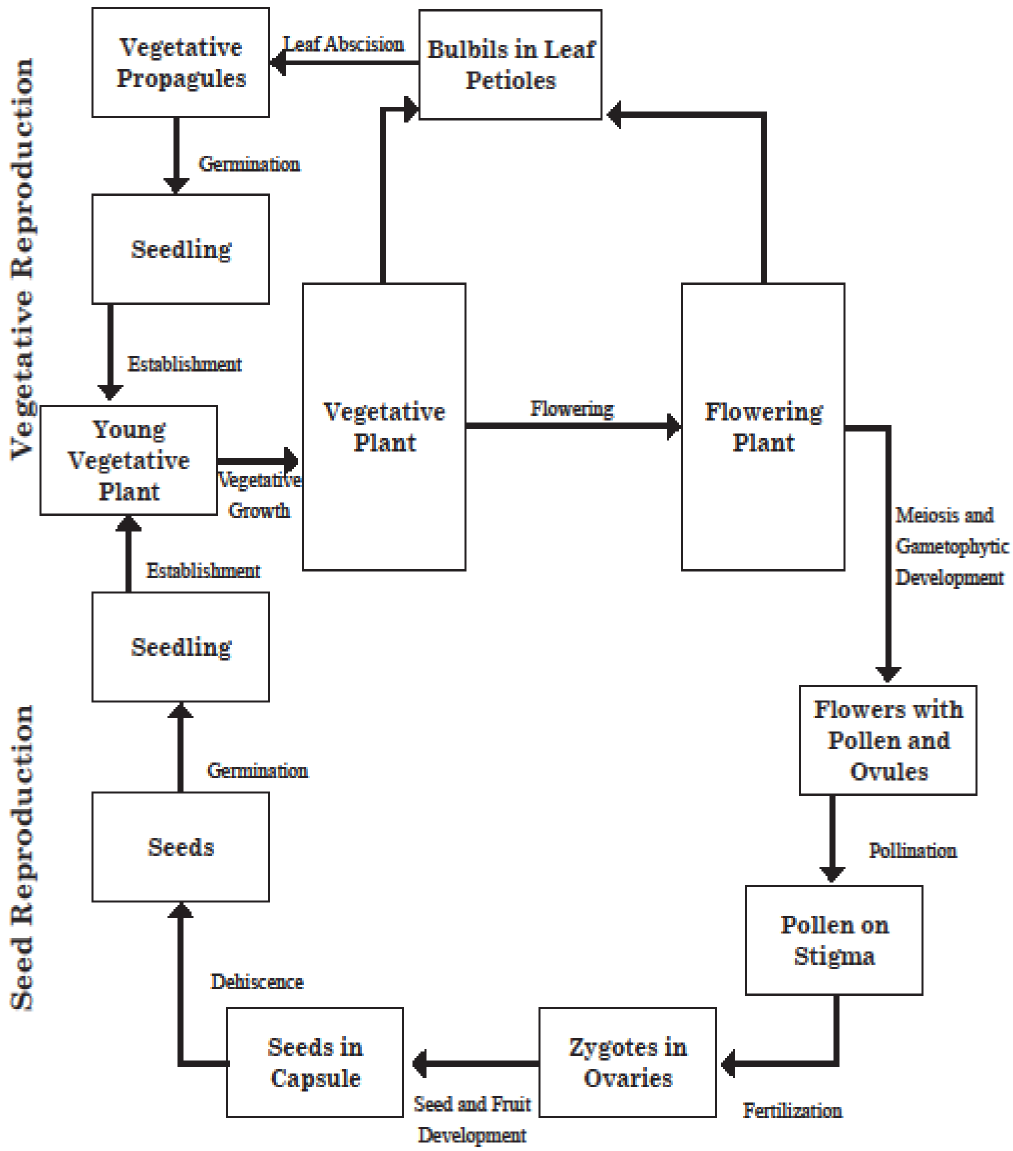

Figure 5. Schematic representation of the hypothesized life history of the monkeyflower, including both asexual and sexual reproductive circuits. Asexual reproduction is the predominant form of reproduction in natural populations. Please note that gametophyte development may occur through an alternate method. Additionally, although pollen is fertile, fertilization itself has not been observed in this species and may not be necessary. This figure is adapted from Beardsley (1997) (Beattey et al. 2003, p. 21).

Reproduction

The monkeyflower exhibits a highly unique form of asexual reproduction not seen within the *Mimulus* genus or in any other Holarctic species (Weber 1972, p. 6, Beardsley 1997 in Beatty 2003, p. 19). Monkeyflower plants produce propagules comprised of "bulbils" (or "gemmae" [Weber 1972, p. 7]) within deep sacs developed from the petioles of all leaves, except the first pair of preformed leaves (Beatty 2003, p. 19). The bulbils have all the components needed to develop into a new ramet, including a shoot axis and rudimentary leaves and roots (Beatty 2003, p. 19). The bulbil is technically not an embryo, but it is morphologically and functionally analogous to one (Beatty 2003, p. 19). When the adult plant senesces in early July to early August, the leaf blades wither and the petiole abscises at the stem to disperse the propagules, which consist of the petiolar sac with the bulbil inside (Beatty 2003, p. 19). The bulbils, much like sexually produced seeds, overwinter and germinate in the spring to grow into new adult plants (Weber 1972, p. 7; Beardsley 1997 in Beatty 2003, p. 19).

The monkeyflower infrequently flowers in nature (Weber 1972, p. 7;CNHP 2003 in Beatty 2003, p. 19). However, previous surveys show that some populations flower more frequently than others (Beardsley 2020, pers. comm.). The yellow flowers, if produced, occur in July (CNHP 2003 in Beatty 2003, p, 19). The presence of flowers has been recorded at the Horseshoe Park alluvial fan, East Inlet Trail, North Inlet Trail, Old Fall River Road, and Guanella Pass populations (CNHP 2003 in Beatty 2003, p. 19). In most cases, only one flowering ramet was reported; the largest number of flowering ramets (29) was recorded at the East Inlet Trail location in 1982 (Beatty 2003, p. 19). Flowers have not been reported from Hankins Gulch, Staunton State Park, or the Saint Vrain populations (CNHP 2003 in Beatty 2003, p. 19). Many capsules, or fruits, were observed at the East Inlet Trail and Old Fall River Road locations, but there were no seeds (Weber 1972, CNHP 2003 in Beatty 2003, p. 19).

Several authors (Weber 1972; O'Kane 1988; Colorado Native Plant Society 1989) suggested that the monkeyflower is incapable of reproducing by seeds because the pollen is sterile, thus making this species an obligate asexual annual species (Beatty 2003, pp. 19-20). However, researchers (Paul Beardsley 2003 pers. comm in Beatty 2003) stained pollen from this species and discovered that greater than 95 percent of the pollen grains were viable (Beatty 2003, p. 20). In addition, researchers (Mark Bearsley 1997) grew monkeyflower plants in the greenhouse, cross-pollinated flowers, collected seeds, germinated the seeds, and produced a new generation of adult plants, discovering that each plant was capable of producing flowers and seeds (Beatty 2003, p. 20). However, the exact environmental conditions necessary to induce flowering in natural populations are unknown (Beatty 2003, p. 20).

Pollinators and pollination ecology

The appearance of flowers in natural populations is so infrequent that pollination biology and specific pollination mechanisms for this species have not been studied (Beatty 2003, p. 20). The flower of this species is structurally similar to many yellow, bee-pollinated species in the *Mimulus* genus (Paul Bearsley, pers. comm. 2003 in Beatty 2003, p. 20). Beardsley (1997) performed artificial pollination in the greenhouse by brushing dehiscent anthers with a cotton swab and inserting the swab into open flowers (Beatty 2003, p. 20). This process presumably facilitated both cross-pollination and self-pollination. Pollination is not required for the production of bulbils (Beatty 2003, p. 20).

Dispersal mechanisms

The asexually produced propagules of the monkeyflower are units comprised of the bulbil encased in the petiolar sac (Weber 1972, p. 7; Bearsley 1997 in Beatty 2003, p 20). Dispersal of the propagules usually occurs during plant senescence (Beatty 2003, p. 20). The leaf blades wither, and when the petiole abscises from the dying stem, the entire propagule dissociates (Weber 1972, p. 4). When the adult plant is brushed by a passing object or blown by the wind, propagules are "catapulted" by the dry, springy stem up to 30 cm or more (Beardsley 1997, Mark Beardsley pers. comm. 2003 in Beatty 2003, p, 22). Because there is a hollow space around the bulbil within the sac, the propagule is relatively light in density and therefore buoyant (Beatty 2003, p. 22). Animals may also play a role in propagule dispersal because propagules are small and light with rough surfaces that easily attach to the fur of an animal (Beardsley 1997 in Beatty 2003, p. 22).

Seed viability and germination requirements

Because monkeyflower populations are dependent on asexual reproduction for replacement of populations every year, the overwintering and germination success of bulbils is critical (Beatty 2003, p. 22). In the greenhouse, Beardsley (1997) reports a maximum of 45 percent germination/survival across a wide range of temperature regimes. In natural habitats, bulbils are typically exposed to cold temperatures and dry conditions (Beatty 2003, p. 22). Beardsley (1997) performed greenhouse experiments testing the responses of bulbils to desiccation and temperature stress and the germination success of bulbils under different conditions of substrate, temperature, and light (Beatty 2003, p. 22). The results of Beardsley's experiment indicated that propagules are fairly resistant to desiccation with their protective petiolar coat; exposed bulbils, those that lack a petiolar coat, are more susceptible to drying out (Beatty 2003, p. 22). Germination was affected by water availability, temperature, substrate characteristics (e.g., depth, water holding capacity), size of the bulbil, and presence of the petiolar coat (Beardsley 1997 in Beatty 2003, P. 22). The longevity of monkeyflower propagules or the extent of a propagule “bank” in the soil are unknown; however, it is unlikely that a significant soil bank of propagules exists because the soils are generally fairly thin where this species occurs and the propagules need to maintain a high moisture content (Beatty 2003, p. 22).

The precise germination requirements of sexually produced seeds are unknown, but may be similar to the requirements of the asexually produced propagules (Beatty 2003, p. 22). In greenhouse experiments, approximately 25 percent of seeds successfully germinated in moist potting soil (Beardsley 1997 in Beatty 2003, p. 22).

Phenotypic plasticity

Phenotypic plasticity is demonstrated when members of a species vary in morphology, phenology, or other attributes, with change in light intensity, latitude, elevation, or other macrosite or microsite characteristics. Based on experiments of genetically identical adult monkeyflower plants growing in different environmental conditions (light or nutrient deficient), Beardsley (1997) concluded that phenotypic plasticity is an important component of the monkeyflower’s life history (Beatty 2003, pp. 22-23). The production of bulbils with a variety of morphologies is also an illustration of phenotypic plasticity (Beatty 2003, p. 23). In addition to the “normal” bulbils produced in the petiolar sacs of the leaves, Beardsley (1997) also observed the growth of “free” bulbils in the greenhouse (Beatty 2003, p. 23). These naked bulbils grew directly from axillary buds and looked identical to the petiolar bulbils but were not surrounded by any petiolar tissue and were produced during periods of dryness (Beatty 2003, p. 23). However, these “free” bulbils have not been observed in natural populations (Beardsley 1997 in Beatty 2003, p. 23). Weber (1972) also described another variation in bulbil production where “abortive lateral shoots from the leaf-axils may bare minute leaves and saccate gemmiparous petioles.” In other words, multiple bulbils were observed within the petiolar sacs. It appears that the monkeyflower can produce at least three variations of bulbils (non-axillary and petiolar, axillary and petiolar, and axillary and “free”) (Beatty 2003, p 23). Another example of phenotypic plasticity may be seen in the different flower phenotypes of this species (Beatty 2003, p. 23). Herbarium specimens of this species reflect a wide variation in flower markings, palatal fold, and pubescence (Beatty 2003, p. 23).

The plant’s ability to reproduce asexually could represent another type of phenotypic plasticity. Asexual reproduction, as opposed to sexual reproduction, could be a way to increase fitness despite resource-limitations and may increase the plant’s long-term viability in harsh or variable conditions (Beardsley 1997 in Beatty 2003, p. 23). However, we do not have enough information about what drives asexual reproduction in wild populations, and whether sexual reproduction could occur, to know whether this is a potential type of plasticity.

Habitat

The monkeyflower is a montane to subapline species that grows at elevations of 2,400 - 3,400 m (7,874 - 11,154 ft) and is found under overhangs of south-facing cliffs or boulders (Beardsley 1997, p.6). The monkeyflower is further restricted to sites that are supplied by a consistent supply of water such as a seep or spring (Beardsley 1997, p. 6). The areas where the plant grows are typically occupied by few plants of other species (Beardsley 1997, p. 6). Microhabitat descriptions indicate that the monkeyflower forms patches in the protection of rocky (granite, biotite schist) outcrops, under overhanging surfaces of boulders, on alluvial deposits, or amongst roots of dead trees (CNHP 2003 in Beatty 2003, p.17).

