Conservation Agreement and Strategy for Graham's Beardtongue (*Penstemon grahamii*) and White River Beardtongue (*P. scariosus* var. *albifluvis*)

2020 ANNUAL REPORT

Prepared by the Penstemon Conservation Team

State of Utah School and Institutional Trust Lands Administration
Uintah County, Utah
Utah Public Lands Policy Coordination Office
Utah Division of Wildlife Resources
Rio Blanco County, Colorado
Bureau of Land Management
U.S. Fish and Wildlife Service

March 2021

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CONSERVATION AGREEMENT AND STRATEGY FOR GRAHAM'S BEARDTONGUE (*PENSTEMON GRAHAMII*) AND WHITE RIVER BEARDTONGUE (*P. SCARIOSUS* VAR. *ALBIFLUVIS*):

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APPENDICES

1 PENSTEMON CONSERVATION TEAM ACTIVITIES

The Penstemon Conservation Team was established in 2014 and comprises the signatories of the Penstemon *Conservation Agreement and Strategy for Graham's beardtongue (*Penstemon grahamii) a*nd White River beardtongue (*P. scariosus *var.* albifluvis) (Penstemon Conservation Team 2014). The conservation agreement should be cited as follows:

> Penstemon Conservation Team. 2014. *Conservation Agreement and Strategy for Graham's Beardtongue (*Penstemon grahamii*) and White River Beardtongue (*P. scariosus *var.* albifluvis*)*. Prepared for the State of Utah School and Institutional Trust Lands Administration; Uintah County, Utah; Utah Public Lands Coordination Office; Utah Division of Wildlife Resources; Rio Blanco County, Colorado; Bureau of Land Management; and U.S. Fish and Wildlife Service. Prepared by SWCA Environmental Consultants, Salt Lake City, Utah. July 22, 2014.

All plans and reports for the Utah Conservation Team are available electronically on the SITLA website at:

https://trustlands.utah.gov/in-your-community/conservation/penstemon-conservation-project/

Information included in this annual report summarizes Penstemon Conservation Team (PCT) activities from January 1 – December 31, 2020.

1.1 Mitigation Plan

There were no changes to the Mitigation Plan (PCT 2015a) in 2020.

1.2 Weed Management Plan

There were no changes to the Weed Management Plan (PCT 2015b) in 2020. The Team is currently revising this plan with a revised document expected in 2021.

1.3 Livestock Grazing Management Plan

There were no changes to the Livestock Grazing Management Plan (PCT 2015c) in 2020. The Team is currently revising this plan with a revised document expected in 2021.

1.4 Surface Disturbance Plan

There were no changes the Surface Disturbance Plan (PCT 2015d) in 2020.

1.5 Demographic Monitoring Plan

The Penstemon Range-wide Demographic Monitoring Plan (PCT 2017a) was implemented by BLM VFO in 2017 and continued through 2019. In 2020, the PCT Population Monitoring

Subcommittee revised the plan and reimplemented a range-wide monitoring program for both species in May and June 2020. The revised plan allows more efficient range-wide population monitoring and quantification of livestock and native ungulate grazing and weed impacts in beardtongue habitats. The revised plan and first year (2020) reimplementation results are included in Appendix A and B, respectively, and summarized in Section 7.1.

1.6 Seed Management Strategy

There were no changes to Seed Management Strategy in 2020.

1.7 Restoration Plan

The Restoration Plan Subcommittee developed an early draft Beardtongue Restoration Plan in late 2017. We expect the plan to be finalized in 2021.

2 IMPLEMENTATION OF CONSERVATION AGREEMENT IN BEARDTONGUE HABITATS

2.1 BLM Vernal Field Office (Utah)

In 2020, the Utah BLM Vernal Field Office did not authorize any disturbance or permits within the BLM surface Conservation Units. No new mineral materials permits were granted in or near Penstemon conservation areas or habitat.

2.2 BLM White River Field Office (Colorado)

In 2020, the BLM Colorado White River Field Office did not authorize any disturbance or permits within the BLM surface Conservation Units. No new mineral materials permits were granted in or near Penstemon conservation areas or habitat.

2.3 SITLA

SITLA provided funding in support of the implementation of the Penstemon Conservation Agreement totaling $4,795.84 in 2020. No new leases were issued within Penstemon conservation Areas in 2020.

TomCo's infraction mitigation was resolved with SITLA. Based upon a revised estimate, TomCo agreed to pay $19,266.00 for the disturbance created in 2019 in a SITLA interim conservation area before surveys could be conducted. SITLA has placed the funds into the Penstemon Mitigation Fund that it maintains on behalf of the Conservation Team.

2.4 Uintah County

Uintah County actively participated as a Team member throughout 2020. Uinta County also provided $4,320.00 in funding and significant in-kind resources including approximately $550.00 in equipment and volunteers for Penstemon Population Monitoring Reimplementation in May and June 2020.

2.5 Rio Blanco County

Rio Blanco County did not participate in the Team in 2020 due to changes to Rio Blanco County Commission leadership and organizational structure. The Team will work with Rio Blanco County to continue participation in 2021.

2.6 State of Utah/The Nature Conservancy

The State of Utah Department of Natural Resources ESMF provided $5,513.79 in FY2020 for support of the Penstemon Conservation Team and monitoring activities associated with Agreement.

2.7 Summary of Financial Contributions by Partnering Agencies

The Penstemon Conservation Team met five times in 2020 comprising one in-person meeting in Vernal, Utah and four conference calls. The direct funds and in-kind contributions associated with these meetings and other Agreement-related activities are summarized in Table 1.

Table 1. 2020 Conservation Agreement Financial Contributions by Partner Agencies

Partner	Direct Funds	In-Kind (hours)
BLM - CO	$500.00	261
BLM - UT	--	182
Utah DNR	$5,513.79	220
PLPCO	--	60
Rio Blanco County, Colorado	--	--
SITLA	$4,795.84	45
Uintah County, Utah	$4,870.00	26
USFWS - CO	--	30
USFWS - UT	--	90
TOTAL	**$15,679.63**	**914 hours**

A similar level of participation by the Agreement partner agencies is expected in 2021.

3 CONSERVATION AGREEMENT UPDATES

There were no changes to the Penstemon Conservation Agreement and Strategy in 2020.

4 DATA MANAGEMENT STRATEGY

All reports, publications, data, and literature mentioned in this annual report are compiled in the Penstemon Conservation Team Google Drive site, hosted by SITLA, and are accessible to all conservation team members. Disturbance shapefiles are updated and managed by Uintah County.

4.1 BLM

Any Utah BLM survey data for the beardtongues is submitted to the Utah Natural Heritage Program and Utah Fish and Wildlife Ecological Services