The monkeyflower occurs within spruce-fir-aspen communities (*Picea* spp.-*Abies* spp.-*Populus tremuloides*.), communities that often have other *Mimulus* species (e.g., *M. floribundus*, *M. guttatus*, *M. rubellus*) nearby (Weber 1972, CNHP 2003 in Beatty 2003, p. 19). Species occurring in the habitat areas may include *Pseudotsuga menziesii* (Douglas-fir), *Cerastium* spp. (chickweed), *Jamesia americana* (fivepetal cliffbush), *Dodecatheon pulchellum*. (shootingstar), *Aquilegia saximontana* (Rocky Mountain blue columbine), *Epilobium* spp. (fireweed), *Salix* spp. (willow), *Campanula rotundifolia* (bluebell bellflower), *Artemisia ludoviciana* (white sagebrush), *Packera plattensis* (prairie groundsel), *Erigeron subtrinervis* (threenerve fleabane), *Rhodiola integrifolia* (ledge stonecrop), *Oreochrysum parryi* (Parry's goldenrod), *Brickellia microphylla* (littleleaf brickellbush), *Amelanchier utahensis* (Utah serviceberry), and *Montia chamissoi* (water minerslettuce) (Beatty 2003, p. 19). Mosses, liverworts, algae, and ferns can also inhabit these wet areas (Beatty 2003, p. 19).

Individual Needs

We evaluate the individual needs of the monkeyflower in terms of the resource needs and/or the circumstances that are necessary to complete each stage of its life cycle. The extremely limited range of the monkeyflower suggests specific habitat requirements (Beardsley 2014, p. 22). Therefore, the species' specific habitat is a necessary and integral part of each stage of the life cycle.

However, little information exists about the ecological factors that affect growth and establishment of the monkeyflower in nature (Beatty 2003, p. 24). Beardsley (1997) found that the survival of propagules, in the greenhouse, was strongly influenced by moisture, temperature, and substrate type (Beatty 2003, p. 24). The growth of adults and allocation of resources to the different reproductive structures was also influenced by nutrient and light availability (Beardsley 1997 in Beatty 2003, p. 24). The growth of adults was strongly dependent on moisture availability; if there was not enough water for two or more days, greenhouse plants immediately dried up and died (D. Steingraber pers. comm. 2002 in Beatty 2003, p. 24). Beardsley (2014) identified 14 habitat parameters (site size, overhang, cliff association, aspect, hydrology, micro-topography, substrate, soil depth, moss, other herbs, mean light, direct sun, mean temperature, higher temperature) based on what was considered to be the most important habitat factors for this species (Beardsley 2014, p. 21). The study showed that correlations between these selected habitat parameters and establishment success were difficult to make, however this study was not statistically robust (Beardsley 2014, p. 21). A few patterns are apparent; all of the previous studies and species descriptions suggest that periods of very moist or saturated soil are important, but it appears that too much water can be problematic for this species (Beardsley 2014, p. 21). The optimal hydrological conditions appear to be sites that are periodically saturated or, at most, consistently moist with no long periods of standing water (Beardsley 2014, p. 21). Similarly, successful sites appeared to have very shallow soil, typically fewer than two centimeters deep (Beardsley 2014, p. 21).

Population Needs

We evaluate the population needs of the monkeyflower in terms of what is required for each population to be resilient, or able to withstand environmental stochasticity. The measure of resiliency is based on a population's ability to withstand or recover from environmental or demographic stochastic events, such as prolonged drought. We evaluate resiliency in terms of resources and/or the circumstances that are necessary to maintain abundance, recruitment, reproduction, and dispersal.

The following conditions are needed to support resilient monkeyflower populations:

- *Number of ramets* – we believe that the number of ramets is an indication of suitable conditions for the monkeyflower, because sites with a higher number of ramets indicate that this species' biotic and abiotic factors are present at sufficient levels. We expect that the monkeyflower needs some number of ramets for each population to be resilient; however we do not have data that suggests a specific range of ramet numbers necessary for each population to be resilient.

- *Recruitment* – in order for the monkeyflower to be resilient, populations must maintain a sufficient level of recruitment to persist; recruitment is an important means of regeneration for plants especially in the face of changing environmental conditions (Chesser and Brewer, 2011, p. 245). Species that are unable to colonize new sites or adapt to changing environmental conditions will risk extinction (Chesser and Brewer 2011, p. 245). Although many factors affect recruitment (i.e., genetic and environmental), propagule supply and bulbil establishment are among the most important.

- *Reproduction* – in order for monkeyflower populations to be resilient, populations must consist of reproductive ramets. Because the monkeyflower primarily exhibits asexual reproduction; it may be necessary for each population to reproduce sexually in order to add new genetic combinations to each population. Otherwise, the generation of new genes only occurs through changes in DNA sequences (i.e., mutation).

- *Dispersal* – we believe that dispersal is important for the monkeyflower to be resilient because it is the primary way for this species to colonize surrounding suitable habitat. Gene flow (genetic exchange between patches) can occur either through pollen dispersal or through dispersal of bulbils (Karron 2020, pers. comm.). Theoretically, one propagule could start a new population because reproduction primarily occurs through asexual propagation (Beardsley 1997 in Beatty 2003, p. 22). Since flowering is extremely rare, it is unlikely that pollen-mediated genetic exchange is occurring between patches (Karron 2020, pers. comm.)

These demographic or distribution factors that a population needs to be resilient are influenced by the presence of resource and habitat factors, which correspond to individual needs. These influences are displayed in Figure 6 below.

<u>Uncertainties Relating to Population Needs</u>

We expect that these factors must be present at some level for a population to maintain itself and have the resiliency to withstand stochastic events. However, we lack sufficient quantitative information on the conditions mentioned above, so we are unable to quantify the specific levels of each factor that the monkeyflower populations need in order to be resilient. There is some uncertainty regarding what factors are influencing the population dynamics of the monkeyflower. We do not know what genetic variability, if any, exists between populations. We also do not know what dispersal mechanisms are for pollen dispersal, if sexual reproduction occurs within a wild population. Overall, we lack certainty regarding the pathways illustrated in Figure 6 and the amount of influence each of these factors may have on monkeyflower populations.

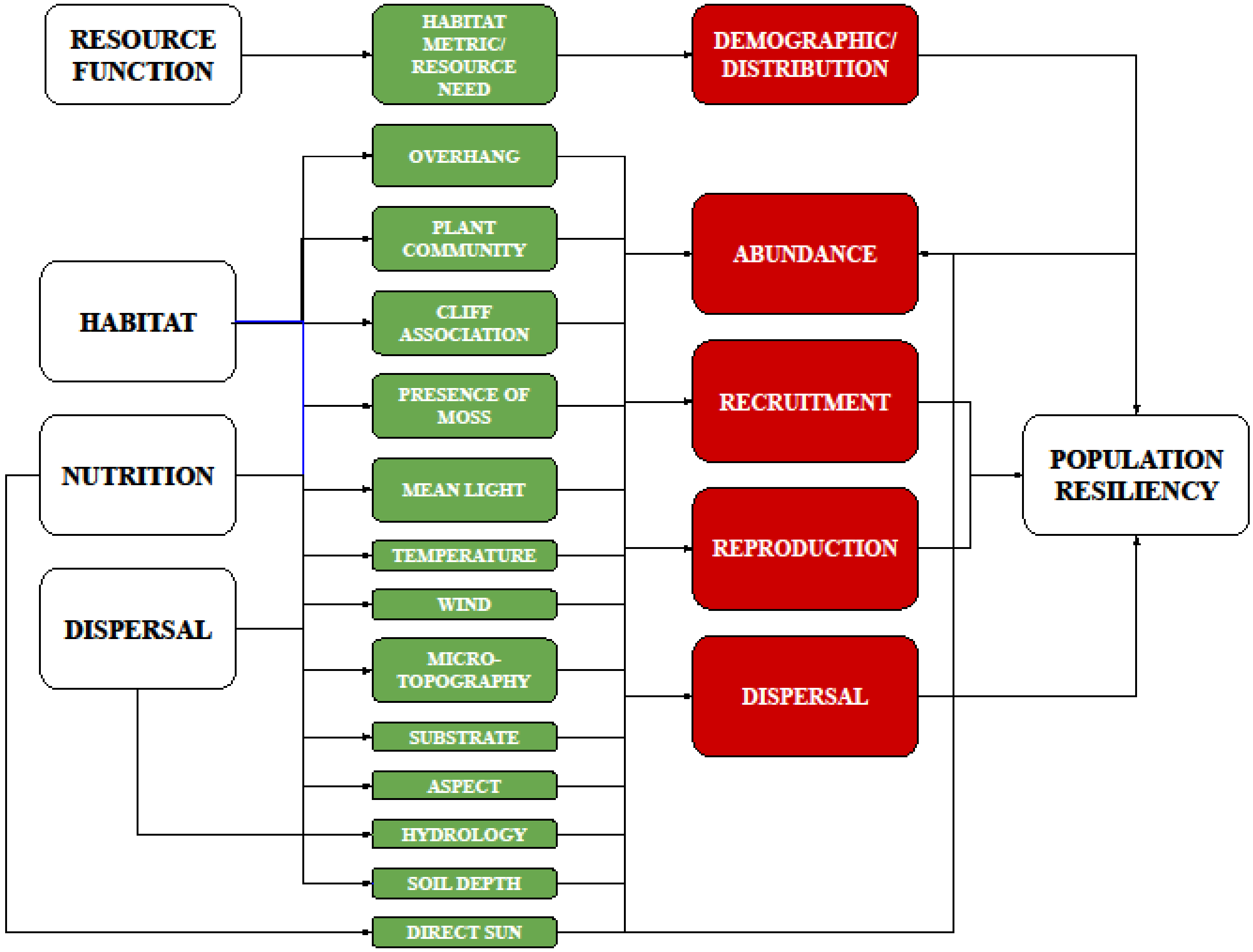

Figure 6. Conceptual model of the habitat and demographic factors that affect monkeyflower resiliency.

Species Needs

We evaluate species' needs in terms of the resources and/or the circumstances that support the redundancy and representation of the species. Therefore, we evaluate the redundancy of this species by the number, size, and distribution of populations. Having multiple populations distributed across the species range spreads the risk of catastrophic events, such as wildfires.

Viability of the monkeyflower is evaluated based on the presence of multiple, resilient populations across the range of the species, and their contribution to providing adaptive capacity to the species in the face of changing conditions. Each population provides the same habitat characteristics that are essential for the monkeyflower. Therefore, we believe that the species needs multiple resilient populations distributed across the species range (i.e., redundancy) in the three analysis units (i.e., representation). We delineated each analysis unit based on their geographic proximities to each other.

Uncertainties Relating to Species Needs

We do not know if all populations or sites are functioning the same way (i.e., if all monkeyflower ramets and populations respond to the environment in the same way); however, we do have observation data from several of the sites, and in each analysis unit, which provides insight into how the species functions across its range.

Chapter 3: Current Condition

In this chapter, we describe the current condition of the monkeyflower, using the same demographic and habitat factors that we identified as species needs above. We first provide a summary of potential stressors affecting the species, as well as positive influences on the species, followed by our methodology for evaluating the current condition, and then a specific description for each factor that describes the current condition.

3.1 Potential Stressors Affecting Rocky Mountain Monkeyflower and Habitat

Potential stressors to the monkey flower include recreation (and associated roads and trails), livestock and herbivore grazing, changes in natural regimes, climate change, and biologically vulnerable small population sizes. In Appendix A, we evaluate each potential stressor, including its source, affected resources, exposure, immediacy, geographic scope, magnitude, and impacts on ramets, populations, and the species. In addition we assess our level of certainty regarding this information to determine which stressors are likely to be drivers of the species' current or future conditions (Appendix A – Cause and effects tables).

For this SSA, we evaluated the impacts of these potential stressors by overlaying Geographic Information System (GIS) shapefiles for different types of disturbances with a shapefile of the monkeyflower's known overall range, to analyze the spatial extent of these disturbances. Our analysis identified that most of the stressors in Appendix A may cause a local or low-level impact to monkeyflower ramets or habitat because individual ramets may be exposed; however, we determined that they do not result in a species-level impact (Appendix A – Cause and effects tables). We are aware of other potential stressors such as forest clearing or thinning, pollution, non-native plant invasion, or fragmentation; however, we do not currently have data to suggest that these issues are impacting the monkeyflower ramets, populations, or the species.

Through this analysis, we found only climate change and biologically vulnerable small population sizes to be potential species-level threats. However, the Service does not consider small population sizes by themselves to be a threat. The monkeyflower has existed with small populations throughout its life history. Additionally, demographic monitoring efforts have increased our awareness of the monkeyflower across its range, from records of approximately 125,733 ramets in 2005 (77 FR 168 52293) to approximately 14,634,300 ramets in 2017 (Beardsley 2017, pp. 14-145). Therefore, our analysis focuses primarily on climate change. However, some stressors that are not currently causing a species level impact, such as recreation, roads and trails, or wildfire, have the potential to impact the species on a greater scale in the future, if conditions change. Therefore, these stressors are included in our evaluation of future conditions (See *Chapter 4. Species Future Condition and Status*). We also recognize that this species' unique mechanism for reproduction and its restricted range can increase the monkeyflower's vulnerability to extinction in the presence of other threats or stressors.

Here, we summarize how each of the stressors may influence the current condition of the species, both individually and cumulatively; see Appendix A for our complete analysis and more detailed information on the effects of these stressors. The influence diagram in Figure 7 below displays resource needs of ramets and populations, and how these needs are affected by environmental or anthropogenic stressors. Note that, overall, we lack certainty regarding the pathways illustrated in Figure 7 and the amount of influence each of these factors may have on monkeyflower populations.

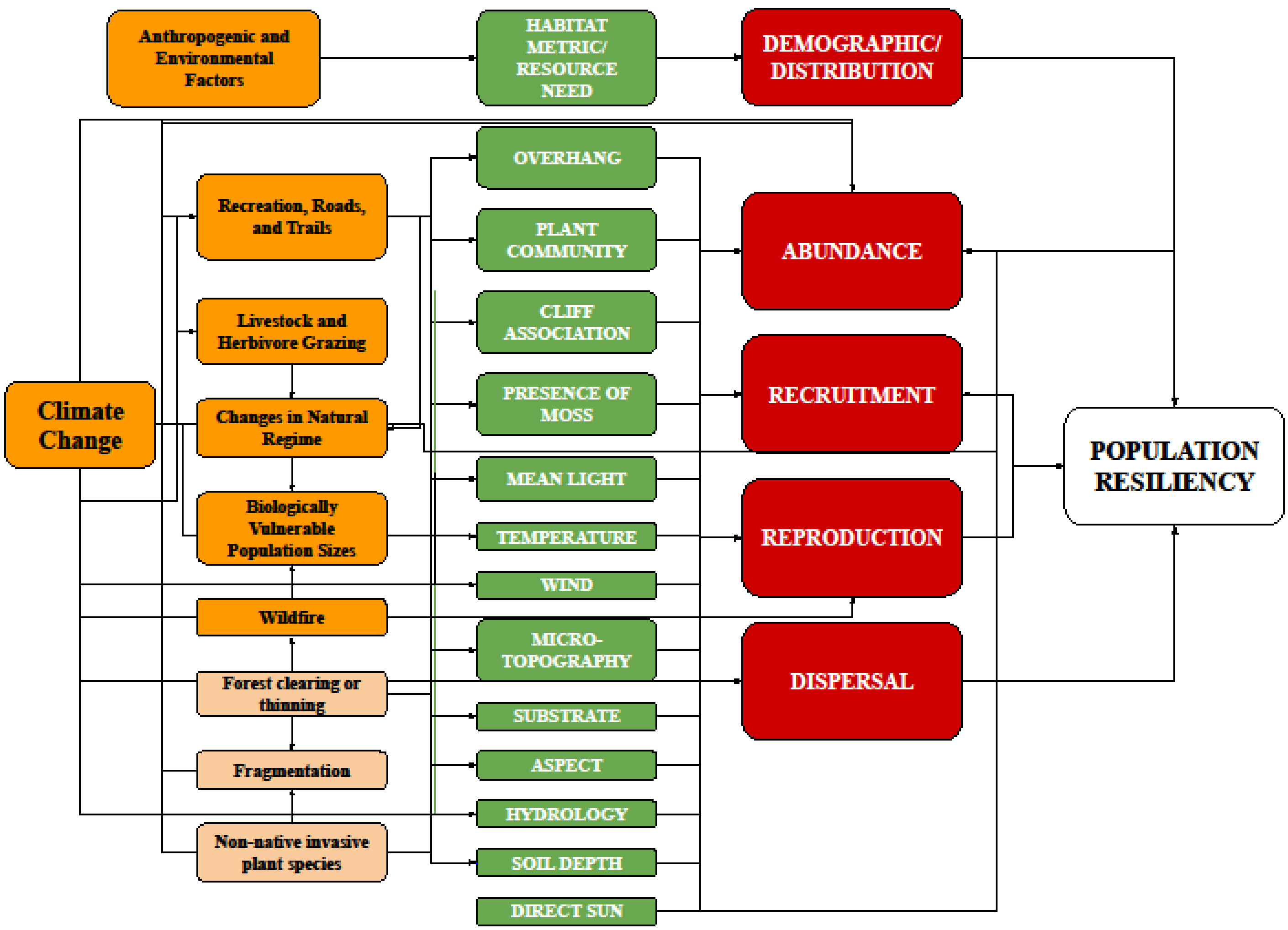

Figure 7. Influence model for the monkeyflower, which identifies relationships between sources and stressors, and the habitat and demographic factors identified as species needs that contribute to the resiliency of each population.

Climate change

Climate change refers to the change in the mean or variability of one or more measures of climate (e.g., temperature or precipitation) that persist for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (IPCC 2014, p. 120). As shown in Figure 7, climate change can impact the monkeyflower by altering several factors, such as temperature, precipitation, or wildfire. Long-term observational records (since late 19th century) show that temperatures in the Pike-San Isabel and Arapahoe-Roosevelt National Forests have increased by 2°F; the largest portion of warming has occurred since the 1990s (Rangwala 2019, p. 2). Since 1994, only one year (2008) has been cooler than the long-term average, albeit only marginally (Rangwala 2019, p. 2). The period since 2001 has been 1.5°F warmer than the 20th century (Rangwala 2019, p. 2). Recent decades have been slightly on the wetter side despite severe droughts in the early 2000s, in 2012, and in 2018 (Rangwala 2019, p. 2). Similar extreme and even longer lasting droughts (e.g., 1930s Dust Bowl era) have occurred in the past; however, when examining different drought metrics, there are indications that the intensities of recent droughts (e.g., 2002) have been higher (Rangwala 2019, p. 2). Please refer to *Chapter 4. Species Future Condition and Status* for more information on the climate scenarios that were used for this analysis.

3.2 Land Management Considerations

In addition to stressors, there are factors that may be having a positive influence on the species' condition. Specifically, Federal and State land management may be providing protections for monkeyflower habitat. For instance, in 2010, the USFS relocated a portion of the trail near the Hankins Gulch population to minimize impacts. In 2015, the CNAP designated the Staunton Natural Area within Staunton State Park. The Staunton Natural Area encompasses two parcels within Staunton State Park: Black Mountain and Elk Falls; these parcels contain monkeyflower populations. The Colorado Natural Areas Program was established by state legislation with the signing of the Colorado Natural Areas Act in 1977. It is a small program within CPW, a Division of the Department of Natural Resources. There have also been efforts to propagate monkeyflower plants and find locations for out-planting ramets to increase the number of known populations; this is done in cooperation with the CNAP, the USFS, and the Service. This effort has had some success in increasing the number of known ramets in the wild and has also led to the discovery of new native populations. In addition, in 2017, researchers conducted a cold storage experiment on monkeyflower propagules, which was funded by the USFS; e*x situ* propagation from field-collected monkeyflower propagules can provide large quantities of plant material for active conservation and helps minimize the risk of species extinction.

3.3 Metrics for Evaluating Current Condition

Currently, there are approximately 24 ac (9.7 ha) of occupied monkeyflower habitat on USFS managed lands, approximately 28 ac (11 ha) of occupied habitat on NPS managed lands, and approximately 7 ac (3 ha) on CPW managed lands (See Figure 8). For the purposes of our analysis we divided the range of the monkeyflower into three analysis units. These analysis units were determined based on natural topographical separation. We analyzed each population and each analysis unit under the following condition categories to determine what the current condition, or current resiliency, for each population and each analysis unit is. However, we do not have current information on four of the populations that occur on NPS managed lands; because we do not have sufficient information to analyze these units, their condition is "unknown" and they were not included in the ranking process for each analysis unit. The following condition categories were selected as metrics because they are considered to be some of the most important habitat and demographic factors that contribute to the resilience of the monkeyflower at the population level, and that we have sufficient data to analyze. We describe the current condition for the monkeyflower in terms of demographic, habitat, and environmental conditions for each analysis unit (Table 3). In order to determine the current condition of each analysis unit, we first rate the condition of each element occurrence for each of the categories below (some populations contain more than one element occurrence). Because an analysis like this has not yet been done, we determined how to categorize these "bins" of "good," "moderate," and "poor" based on input from experts on our technical team.

Number of patches

Patches are groups of monkeyflower plants that are closely associated with each other but separated from other patches by about three meters or more (Beardsley 2017, p. 2). We chose this category because populations with a sufficient number of patches indicate that necessary biotic and abiotic factors are functioning at sufficient levels and that bulbil dispersal is occurring; in addition, higher numbers of patches increase the local redundancy of the monkeyflower. This metric is measured using 2017 monitoring data provided by CNAP.

Number of ramets

The number of ramets is counted as the number of bulbils present because bulbils are the persistent overwintering stage of the monkeyflower (Beardsley 2017, p. 3). The bulbils have all the components needed to develop into new ramets, including a shoot axis and rudimentary leaves and roots (Beatty 2003, p. 19). As we discussed in *Section 2.1.2 Species Distribution* above, since we do not have sufficient information on the survival rate of bulbils to germination and post-germination, our discussions of resiliency are based on pre-germination numbers of bulbils (the life stage for which monitoring data exists). However, since not all bulbils likely survive to germinate, using bulbil counts as a proxy for number of ramets likely results in an overestimation of the number of ramets. We chose this category because it can represent reproductive output for this species; populations with more ramets producing propagules should be healthier and better able to withstand stochastic events. In addition, the number of ramets varies from year-to-year; so this metric indicates population size during good weather conditions (since surveyors usually only endeavor to count bulbils during good weather years). This metric is measured using 2017 monitoring data provided by CNAP.

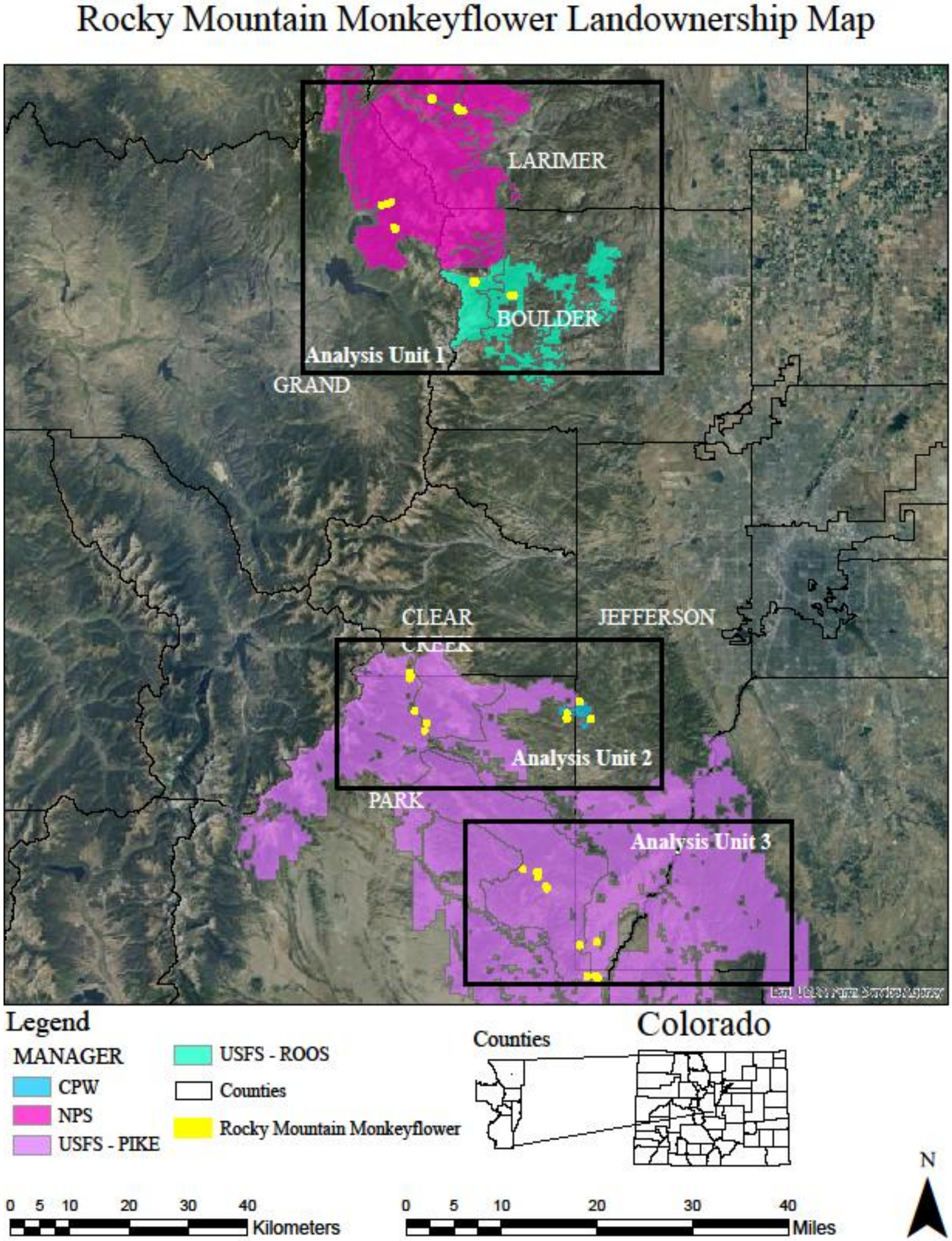

Figure 8. Overall range of the monkeyflower overlaid with land ownership and analysis unit designations.

Hydrology

We evaluated the water availability for each population using observational data provided by Mark Beardsley, the primary investigator for this species. We chose this category because, an assisted migration study (Beardsley 2014) demonstrated that this species requires a specific moisture regime in order to persist. We do not currently have empirical data for soil moisture at this time; however, we do know that this species consistently occurs near waterfalls or water seeps. In addition, we chose to "weight" this category higher than the two other categories because it appears to be one of the most important abiotic factors for this species. All previous studies and species descriptions suggest that periods of very moist soils are important, but it appears that too much water is a detriment (Beardsley 2014, p. 21).

<u>Uncertainties Related to the Metrics for Evaluating Current Condition</u>

We acknowledge that using bulbil count data as a proxy for the number of ramets that we expect to survive in a given year may be an overestimation. It is uncertain how we would need to correct the bulbil count to accurately represent the number of ramets after germination. Lab experiments suggest that less than 50 percent may survive, however we do not have such data for populations in the wild. A 2004 study found that the Rocky Mountain monkeyflower exhibits a considerable amount of genetic diversity, especially for an asexually reproducing species (Beardsley *et al* 2004, pg. 34). However, the majority of the genetic diversity was found within populations and less so between the populations (Beardsley *et al* 2004, pg. 35). Because the 2004 study was only conducted on the East Inlet, Guanella Pass, Hankins Gulch, North Inlet, Staunton Park, and Saint Vrain populations, some uncertainty still remains as to the overall amount of genetic diversity for this species.

3.4 Description of Current Conditions

Suitable habitat conditions for the monkeyflower consist of south facing cliffs or boulders under overhangs between elevations of 2,400 - 3,400 m (7,874 - 11,154 ft) in montane to subalpine areas (Beardsley 1997, p.6). Based on our GIS analysis, there are approximately 24 ac (9.7 ha) of occupied monkeyflower habitat on USFS managed lands, approximately 25 ac (10 ha) of occupied habitat on NPS managed lands, and approximately 7 ac (3 ha) on CPW managed lands. These values represent the acres of verified occupied habitat; these values were calculated using GIS shapefiles provided by the CNHP. We analyzed the resiliency of each analysis unit by looking at the monitoring data for each population. Below, we describe our evaluation of each analysis unit with respect to each of the metrics from *Section 3.3*; Table 3 summarizes the metrics for the "good," "moderate," and "poor" condition categories.

Number of patches

We considered the number of patches to be "good" at a site if there were six or more patches observed; "moderate" if there were two to five patches; and "poor" if there was one or fewer patches. Based on the Beardsley (2017) monitoring data, Saint Vrain (native), Peaceful Valley (native and planted), Guanella Pass (native), Geneva Basin (native), Lost Creek (planted), Corral Dome (native), and Corral Creek (native and planted) are all in "good" condition. The Beardsley (2017) monitoring data also suggests that Guanella Pass (planted), Threemile Creek (planted), Black Mountain (native and planted), Elk Creek (planted), Mason Creek (planted), Hankins Gulch (native) are all considered to be in "moderate" condition while Burning Bear (planted), Elk Creek (native), Lost Park (planted), and Rainy Day Rock (planted) are considered to be in "poor" condition. Table 4 below shows each population (native and/or planted) and their analysis units' overall condition for this category.

Number of ramets

We consider the number of ramets to be "good" at a site if there are 300,000 or more ramets observed, "moderate" if there are between 100,000 and 299,999 ramets observed, and "poor" if there are fewer than 100,000 ramets observed. As discussed in *Section 3.3*, we use observed number bulbils to represent the number of ramets because bulbils are the persistent overwintering stage of the monkeyflower (Beardsley 2017, p. 3). Based on the Beardsley (2017) monitoring data, Saint Vrain (native), Guanella Pass (native and planted), Hankins Gulch (native), Corral Dome (native), Corral Creek (native) are all considered to be in "good" condition.; Peaceful Valley (native), Black Mountain (native), Elk Creek (native), and Lost Creek (planted) are all considered to be in "moderate" condition; and Peaceful Valley (planted), Geneva Basin (native), Burning Bear (planted), Threemile Creek (planted), Black Mountain (planted), Elk Creek (planted), Mason Creek (planted), Lost Park (planted), Rainy Day Rock (planted), and Corral Creek (planted) are all considered to be in "poor" condition. Table 4 below shows each population (native and/or planted) and their analysis units' overall condition for this category.

Hydrology

We considered the hydrology to be "good" if there is a dependable water supply and moist soil for most of the growing season on most or all of the patches within the population, even in exceptionally dry years; "moderate" if some patches exist in areas where soil is occasionally too dry to support sustained bulbil production and growth over the growing season; and "poor" if there is an undependable source of water and if there are frequently years when the soil is too dry or too saturated to support bulbil production and growth over the growing season on most or all of the patches within the population (Beardsley 2019, pers. comm.). Saint Vrain (native), Peaceful Valley (native), Guanella Pass (native), Black Mountain (native), Lost Creek (planted), Hankins Gulch (native), Corral Dome (native), Corral Creek (native) are all considered to be in “good” condition; Peaceful Valley (planted), Guanella Pass (planted), Geneva Basin (native), Burning Bear (planted), Threemile Creek (planted), Black Mountain (planted), Elk Creek (native and planted), Lost Park (planted), Rainy Day Rock (planted), Corral Creek (planted) are all considered to be in “moderate” condition; and Mason Creek (planted) is considered to be in “poor” condition. Table 4 shows each population (native and/or planted) and their analysis units’ overall condition for this category.

Table 3. Metrics used to measure current condition. The demographic variables are highlighted in light red and the habitat variables are highlighted in light blue.

Rating		Demographic Metrics		Habitat Metric
		Number of Patches	**Number of Ramets**	**Hydrology**
3	**Good**	Six or more patches	300,000 or more ramets	Dependable water supply and moist soil for most of the growing season, even in exceptionally dry years, on most or all patch sites.
2	**Moderate**	Two to five patches	100,000-299,999 ramets	Some patches in areas where soil is occasionally too dry to support sustained growth and bulbil production over the growing season.
1	**Poor**	One or fewer patches	Fewer than 100,000 ramets	Undependable water supply. There are frequently years when soil is too dry or too saturated to support sustained growth and bulbil production over the growing seasonon most or all of the patch sites.

Table 4. Summary of Current Conditions using the resiliency categories from Table 3. We do not have information on the populations that are located within Rocky Mountain National Park. Thus, these populations were not included in our "ranking" process for current and future condition and are not included in the table below. As a result, the ranking for analysis unit 1 was determined using only the information available for the USFS-ROOS Element Occurrences.

Land Ownership	Analysis Unit	Population Name	Element Occurrence (Native or Planted)	Demographics: Number of Patches	Demographics: Number of Ramets	Habitat: Hydrology	Overall Element Occurence Ranking	Analysis Unit Ranking
NPS	1	Old Fall River Road	Native-Historical	Unknown	Unknown	Unknown	Unknown	Unit 1 - Good
	1	Horseshoe Park	Native	Unknown	Unknown	Unknown	Unknown	
	1	Cascade Falls	Native	Unknown	Unknown	Unknown	Unknown	
	1	Devil's Staircase	Native	Unknown	Unknown	Unknown	Unknown	
USFS-ROOS	1	Saint Vrain	Native	Good	Good	Good	Good	
	1	Peaceful Valley	Native	Good	Moderate	Good	Good	
			Planted	Good	Poor	Moderate	Moderate	
USFS-PIKE	2	Guanella Pass	Native	Good	Good	Good	Good	Unit 2 - Moderate
			Planted	Moderate	Good	Moderate	Moderate	
	2	Geneva Basin	Native	Good	Poor	Moderate	Moderate	
	2	Burning Bear	Planted	Poor	Poor	Moderate	Poor	
	2	Threemile Creek	Planted	Moderate	Poor	Moderate	Moderate	
CPW-Staunton	2	Black Mountain	Native	Moderate	Moderate	Good	Good	
			Planted	Moderate	Poor	Moderate	Moderate	
	2	Elk Creek	Native	Poor	Moderate	Good	Moderate	
			Planted	Moderate	Poor	Good	Moderate	
	2	Mason Creek	Planted	Moderate	Poor	Poor	Poor	
USFS-PIKE	3	Lost Park	Planted	Poor	Poor	Moderate	Poor	Unit 3 - Moderate
	3	Lost Creek	Planted	Good	Moderate	Good	Good	
	3	Hankins Gulch	Native	Moderate	Good	Good	Good	
	3	Rainy Day Rock	Planted	Poor	Poor	Moderate	Poor	
	3	Corral Dome	Native	Good	Good	Good	Good	
	3	Corral Creek	Native	Good	Good	Good	Good	
			Planted	Good	Poor	Moderate	Moderate	

3.5 Current Condition – Resiliency, Redundancy, and Representation

To evaluate the current condition of the monkeyflower, we evaluated a range of habitat and demographic conditions for each analysis unit. This allows us to consider the species' current resiliency, redundancy, and representation.

Resiliency

There are currently 19 populations comprised of 24 element occurrences; we have some level of monitoring data for 15 of these populations and 20 of these element occurrences. Of the 20 element occurrences for which we have data, 8 have high resiliency, 8 have moderate resiliency, and 4 have low resiliency. We consider the Saint Vrain, Guanella Pass, Corral Dome, and Corral Creek populations to be the most resilient populations because they each have six or more patches, more than 300,000 ramets, and the site hydrology is sufficient to maintain these populations throughout the growing season.

Redundancy

There are 105 small sites (mapped locations submitted to CNHP) that make up 19 populations that are distributed across three analysis units, which may provide some ability to withstand catastrophic events, such as increased periods of prolonged drought. Like many narrow endemic species, the redundancy of the monkeyflower is, and has likely always been, inherently low as a result of its limited geographic range.

Representation

Although there are numerous studies that indicate that asexually reproducing species exhibit low levels of genetic diversity, a 2004 study found that the monkeyflower exhibits a considerable amount of genetic diversity (Beardsley *et al* 2004, pg. 34). Because the monkeyflower primarily reproduces asexually, it would be logical to assume that the populations have low levels of genetic diversity within them and are more genetically diverse between populations (Beardsley *et al* 2004, pg. 35). However, the majority of the genetic diversity was found within populations and less so between the populations (Beardsley *et al* 2004, pg. 35). Because the 2004 study was only conducted on the East Inlet, Guanella Pass, Hankins Gulch, North Inlet, Staunton Park, and Saint Vrain populations, some uncertainty still remains as to the overall amount of genetic diversity for this species. Therefore, for the purposes of this analysis, we evaluated whether there are other types of diversity that could indicate some ability to adapt to change (adaptive capacity), such as morphological or phenotypical differences or the different habitat types within the species' range. For example, the northern analysis unit differs in some ecological attributes, especially geology, from the other two units (Olson 2020, pers. comm.). Also, the monkeyflower demonstrates phenotypic plasticity because genetically identical adult monkeyflower plants grow in different environmental conditions (light or nutrient deficient) (Beardsley 1997). The production of bulbils with a variety of morphologies is also an illustration of phenotypic plasticity (Beatty 2003, p. 23). In addition to the "normal" bulbils produced in the petiolar sacs of the leaves, Beardsley (1997) also observed the growth of "free" bulbils in the greenhouse (Beatty 2003, p. 23). These naked bulbils grew directly from axillary buds and looked identical to the petiolar bulbils but were not surrounded by any petiolar tissue and were produced during periods of dryness (Beatty 2003, p. 23). It appears that the monkeyflower can produce at least three variations of bulbils (non-axillary and petiolar, axillary and petiolar, and axillary and "free") (Beatty 2003, p 23); however, it is unclear if these variations occur in natural settings. The different flower phenotypes of this species may represent another example of phenotypic plasticity (Beatty 2003, p. 23). Herbarium specimens of this species reflect a wide variation in flower markings, palatal fold, and pubescence (Beatty 2003, p. 23). The plant's ability to reproduce asexually could represent another type of phenotypic plasticity that could contribute to representation. Asexual reproduction, as opposed to sexual reproduction, could be a way to increase fitness despite resource-limitations and may increase the plant's long-term viability in harsh or variable conditions (Beardsley 1997 in Beatty 2003, p. 23). However, we do not have enough information about what drives asexual reproduction in wild populations, and whether sexual reproduction could occur, to know whether this is a potential type of plasticity. In summary, the monkeyflower's adaptive capacity is shown in its persistence in analysis units that have different ecological attributes, potentially variable bulbil morphologies, its different flower phenotypes, and perhaps the ability to reproduce asexually during resource limiting conditions.

Chapter 4: Species Future Condition and Status

We have described the natural history and distribution of the monkeyflower (Chapter 2: Species Ecology). We have considered the ecological needs for the species (Chapter 2: Species Ecology) and its current condition (Chapter 3: Current Condition). In this chapter, we now evaluate the species' expected future conditions using projections and plausible future scenarios. We utilize the current condition as the baseline from which to evaluate changes to those factors considered important to the monkeyflower over a biologically meaningful future timeframe.

The viability of the monkeyflower depends on maintaining multiple self-sustaining analysis units throughout its range into the future. Given the monkeyflowers' dependence on its habitat for all stages of its lifecycle, we consider the presence of relatively stable, undisturbed habitat to be necessary to support the resiliency of the populations. Future changes in climate are the primary factor expected to influence the future condition of the monkeyflower, but there is uncertainty on how climate factors, such as temperature and precipitation, may change, and what their effects on the species will be. Secondary drivers influencing future condition include changes in land management and associated impacts from herbivory.

Description of climate models used to develop future scenarios

A downscaled climate change analysis was done for the Pike-San Isabel and Arapaho-Roosevelt National Forests by the Cooperative Institute for Research in Environmental Sciences (CIRES) and the North Central Climate Adaptation Science Center (NCCASC), University of Colorado, Boulder. These researchers derived a range of projected changes in annual temperature and precipitation from 34 Global Climate Models (GCMs) and two emissions scenarios – Representative Concentration Pathway (RCP) 4.5 (moderate emissions) and RCP 8.5 (high emissions) (a total of 68 climate projections) (Rangwala 2019, p. 2). Because there is very high overlap in climatic responses between the two emissions scenarios the researchers analyzed by 2050, we only considered RCP 8.5 for the final selection of climate scenarios (Rangwala 2019, p. 2). From these 68 projections of changes in future climate, we selected four plausible future climate scenarios, which summarize projected changes in climatic variables by 2050 (2035-2065) relative to the 1985-2015 time period (Rangwala 2019, p. 1). The four climate scenarios are named (Rangwala 2019, p.2):

1. **Very Hot and Dry** (model = IPSL-CM5A-MR.rcp85)
2. **Very Hot and Wet** (model = CanESM2.rcp85)
3. **Hot** (model = CNRM-CM5.rcp85)
4. **Warm and Wet** (model = GFDL-ESM2M.rcp85)

Figure 10 describe changes in several primary climate and hydrological variables by 2050 (relative to 1985-2015) across these four future climate scenarios for the Pike-San Isabel and Arapaho-Roosevelt National Forests, a region bounded by 37.2°N-41°N latitude and 104.85°W-106.6°W longitude (Rangwala 2019, p. 3). A notable summary of these changes includes (Rangwala 2019, p.3):

- Temperature increases by 2.5 to 5.5 °F
- Precipitation changes between -10% and +10%
- Summer soil moisture decreases in all scenarios; except the Warm and Wet, by -1 to -16%
- Snowpack decreases in all scenarios; for three scenarios the decreases are between -10% and -40%
- Potential evapotranspiration (a measure of stress from a drier atmosphere) increases between 5% and 10%
- Coldest winter day warms by 3 to 10°F
- Hottest summer day warms by 4 to 8°F
- First fall freeze occurs 3 to 5 weeks later

- Freezing level (mountain snowline) shifts to higher elevation by 1000 to 2000ft
- Severe droughts, such as 2002 or 2012, occur every 2 to 3 years, except for the warm and wet scenario (in which droughts do not occur); currently, 2002-type severe drought occurs roughly every 10 years (in recent time, they occurred in 2002, 2012, and 2018) (Rangwala 2020, pers. Comm)
- "High" to "extreme" fire danger days increase by several days and weeks
- Extreme rainfall increases by 10 to 20% with higher frequencies of those events in the wetter scenarios

The summary table below describes projected changes in the future climate by 2050 (2035-2065) relative to the 1985-2015 period under four climate scenarios:
Very Hot and Wet (CanESM2.rcp85), **Hot** (CNRM-CM5.rcp85), **Warm and Wet** (GFDL-ESM2M.rcp85) and **Very Hot and Dry** (IPSL-CM5A-MR.rcp85)

Climate Metric	Time Period	Very Hot and Wet	Hot	Warm and Wet	Very Hot and Dry
Temperature (°F)	Annual	5.5	3.8	2.5	5.5
	Winter	5.8	4.6	2.7	5.3
	Spring	6.6	3.0	3.1	5.0
	Summer	4.8	4.0	1.3	6.0
	Fall	4.8	3.8	3.1	5.7
Precipitation (%)	Annual	8	5	11	-8
	Winter	13	3	6	0
	Spring	1	4	10	-14
	Summer	13	7	17	-16
	Fall	7	5	1	-3
Soil Moisture (%)	Annual	-1	1	0	-8
	Spring	7	6	3	-2
	Summer	-8	-1	0	-13
	Fall	-3	-2	-1	-11
Snow Water Equivalent (%)	Annual	-27	-17	-6	-39
	Winter	-15	-22	-4	-29
	Spring	-24	-11	-3	-39
	Fall	-64	-35	-44	-32
Runoff (%)	Annual	1	4	10	-27
	Spring	80	42	50	14
	Summer	-46	-15	-12	-52
	Fall	-15	-13	-1	-43
Evapotranspiration (%)	Annual	14	7	12	-3
	Spring	27	12	16	9
	Summer	7	7	11	-11
	Fall	23	4	11	-1
Potential Evapotranspiration (%)	Annual	9	6	4	13
	Spring	13	4	6	12
	Summer	7	5	2	11
	Fall	7	8	7	11

Changes shown above are for the region within **37.2°N - 41°N; 104.85°W - 106.6°W**. Winter is Dec, Jan, Feb; Spring is Mar, Apr, May; Summer is Jun, Jul, Aug and Fall is Sep, Oct, Nov. Hydrology projections are obtained from the 12 km BCSD Reclamation Dataset. The climate change described above does not include the change that has already occurred prior to 2015.

Figure 9. Summary of climate change projections for the Pike-San Isabel and Arapaho-Roosevelt National Forests (Rangwala 2019).

The summary table below describes patterns and changes under the four climate scenarios by 2050 for a point location at **39.5°N, 106°W** and elevation of 10,270 ft

Climate Metric	Historical (1971-2000)	Very Hot and Wet	Hot	Warm and Wet	Very Hot and Dry
Coldest Winter Day (°F) (warmer relative to historical by °F)	-15	-7 (8)	-9 (6)	-12 (3)	-5 (10)
Hottest Summer Day (°F) (warmer relative to historical by °F)	73	80 (7)	77 (4)	77 (4)	81 (8)
First Fall Freeze (later relative to historical by #days)	Aug 25	Sep 28 (34)	Sep 20 (26)	Sep 16 (22)	Sep 25 (31)
Last Spring Freeze (earlier relative to historical by #days)	Jun 17	May 31 (17)	Jun 3 (14)	Jun 16 (1)	May 29 (19)
Growing Season Length (# days) (higher relative to historical by #days)	69	116 (47)	109 (40)	92 (23)	119 (50)
Growing Degree Days (°F; 32°F base)	2643	4190	3690	3537	4267
Freezing Level or Snowline, ft (higher relative to historical by ft)	8400	10400 (2000)	9600 (1200)	9360 (960)	10250 (1850)
Frequency of Severe Droughts like 2012	-	every 3 years	every 5 years	do not occur	every 2 years
"High" Fire Danger Days (higher relative to historical by #days)	73	76 (3)	87 (14)	61 (-12)	121 (48)
"Very High" Fire Danger Days (higher relative to historical by #days)	36	45 (9)	43 (7)	32 (-4)	74 (38)
"Extreme" Fire Danger Days (higher relative to historical by #days)	11	17 (6)	17 (6)	11 (0)	36 (25)
Extreme Rainfall, i.e., % increase in short duration extreme value	-	20	15	10	20

Above values are based on MACA metdata v2 (4km downscaled climate projections) and gridMET (4km observed climate data for Historical). Drought severity is estimated using Forest Drought Stress Index (FDSI). Freezing level (FL) changes are estimated based on historical relationship between Oct-May FL and temperature. Extreme rainfall risk is estimated using a scaling factor with temperature.

Very Hot and Wet	• Largest increase in spring runoff (80%), but large declines in summer and fall runoff; substantial increase in extreme rainfall events • Despite increased precipitation, especially winter and summer, frequent severe droughts and largest upward shift in snowline • Latest fall freeze; growing season expands by month and a half; droughts like 2012 every three years
Hot	• Modest increase in precipitation but substantial increase in temperature • Droughts like 2012 occur twice per decade • Considerable reductions in snowpack and late season runoff
Warm and Wet	• Least increase in temperature but substantial increase in precipitation • Droughts like 2012 do not occur, and there is a slight decline in fire danger • Spring runoff increases by 50%, but decline in summer flows • Least change in growing season length, but still extended by >3 weeks
Very Hot and Dry	• Large temperature increases combined with decreases in precipitation; as well as largest declines in soil moisture and SWE • Chronic drought and fire danger; droughts like 2012 every 2 years; substantial increase in snowline; growing season extended by 50 days • Despite reduction in summer rains there is a very high risk of extreme rainfall events when they occur

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Figure 10. Description of patterns and changes under the four climate scenarios by 2050 (Rangwala 2019).

Development of future scenarios

Given our uncertainties regarding the future effects of climate change, as well as uncertainties regarding the potential future stressors to this species, we have evaluated the future condition of the monkeyflower under four plausible future scenarios out to 2050; these scenarios have been designed to capture the uncertainties regarding temperature, precipitation trends, and other factors that influence the monkeyflower (such as management activities and development), to include a range of plausible future conditions. We chose 2050 because the available climate projections were calculated from the years 2035 out to the year 2065, relative to the 1985-2015 time period.

These scenarios are:

- Scenario 1 – continuation of the current land management activities under the “Warm and Wet” climate change model;
- Scenario 2 – an increase in land management activities that protect the monkeyflower under the “Very Hot and Wet” climate change model;
- Scenario 3 – a decrease in land management activities that protect the monkeyflower under the “Very Hot and Dry” climate change model; and
- Scenario 4 – continuation of the current land management activities and increased herbivory under the “Hot” climate change model.

We note that climate change is the primary driver and is expected to have the biggest impact on the status of the species in the future. Changes in land management activities and herbivory are secondary drivers and are expected to have a low-level, but cumulative, impact to the status of the species in the future. These changes in climate and land management activities are plausible; however, their likelihoods may vary. Actual conditions in the future could include a combination of factors from any of these four scenarios, or fall somewhere in between these scenarios, however, we selected these scenarios to represent the full range of plausible conditions that could occur. Each of these scenarios was evaluated in terms of how it would be expected to impact resiliency, redundancy, and representation of the species by the year 2050. We include a complete description of the four scenarios we considered in Table 5 below:

Table 5. Scenarios used to evaluate a full range of plausible conditions that could occur.

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Primary Driver	Warm and Wet Climate Change Model	Very Hot and Wet Climate Change Model	Very Hot and Dry Climate Change Model	Hot Climate Change Model
Secondary Drivers	• Continuation of the current land management activities • The rate of recreation stays the same inside the species habitat • Herbivory continues at the current rate	• An increase in land management activities that are more protective for the monkeyflower • Recreation decreases inside the species habitat • Herbivory continues at the current rate	• A decrease in land management activities that protect the monkeyflower • Recreation increases inside species habitat • Increase in herbivory	• Continuation of current land management activities • Recreation stays the same inside the species habitat • Increase in herbivory

For each scenario, we evaluated the anticipated condition of each analysis unit using the same metrics as our evaluation of current condition, namely number of patches, number of ramets, and hydrology (Table 6). These results are described below.

Table 6. Metrics that were used to evaluate the future condition.

Rating		Demographic Metrics		Habitat Metric
		Number of Patches	**Number of Ramets**	**Hydrology**
3	**Good**	Six or more patches	300,000 or more ramets	Dependable water supply and moist soil for most of the growing season, even in exceptionally dry years, on most or all patch sites.
2	**Moderate**	Two to five patches	100,000-299,999 ramets	Some patches in areas where soil is occasionally too dry to support sustained growth and bulbil production over the growing season.
1	**Poor**	One or fewer patches	Fewer than 100,000 ramets	Undependable water supply. Years when soil is too dry or too saturated to support sustained growth and bulbil production over the growing season are frequent on most or all of the patch sites.

4.1 Characterization of Species' Resiliency, Redundancy, and Representation by Future Scenarios

Scenario 1

Resiliency – Under this scenario, we anticipate that the resiliency of all three analysis units will be stable (i.e., same as the current condition rating) or increasing because (1) there is an increase in precipitation, (2) land management activities continue to provide protection for the monkeyflower's habitat, and (3) extreme droughts, like the one that occurred in 2012, do not occur. Therefore, we expect the resiliency of each analysis unit to be at least as good as it currently is, or better, such that each analysis unit retains its ability to withstand stochastic events.

Redundancy – Under this scenario, we anticipate that each of the three analysis units will continue to contain multiple populations in good to moderate resiliency categories as a result of improved habitat and environmental factors, such as an increase in precipitation. We expect that the redundancy will remain unchanged from the current condition (i.e., redundancy will continue to be relatively low, which is typical of many narrow endemic species).

Representation – Under this scenario, we anticipate that each of the three analysis units will persist in good to moderate condition as a result of improved habitat and environmental factors, such as an increase in precipitation. We expect that the representation will remain unchanged from the current condition (i.e., relatively low representation). We expect that the species will retain any morphological, ecological, or phenotypical differences that may be important for future adaptive capacity in this scenario.

Summary of Scenario 1 – We expect that each analysis unit will continue to be occupied and stable or increasing in number of ramets, stable or increasing in number of patches, and have consistent and dependable water sources. We do not anticipate any significant changes in population sizes during this time period; although, there could be an increase in number of ramets due to improved habitat and environmental conditions. These conditions are summarized in Table 7.

Table 7. Summary of the future conditions under scenario 1. We do not have information on the populations that are located within Rocky Mountain National Park. Thus, these populations were not included in our "ranking" process for current and future condition and are not included in the table below. As a result, the ranking for analysis unit 1 was determined using only the information available for the USFS-ROOS Element Occurrences.

Land Ownership	Analysis Unit	Population Name	Element Occurrence (Native or Planted)	Demographics		Habitat	Overall Element Occurence Ranking	Analysis Unit Ranking
				Number of Patches	Number of Ramets	Hydrology		
NPS	1	Old Fall River Road	**Native-Historical**	Unknown	Unknown	Unknown	Unknown	Unit 1-Good
	1	Horseshoe Park	**Native**	Unknown	Unknown	Unknown	Unknown	
	1	Cascade Falls	**Native**	Unknown	Unknown	Unknown	Unknown	
	1	Devil's Staircase	**Native**	Unknown	Unknown	Unknown	Unknown	
USFS-ROOS	1	Saint Vrain	**Native**	Good	Good	Good	Good	
	1	Peaceful Valley	**Native**	Good	Good	Good	Good	
			Planted	Good	Poor	Good	Good	
USFS-PIKE	2	Guanella Pass	**Native**	Good	Good	Good	Good	Unit 2-Moderate
			Planted	Moderate	Good	Good	Good	
	2	Geneva Basin	**Native**	Good	Moderate	Good	Good	
	2	Burning Bear	Planted	Poor	Poor	Good	Moderate	
	2	Threemile Creek	Planted	Moderate	Poor	Good	Moderate	
CPW-Staunton	2	Black Mountain	**Native**	Moderate	Moderate	Good	Good	
			Planted	Moderate	Poor	Good	Moderate	
	2	Elk Creek	**Native**	Poor	Moderate	Good	Moderate	
			Planted	Moderate	Poor	Good	Moderate	
	2	Mason Creek	Planted	Moderate	Poor	Moderate	Moderate	
USFS-PIKE	3	Lost Park	Planted	Poor	Poor	Good	Moderate	Unit 3-Good
	3	Lost Creek	Planted	Good	Moderate	Good	Good	
	3	Hankins Gulch	**Native**	Moderate	Good	Good	Good	
	3	Rainy Day Rock	Planted	Poor	Poor	Good	Moderate	
	3	Corral Dome	**Native**	Good	Good	Good	Good	
	3	Corral Creek	**Native**	Good	Good	Good	Good	
			Planted	Good	Moderate	Good	Good	

Scenario 2

Resiliency – Under this scenario, we anticipate that all three analysis units will be stable as a result of (1) an increase in precipitation and (2) an increase in land management activities that provide protection for the monkeyflower's habitat. Even though we expect severe droughts, similar to the 2012 drought, to occur every three years (more frequently than current situations), we believe that there will still be precipitation events occurring across the species' growing season to provide moist conditions for adult growth. Therefore, we expect the resiliency of each unit to be at least as good as the current condition, and each unit will retain its ability to withstand stochastic events.

Redundancy – Under this scenario, we anticipate that each of the three analysis units will continue to contain multiple populations in good to moderate resiliency categories as a result of improved land management actions that increase protections for the monkeyflower, an increase in precipitation, and a decrease in herbivory. We expect that the redundancy will remain unchanged from the current condition (i.e., redundancy will continue to be relatively low, which is typical of many narrow endemic species).

Representation – Under this scenario, we anticipate that each of the three analysis units will continue to be in good to moderate condition as a result of improved land management actions that increase protections for the monkeyflower, an increase in precipitation, and a decrease in herbivory. We expect that the representation will remain unchanged from the current condition (i.e., relatively low representation).

Summary of Scenario 2 – Under this scenario, we anticipate that each analysis unit will continue to in good to moderate condition as a result of improved land management actions that increase protections for the monkeyflower, an increase in precipitation, and a decrease in herbivory. We do not anticipate any significant changes in population sizes during this time period; although, there could be a decrease in number of ramets due to an increase in temperature and therefore an increase in evapotranspiration. These conditions are summarized in Table 8.

Table 8. Summary of the future conditions under scenario 2. We do not have information on the populations that are located within Rocky Mountain National Park. Thus, these populations were not included in our "ranking" process for current and future condition and are not included in the table below. As a result, the ranking for analysis unit 1 was determined using only the information available for the USFS-ROOS Element Occurrences.

Land Ownership	Analysis Unit	Population Name	Element Occurrence (Native or Planted)	Demographics: Number of Patches	Demographics: Number of Ramets	Habitat: Hydrology	Overall Element Occurrence Ranking	Analysis Unit Ranking
NPS	1	Old Fall River Road	**Native-Historical**	Unknown	Unknown	Unknown	Unknown	Unit 1-Good
NPS	1	Horseshoe Park	**Native**	Unknown	Unknown	Unknown	Unknown	
NPS	1	Cascade Falls	**Native**	Unknown	Unknown	Unknown	Unknown	
NPS	1	Devil's Staircase	**Native**	Unknown	Unknown	Unknown	Unknown	
USFS-ROOS	1	Saint Vrain	**Native**	Good	Good	Good	Good	
USFS-ROOS	1	Peaceful Valley	**Native**	Good	Good	Good	Good	
			Planted	Moderate	Poor	Moderate	Moderate	
USFS-PIKE	2	Guanella Pass	**Native**	Good	Good	Good	Good	Unit 2-Moderate
			Planted	Moderate	Good	Moderate	Moderate	
USFS-PIKE	2	Geneva Basin	**Native**	Good	Poor	Moderate	Moderate	
USFS-PIKE	2	Burning Bear	Planted	Poor	Poor	Moderate	Poor	
USFS-PIKE	2	Threemile Creek	Planted	Moderate	Poor	Moderate	Moderate	
CPW-Staunton	2	Black Mountain	**Native**	Moderate	Poor	Good	Moderate	
			Planted	Moderate	Poor	Moderate	Moderate	
CPW-Staunton	2	Elk Creek	**Native**	Poor	Poor	Good	Moderate	
			Planted	Moderate	Poor	Good	Moderate	
CPW-Staunton	2	Mason Creek	Planted	Moderate	Poor	Poor	Poor	
USFS-PIKE	3	Lost Park	Planted	Poor	Poor	Moderate	Poor	Unit 3-Moderate
USFS-PIKE	3	Lost Creek	Planted	Good	Moderate	Good	Good	
USFS-PIKE	3	Hankins Gulch	**Native**	Moderate	Good	Good	Good	
USFS-PIKE	3	Rainy Day Rock	Planted	Poor	Poor	Moderate	Poor	
USFS-PIKE	3	Corral Dome	**Native**	Good	Good	Good	Good	
USFS-PIKE	3	Corral Creek	**Native**	Good	Good	Good	Good	
			Planted	Good	Poor	Moderate	Moderate	

Scenario 3

***Resiliency* -** Under this scenario, we anticipate that one analysis unit will be stable and two analysis units may have decreased resiliency as a result of (1) a significant decrease in precipitation, (2) a decrease in land management activities that provide protection for the monkeyflower's habitat, (3) an increase in temperature across the growing season, and (4) severe droughts, similar to the 2012 drought, occurring every two years. Specifically, we expect that the resiliency of analysis unit 3 will remain the same as the current condition while analysis units 1 and 2 will have decreased resiliency from the current condition.

Redundancy – Under this scenario, we anticipate that each analysis unit will continue to have multiple populations in moderate condition, even though environmental and management conditions have decreased. Although we expect that the redundancy will remain unchanged from the current condition (i.e., redundancy will continue to be relatively low, which is typical of many narrow endemic species), the resiliency of several populations may decrease. If management and environmental factors continue to decline, several populations may no longer be occupied.

Representation – Under this scenario, we anticipate that analysis units one and three will be in moderate condition, even though environmental and management conditions are predicted to decrease, and analysis unit two is anticipated to be in poor condition. We expect that the representation will remain unchanged from the current condition (i.e., relatively low representation).

Summary of Scenario 3 – Under this scenario, we anticipate that each analysis unit will continue to be present; however, the resiliency of two analysis units is predicted to decrease. Significant population changes may occur due to increases in temperature, decreases in precipitation, and fewer land management activities that provide protections for the monkeyflower. These conditions are summarized in Table 9.

Table 9. Summary of the future conditions under scenario 3. We do not have information on the populations that are located within Rocky Mountain National Park. Thus, these populations were not included in our "ranking" process for current and future condition and are not included in the table below. As a result, the ranking for analysis unit 1 was determined using only the information available for the USFS-ROOS Element Occurrences.

Land Ownership	Analysis Unit	Population Name	Element Occurrence (Native or Planted)	Demographics		Habitat	Overall Element Occurrence Ranking	Analysis Unit Ranking
				Number of Patches	Number of Ramets	Hydrology		
NPS	1	Old Fall River Road	**Native-Historical**	Unknown	Unknown	Unknown	Unknown	Unit 1-Moderate
	1	Horseshoe Park	**Native**	Unknown	Unknown	Unknown	Unknown	
	1	Cascade Falls	**Native**	Unknown	Unknown	Unknown	Unknown	
	1	Devil's Staircase	**Native**	Unknown	Unknown	Unknown	Unknown	
USFS-ROOS	1	Saint Vrain	**Native**	Good	Good	Poor	Moderate	
	1	Peaceful Valley	**Native**	Moderate	Moderate	Poor	Poor	
			Planted	Good	Poor	Poor	Poor	
USFS-PIKE	2	Guanella Pass	**Native**	Good	Good	Poor	Moderate	Unit 2-Poor
			Planted	Moderate	Good	Poor	Moderate	
	2	Geneva Basin	**Native**	Moderate	Poor	Poor	Poor	
	2	Burning Bear	Planted	Poor	Poor	Poor	Poor	
	2	Threemile Creek	Planted	Moderate	Poor	Poor	Poor	
CPW-Staunton	2	Black Mountain	**Native**	Poor	Poor	Poor	Poor	
			Planted	Moderate	Poor	Poor	Poor	
	2	Elk Creek	**Native**	Poor	Poor	Poor	Poor	
			Planted	Poor	Poor	Poor	Poor	
	2	Mason Creek	Planted	Moderate	Poor	Poor	Poor	
USFS-PIKE	3	Lost Park	Planted	Poor	Poor	Poor	Poor	Unit 3-Moderate
	3	Lost Creek	Planted	Good	Poor	Poor	Poor	
	3	Hankins Gulch	**Native**	Moderate	Good	Poor	Moderate	
	3	Rainy Day Rock	Planted	Poor	Poor	Poor	Poor	
	3	Corral Dome	**Native**	Good	Good	Poor	Moderate	
	3	Corral Creek	**Native**	Good	Good	Poor	Moderate	

			Planted	Moderate	Poor	Poor	Poor	

Scenario 4

***Resiliency* -** Under this scenario, we anticipate that two analysis units will be in moderate condition and one analysis unit will be in poor condition as a result of (1) decreases in precipitation, (2) a continuation of land management activities that provide protection for the monkeyflower's habitat, (3) an increase in temperature across the growing season, (4) severe droughts, similar to the 2012 drought, occurring every five years, and (5) increases in herbivory. Therefore, we expect that the resiliency of analysis unit 3 will remain the same as the current condition while analysis units 1 and 2 will have decreased resiliency from the current condition.

Redundancy – Under this scenario, we anticipate that each analysis unit will continue to have multiple populations in good to moderate condition, even though environmental conditions are predicted to degrade. Although we expect that the redundancy will remain unchanged from the current condition (i.e., redundancy will continue to be relatively low, which is typical of many narrow endemic species), the resiliency of several populations may decrease. If management and environmental factors continue to decline, several populations may become extirpated.

Representation – Under this scenario, we anticipate that analysis units one and three will be in moderate condition even though environmental conditions are predicted to decrease, and analysis unit two will be in poor condition. We expect that the representation will remain unchanged from the current condition (i.e., relatively low representation).

Summary of Scenario 4 – Under this scenario, we anticipate that each analysis unit will continue to be present; however, the resiliency of two analysis units is predicted to decrease. Significant population changes may occur due to increases in temperature, decreases in precipitation, and fewer land management activities that provide protections for the monkeyflower. These conditions are summarized in Table 10.

Table 10. Summary of the future conditions under scenario 4. We do not have information on the populations that are located within Rocky Mountain National Park. Thus, these populations were not included in our "ranking" process for current and future condition and are not included in the table below. As a result, the ranking for analysis unit 1 was determined using only the information available for the USFS-ROOS Element Occurrences.

Land Ownership	Analysis Unit	Population Name	Element Occurrence (Native or Planted)	Demographics: Number of Patches	Demographics: Number of Ramets	Habitat: Hydrology	Overall Element Occurrence Ranking	Analysis Unit Ranking
NPS	1	Old Fall River Road	**Native-Historical**	Unknown	Unknown	Unknown	Unknown	Moderate
NPS	1	Horseshoe Park	**Native**	Unknown	Unknown	Unknown	Unknown	
NPS	1	Cascade Falls	**Native**	Unknown	Unknown	Unknown	Unknown	
NPS	1	Devil's Staircase	**Native**	Unknown	Unknown	Unknown	Unknown	
USFS-ROOS	1	Saint Vrain	**Native**	Good	Good	Moderate	Good	
USFS-ROOS	1	Peaceful Valley	**Native**	Moderate	Moderate	Moderate	Moderate	
			Planted	Good	Poor	Poor	Poor	
USFS-PIKE	2	Guanella Pass	**Native**	Good	Good	Moderate	Good	Poor
			Planted	Moderate	Good	Poor	Moderate	
USFS-PIKE	2	Geneva Basin	**Native**	Moderate	Poor	Poor	Poor	
USFS-PIKE	2	Burning Bear	Planted	Poor	Poor	Poor	Poor	
USFS-PIKE	2	Threemile Creek	Planted	Moderate	Poor	Poor	Poor	
CPW-Staunton	2	Black Mountain	**Native**	Poor	Poor	Moderate	Poor	
			Planted	Moderate	Poor	Poor	Poor	
CPW-Staunton	2	Elk Creek	**Native**	Poor	Poor	Moderate	Poor	
			Planted	Poor	Poor	Moderate	Poor	
CPW-Staunton	2	Mason Creek	Planted	Moderate	Poor	Poor	Poor	
USFS-PIKE	3	Lost Park	Planted	Poor	Poor	Poor	Poor	Moderate
USFS-PIKE	3	Lost Creek	Planted	Good	Poor	Moderate	Moderate	
USFS-PIKE	3	Hankins Gulch	**Native**	Moderate	Good	Moderate	Moderate	
USFS-PIKE	3	Rainy Day Rock	Planted	Poor	Poor	Poor	Poor	
USFS-PIKE	3	Corral Dome	**Native**	Good	Good	Moderate	Good	
USFS-PIKE	3	Corral Creek	**Native**	Good	Good	Moderate	Good	
			Planted	Moderate	Poor	Poor	Poor	

4.2 Summary of Evaluation

In summary, the three analysis units for the monkeyflower are currently in good to moderate condition. We anticipate that each analysis unit will continue to be occupied at some level under all future scenarios; however, the smaller populations within the analysis units may no longer be occupied by the monkeyflower, in some scenarios. Our analysis shows one future scenario (i.e., Scenario 1) where resiliency may improve (analysis unit 3 may move from moderate condition to good condition, while analysis units 1 and 2 remain the same as the current condition) (refer to Table 11 and Figure 11. Current and future conditions for the monkeyflower. Green represents a population in good condition, orange represents a population in moderate condition, and red represents poor condition. Refer to Sections 3.3-3.5 and Chapter 4 for more detail on these categories and how they were used to evaluate current and future conditions.). In Scenarios 3 and 4 we anticipate decreases in resiliency, which may put the species at an increased risk of being impacted by stochastic and catastrophic events, such that the smaller populations may no longer be occupied by the monkeyflower. Because there are only three analysis units that are comprised of relatively small and scattered populations, this species likely has always been at some risk of catastrophic events. The monkeyflower exhibits asexual reproduction, which may provide a defense against the impacts from severe drought conditions, since asexual reproduction is less energy intensive than sexual reproduction; however, some populations may not be able to withstand an increase in the frequency of prolonged drought conditions.

Table 11. Summary table of the current and future conditions.

<table>
<tr><th>Land Ownership</th><th>Analysis Units</th><th>Current Condition</th><th>Scenario 1</th><th>Scenario 2</th><th>Scenario 3</th><th>Scenario 4</th></tr>
<tr><td>NPS</td><td rowspan="2">1</td><td rowspan="2">Good</td><td rowspan="2">Good</td><td rowspan="2">Good</td><td rowspan="2">Moderate</td><td rowspan="2">Moderate</td></tr>
<tr><td>USFS-ROOS</td></tr>
<tr><td>USFS-PIKE</td><td rowspan="2">2</td><td rowspan="2">Moderate</td><td rowspan="2">Moderate</td><td rowspan="2">Moderate</td><td rowspan="2">Poor</td><td rowspan="2">Poor</td></tr>
<tr><td>CPW-Staunton</td></tr>
<tr><td>USFS-PIKE</td><td>3</td><td>Moderate</td><td>Good</td><td>Moderate</td><td>Moderate</td><td>Moderate</td></tr>
</table>

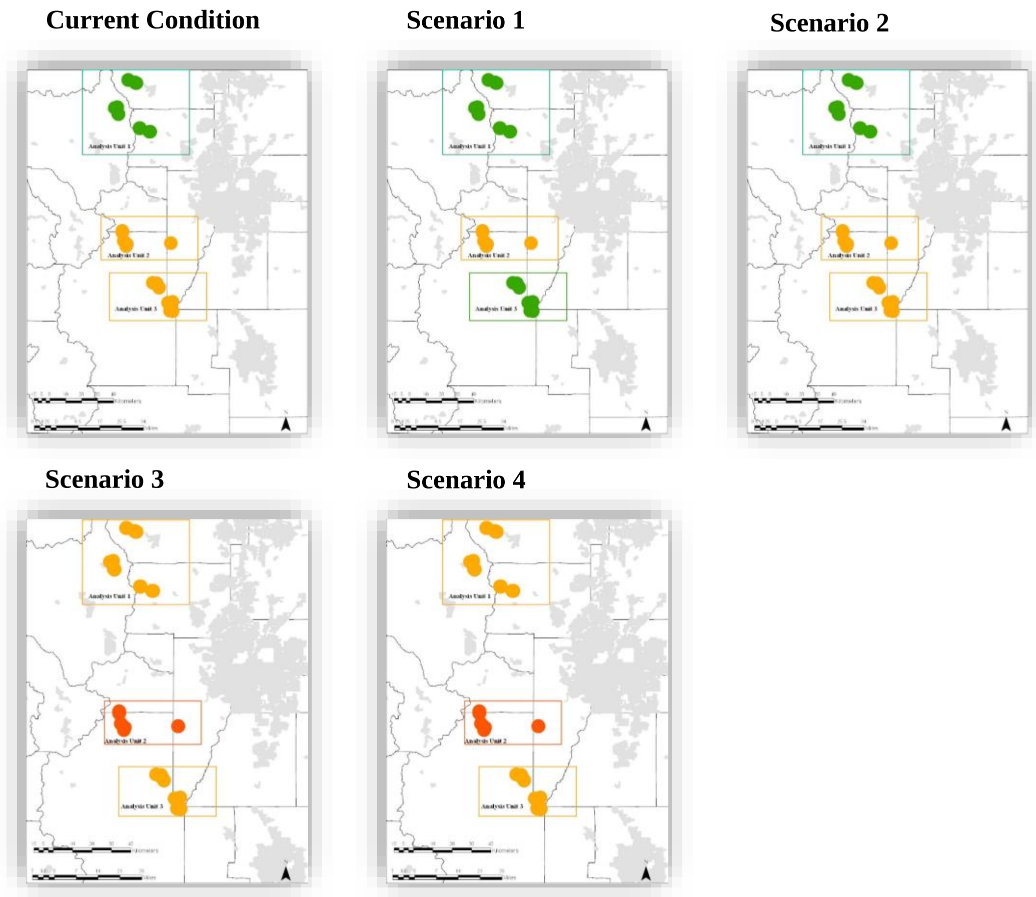

Figure 11. Current and future conditions for the monkeyflower. Green represents a population in good condition, orange represents a population in moderate condition, and red represents poor condition. Refer to Sections 3.3-3.5 and Chapter 4 for more detail on these categories and how they were used to evaluate current and future conditions.

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Appendix A – Cause and effects tables

THEME:	Livestock and Herbivore Grazing		
[ESA Factor(s): A]	**Analysis**	Confidence / Uncertainty	Supporting Information
SOURCE(S)			
- Activity(ies)	Grazing by livestock and other herbivores.		
STRESSOR(S)			
- Affected Resource(s)	Removal of ramets by grazing and trampling leads to decreases in the number of ramets, lowers reproductive output and recruitment.	Moderately Confident	
- Exposure of Stressor(s)	Exposure would occur during the plants growing season (April-September).	Moderately Confident	
- Immediacy of Stressor(s)	This stressor is likely not occurring frequently due to the nature of this species habitat. This species occupies habitat that is found on steep, rocky, outcrops that are inaccessible to most grazing animals.	Moderately Confident	USFS 2003, p. 28
Changes in Resource(s)	Removal of ramets by grazing and trampling leads to decreases in the number of ramets, lowers reproductive output and recruitment.	Moderately Confident	
Response to Stressors: - INDIVIDUALS	Loss of ramets as a result of grazing activities by livestock and herbivores.	Moderately Confident	
POPULATION & SPECIES RESPONSES			
Effects of Stressors: - POPULATIONS [RESILIENCY]	This stressor can lower the number of reproductive ramets. Thus, lowering the reproductive output and lowering recruitment for an affected population.	Moderately Confident	
- GEOGRAPHIC SCOPE	This stressor is not known to be currently affecting any of the monkeyflower populations.	Low Confidence	
- MAGNITUDE	This stressor is not expected to have a significant impact due to the nature of the monkeyflower habitat. If this stressor occurs it will likely have a minimal impact to the species as a whole.	Moderately Confident	
SUMMARY	This stressor is not currently considered to be a species level threat because this stressor impacts the species at local and individual levels only.		

THEME:	Recreation, Trails, and Roads		
[ESA Factor(s): A]	**Analysis**	Confidence / Uncertainty	Supporting Information
SOURCE(S)			
- Activity(ies)	Hiking, biking, camping, fishing, horseback riding, dogs, off road vehicles, rock climbing, and road and trail maintenance.		
STRESSOR(S)			
- Affected Resource(s)	Trampling of ramets and habitat fragmentation.	Moderately Confident	USFS 2003, p. 28
- Exposure of Stressor(s)	Trampling can occur throughout the species growing season (April-September). Habitat fragmentation occurs among the sites that are located adjacent to roads, trails, and camping sites.	Moderately Confident	USFS 2003, p. 28
- Immediacy of Stressor(s)	Trampling or crushing as a result of these activities can occur throughout the plants growing season (April-September) which overlaps with typical spring/summer outdoor recreation.	Moderately Confident	
Changes in Resource(s)	Loss of ramets, reproductive output, and recruitment is the primary change in resource. However, habitat fragmentation can alter habitat and/or the natural hydrologic regime in that area resulting in an even greater loss of ramets, reproductive output, and recruitment.	Moderately Confident	USFS 2003, p. 28
Response to Stressors: - INDIVIDUALS	Loss of individuals, reproductive output, and recruitment is the primary response to the stressor.	Moderately Confident	
POPULATION & SPECIES RESPONSES			
Effects of Stressors: - POPULATIONS [RESILIENCY]	Habitat fragmentation can change the hydrologic regime which can affect water availability and limit the dispersal mechanisms that are available to that population. As a result, the population would exhibit lower growth rates, lower reproductive rates, lower recruitment rates, and have a reduced capacity to disperse propagules to new areas.	Moderately Confident	
- GEOGRAPHIC SCOPE	Six out of the nineteen populations are in close proximity to roads or trails; some are bisected by a road or a trail. One of the populations has been used as a campsite where a fire had been built. Approximately 777 feet (237 meters or .15 miles) of trails intersect with monkeyflower sites and approximately 1,489 feet (454 meters or .28 miles) of roads intersect with monkeyflower sites.	Moderately Confident	Beardsley 2017 (entire)
- MAGNITUDE	This stressor has impacts at a local level that can impact individuals and populations. However, it is not expected that this stressor will result in a significant impact at the species level at this time.		
SUMMARY	Even though this stressor is impacting the monkeyflower; it isn't impacting the monkeyflower on a species level. Therefore, this stressor is currently not considered to be a species level threat. However, because this species primarily occurs on public lands and human activity is expected to increase, this level may change in the future.		

THEME:	Changes in Natural Regimes		
[ESA Factor(s): A]	**Analysis**	Confidence / Uncertainty	Supporting Information
SOURCE(S)			
- Activity(ies)	Wildfires, drought, rock falls, flash floods, climate change, erosion, blow-downs, and timber harvests.		USFS 2003, p. 28
STRESSOR(S)			
- Affected Resource(s)	Hydrology, topography, soils of the monkeyflower habitat.	Moderately Confident	USFS 2003, p. 28
- Exposure of Stressor(s)	This stressor will overlap with the monkeyflowers habitat and potentially interfere with the natural abiotic conditions of the habitat (i.e., a natural seep could be eliminated).	Moderately Confident	
- Immediacy of Stressor(s)	In 2002, a wildfire burned within 9 to 12 meters (30 to 40 feet) of a monkeyflower population at the Hankins Gulch. This population was protected by the adjacent riparian corridor; however, the ecology of the site was reportedly altered in its hydrology and vegetation. Soils, water runoff, erosion, and deposition of biotic mass may have been altered as well. We have no information to suggest that this stressor is currently affecting populations at this time.	Moderately Confident	USFS 2003, p. 28; Steingraeber Beardsley 2005, p. 9
Changes in Resource(s)	Loss of ramets, reproductive output, and recruitment could occur as a result of habitat loss, a decrease in water availability, and soil drying.	Highly Confident	USFS 2003, p. 28; Steingraeber Beardsley 2005, p. 9
Response to Stressors: - INDIVIDUALS	Loss of ramets, reproductive output, and recruitment could occur as a result of habitat loss, a decrease in water availability, and soil drying.	Moderately Confident	
POPULATION & SPECIES RESPONSES			
Effects of Stressors: - POPULATIONS [RESILIENCY]	This stressor can lower the number of ramets and the number of reproductive ramets. Thus, lowering the reproductive output and lowering recruitment for an affected populations. If conditions are severe enough it could result in loss of the entire population.	Moderately Confident	
- GEOGRAPHIC SCOPE	It is unclear to what extent this stressor has on this species.	Low Confidence	
- MAGNITUDE	This stressor can have a significant impact on an individual and population scale; however, it is not expected to have a species level impact due to the sparse distribution of this species (i.e., the populations are spread out across the species range). Climate change could be a species level threat if it became severe enough and will be discussed in a separate section.	Highly Confident	
SUMMARY	This stressor is not considered to be a species level threat at this time because most impacts would occur at the individual or population levels. The impacts of climate change on this species will be discussed in further detail in a separate section.		

THEME:	Climate Change		
[ESA Factor(s): A]	**Analysis**	Confidence / Uncertainty	Supporting Information
SOURCE(S)			
- Activity(ies)	Climate change has the ability to change the plant community, allow for an increase in nonnative invasive plant species, alter normal drought regimes, and change the fire frequency.		
STRESSOR(S)			
- Affected Resource(s)	Climate change can alter the fire frequency, which is currently low for this species habitat, alter community assemblages, and increases the ability of nonnative invasive plant species to proliferate.	Moderately Confident	
- Exposure of Stressor(s)	This stressor overlaps with the monkeyflowers habitat and potentially interferes with the natural abiotic conditions of the habitat (i.e., a natural seep could be eliminated).	Moderately Confident	
- Immediacy of Stressor(s)	This stressor is currently affecting the monkeyflower and its habitat and is anticipated to continue; however we do not know to what degree.	Moderately Confident	
Changes in Resource(s)	Loss of ramets, reproductive output, and recruitment could occur as a result of habitat loss, a decrease in water availability, and soil drying.	Highly Confident	
Response to Stressors: - INDIVIDUALS	Loss of ramets, reproductive output, and recruitment could occur as a result of habitat loss, a decrease in water availability, and soil drying.	Moderately Confident	
POPULATION & SPECIES RESPONSES			
Effects of Stressors: - POPULATIONS [RESILIENCY]	This stressor can lower the number of ramets and the number of reproductive ramets. Thus, lowering the reproductive output and lowering recruitment for an affected populations. If conditions are severe enough, it could result in loss of the entire population.	Moderately Confident	
- GEOGRAPHIC SCOPE	This stressor impacts the monkeyflower throughout its range.	Low Confidence	
- MAGNITUDE	In the short term, climate change would likely have a low level impact on the monkeyflower because of this species ability to reproduce asexually during resource limited conditions. However, over the long term, climate change would likely have a high level impact.	Highly Confident	
SUMMARY	Given currently available climate data out to the year 2050 and the level of impact that climate change may have on monkeyflower, we consider this stressor to be a species-level threat and will be carrying this forward in our analysis.		

THEME:	Biologically Vulnerable Small Population Size		
[ESA Factor(s): E]	**Analysis**	Confidence / Uncertainty	Supporting Information
SOURCE(S)			
- Activity(ies)	Limited reproductive mechanism, small populations sizes, restricted range.		
STRESSOR(S)			
- Affected Resource(s)	Asexual reproduction is this species primary mechanism for reproduction. Asexual reproduction does not accommodate for genetic recombination in the same way that sexual reproduction does, resulting in populations that are genetically similar.	Moderately Confident	
- Exposure of Stressor(s)	This species is exposed to this stressor throughout all stages of its life and habitat.	Moderately Confident	
- Immediacy of Stressor(s)	It is not known how this stressor is impacting this species at this time.	Low Confidence	
Changes in Resource(s)	Asexually reproducing species cannot experience inbreeding depression since inbreeding depression is caused by sexual reproduction among closely related individuals. However, asexual reproduction does result in genetically similar populations.	Moderately Confident	
Response to Stressors: - INDIVIDUALS	There is no response from the individual as a result of this stressor.	Low Confidence	
POPULATION & SPECIES RESPONSES			
Effects of Stressors: - POPULATIONS [RESILIENCY]	This stressor can reduce the species ability to add new genes to the populations; however, asexual reproduction seems to be increasing the species fitness during times of limited resource availability.	Moderately Confident	
- GEOGRAPHIC SCOPE	This stressor is affecting the species across its range. While the species may be limited in its geographic range; the number of ramets can be in the millions at any given site.	Moderate Confidence	
- MAGNITUDE	It is unclear what level of impact this stressor is currently having or could potentially have on the species at this time.	Moderately Confident	
SUMMARY	This stressor could potentially be a threat to the species as whole. However, it appears that the species' ability to reproduce asexually is not a detriment to the species. It appears that asexual reproduction allows the species to continue to exist during times of limited resources. Additionally, because this species primarily exhibits asexual reproduction, it is unlikely that inbreeding depression will negatively affect the population dynamics of this species.	Moderately Confident	Bearsley 1997; USFS 2003, p 23

THEME:	Wildfire		
[ESA Factor(s): A]	**Analysis**	Confidence / Uncertainty	Supporting Information
SOURCE(S)			
- Activity(ies)	Lightning or human induced wildfire can alter habitat by removing surrounding native vegetation and exposing plants to temperature extremes.		
STRESSOR(S)			
- Affected Resource(s)	Wildfire that occurs inside of monkeyflower habitat can alter habitat, eliminate ramets, and/or facilitate non-native plant invasion.	Highly Confident	
- Exposure of Stressor(s)	In 2002, the Hayman fire burned in close proximity to the Hankins Gulch population, the Corral Creek population, and the newly discovered Corral Dome population. Currently, we are not aware of other fires that have occurred in monkeyflower habitat or near monkeyflower habitat.	Moderately Confident	
- Immediacy of Stressor(s)	It is not known how this stressor is impacting this species at this time. The 2002 Hayman fire, has introduced non-native invasive plant species to areas surrounding monkeyflower habitat; however, these invasive species have not been observed invading monkeyflower populations.	Moderately Confident	USFS 2003, p. 28
Changes in Resource(s)	Even though the Hayman fire burned in close proximity to two monkeyflower populations; we are currently unaware of any habitat alterations as a result of this fire.	Low confidence	
Response to Stressors: **- INDIVIDUALS**	We are currently unaware of any impacts on monkeyflower ramets as a result of this stressor. However, should a wildfire occur in habitat, it could result in the removal of monkeyflower ramets and/or alter monkeyflower habitat.	Moderately Confident	
POPULATION & SPECIES RESPONSES			
Effects of Stressors: **- POPULATIONS [RESILIENCY]**	We are currently unaware of any impacts on monkeyflower populations as a result of this stressor. However, should a wildfire occur in habitat, it could result in habitat loss, habitat fragmentation, changes in hydrological regimes, and changes in the distribution of the species.	Moderately Confident	
- GEOGRAPHIC SCOPE	Currently, this stressor has only been known to occur in proximity to monkeyflower populations (Hankins Gulch and Corral Dome) and has not been known to directly affect monkeyflower populations and therefore, will not be carried forward in our analysis.	Moderately Confident	
- MAGNITUDE	It is unclear what level of impact this stressor is currently having. However, should a wildfire occur in monkeyflower habitat, the level of impact could be high.	Moderately Confident	
SUMMARY	Considering that wildfire is not known to impact monkeyflower ramets or habitat at this time, we do not consider this stressor to be a species level threat and it will not be carried forward in our analysis.	Moderately Confident	

Appendix B -- Population Summaries (Beardsley 2017)

Chu, K. (2016). **Saint Vrain**			**Peaceful Valley**		
Land Ownership		**National Forest**	**Land Ownership**		**National Forest**
Elevation (m)		**3200**	**Elevation (m)**		**2700**
Aspect		**SW**	**Aspect**		**SSE to SSW**
Cover		**Open - sparse trees**	**Cover**		**Sparse trees**
Season		**July-September**	**Season**		**June-August**
Patches	**Native**	**> 20**	**Patches**	**Native**	**6**
	Established	**0**		**Established**	**9**
	Total	**> 20**		**Total**	**15**
Individuals	**Native**	**$1.0 \times 10^{6.0}$ (~1,000,000)**	**Individuals**	**Native**	**2.0×10^{5} (~200,000)**
	Established	**0**		**Established**	**9.0×10^{4} (~90,000)**
	Total	**$1.0 \times 10^{6.0}$ (~1,000,000)**		**Total**	**2.9×10^{5} (~290,000)**
Many native patches on ledges and slabs on a SW-facing canyon wall. The known population extent spans about 15 acres (approximately 500 M by 200 M). This population has not been extensively surveyed since 2013, but conditions were checked in 2017 and seemed similar. Population estimates are from the 2013 survey.			This population was discovered in 2016, with plants at 2 sites (PV01, 02). An adjacent set of sites about 400 M to the west was planted in 2016 from Saint Vrain stock, with 9 new patches established in 2017 at PV11,13, 14, 16, 19, 20.		

Guanella Pass		
Land Ownership		National Forest
Elevation (m)		3300-3400
Aspect		SSW to SW
Cover		Sparse forest canopy
Season		July-September
Patches	Native	19
	Established	5
	Total	24
Individuals	Native	$1.2x10^6$ (~1,200,000)
	Established	$1.2x10^6$ (~1,200,000)
	Total	$1.2x10^6$ (~1,200,000)

A new site (GP10) was discovered about 500 M south of the known sites of the Guanella Pass population (GP01, 02, 03, 04, 07). The newly discovered site has about 6 patches and ~10^6 individuals which is many times more than the rest of the Guanella Pass sites. New sites were planted in 2016 from Guanella Pass stock, with 5 new patches established in 2017 (GP12, 13, 14, 15, 16).

Geneva Basin		
Land Ownership		National Forest
Elevation (m)		3300
Aspect		ESE to SE
Cover		Open - sparse trees
Season		July-September
Patches	Native	6
	Established	0
	Total	6
Individuals	Native	$3.5x10^4$ (~35,000)
	Established	0
	Total	$3.5x10^4$ (~35,000)

Two native sites discovered in 2016. These sites are only about 500-800 M from the Guanella Pass population, but considered a separate population since they are on the other side of the valley with different aspect. There may be more patches on areas south and west that have not been surveyed.

Burning Bear			Threemile Creek		
Land Ownership		National Forest	Land Ownership		National Forest
Elevation (m)		2900	Elevation (m)		2700-2800
Aspect		SW	Aspect		Various
Cover		Open	Cover		Thick forest canopy
Season		Unknown	Season		July-September
Patches	Native	0	Patches	Native	0
	Established	0		Established	5
	Total	0		Total	5
Individuals	Native	0	Individuals	Native	0
	Established	0		Established	$4.0x10^3$ (~4,000)
	Total	0		Total	$4.0x10^3$ (~4,000)
One site (BB01) along the base of a rock near Burning Bear Campground was planted in 2016. If plants establish there, it would be a new population, but as of 2017 there are no Mimulus gemmiparus here. Establishment apparently failed.			Several sites (3M02, 03, 04) along Threemile Creek, about 1 KM up the trail frrom Guanella Pass Road, were planted in 2016. The other site (3M01) is about 1.3 KM SSW on Guanella Pass Road. A few plants established in 5 new patches, but numbers are very low and persistance is questionable.		

Black Mountain			Elk Creek		
Land Ownership		Staunton State Park	Land Ownership		Staunton State Park
Elevation (m)		3000	Elevation (m)		2600-2700
Aspect		SW	Aspect		SW to WSW
Cover		Open - sparse trees	Cover		Thick forest canopy
Season		July-September	Season		June-September
Patches	Native	2	Patches	Native	1
	Established	4		Established	2
	Total	6		Total	3
Individuals	Native	1.0×10^5 (~100,000)	Individuals	Native	1.0×10^5 (~100,000)
	Established	4.6×10^3 (~4,500)		Established	3.2×10^3 (~3,200)
	Total	1.0×10^5 (~100,000)		Total	1.0×10^5 (~100,000)
In addition to the native patches at BM01, 03, several new patches were planted at sites BM 11, 21, 22, 23, 24, 25 in 2012 from Black Mountain parent stock. No new patches were planted in 2016. Persistent patches are evident at BM11, 21, 22, 23, and 25, with a hundred or more plants at each.			In addition to the native patch that was discovered in 2007 (EC01), several new patches were planted at sites EC06, 11, 21, 24 in 2012 from Elk Creek parent stock. Another 2 patches were planted in at EC31 (about 800 M north) in 2016. Of these, new patches are evident at EC21.		

Mason Creek			Lost Park		
Land Ownership		Staunton State Park	Land Ownership		National Forest
Elevation (m)		2600	Elevation (m)		3000
Aspect		SE to S	Aspect		Various
Cover		Sparse forest canopy	Cover		Thick forest canopy
Season		Unknown	Season		Unknown
Patches	Native	0	Patches	Native	0
	Established	3		Established	1
	Total	3		Total	1
Individuals	Native	0	Individuals	Native	0
	Established	$5.0x10^2$ (~500)		Established	$1.0x10^2$ (~100)
	Total	$5.0x10^2$ (~500)		Total	$1.0x10^2$ (~100)
Several sites were planted in 2016 from Black Mountain parent stock with marginal success. 3 patches were present in 2017 (MC09, 10, 12) with just a few plants in each. Probability of persistence is low.			Planted several sites in three locations in Lost Park in 2016 from Elk Creek parent stock. One patch had plants in 2017, and it is unlikely that they will persist.		

Lost Creek			Hankins Gulch		
Land Ownership		National Forest	Land Ownership		National Forest
Elevation (m)		2900	Elevation (m)		2600
Aspect		W	Aspect		NE to E
Cover		Sparse forest canopy	Cover		Thick forest canopy
Season		June-September	Season		June - August
Patches	Native	0	Patches	Native	3
	Established	7		Established	0
	Total	7		Total	3
Individuals	Native	0	Individuals	Native	$3.2x10^5$ (~320,000)
	Established	$1.0x10^5$ (~100,000)		Established	0
	Total	$1.0x10^5$ (~100,000)		Total	$3.2x10^5$ (~320,000)
Planted 4 sites (LC03, 04, 05, 06) in 2016 from Elk Creek parent stock. Patches established at all sites except LC06, with numerous patches and most plant numbers at LC04.			Native plants at base of rock in 2 patches (HG01) and on rock ramp (HG02). Planted one site along base of NE-facing rock west of native population (HG-11) from Hankins Gulch parent stock, but none established in 2017.		

Rainy Day Rock			Corral Dome		
Land Ownership		National Forest	Land Ownership		National Forest
Elevation (m)		2400	Elevation (m)		2700
Aspect		SW	Aspect		E to ESE
Cover		Open	Cover		Open
Season		May-July	Season		April-June
Patches	Native	0	Patches	Native	> 100
	Established	1		Established	0
	Total	1		Total	> 100
Individuals	Native	0	Individuals	Native	1.0×10^7 (~10,000,000)
	Established	1.0×10^3 (~1,000)		Established	0
	Total	1.0×10^3 (~1,000)		Total	1.0×10^7 (~10,000,000)
Planted patches on rock face with perennial seep and at base in 2016 from Hankins Gulch parent stock (RD01). Few plants established on patch at base in 2017.			The population on Corral Dome, discovered in 2016, contains an estimated 100+ patches in a 16-acre area on and around a granite dome with perennial seeping water. With an estimated 10^7 individuals, it likely has more plants than all other populations combined. The patches have not been surveyed in detail.		

Corral Creek		
Land Ownership		National Forest
Elevation (m)		2400
Aspect		SSW to SW
Cover		Open
Season		April-June
Patches	Native	8
	Established	6
	Total	14
Individuals	Native	$3.2x10^{5}$ (~320,000)
	Established	$4.6x10^{4}$ (~46,000)
	Total	$3.7x10^{5}$ (~370,000)
Discovered native population in 2016 (CC06, 07, 08) on slabs, ledges base of rocks. Planted adjacent sites (CC01, 02, 03, 04, 05) in 2016 from Hankins Gulch parent stock. Multiple patches established in 2017.		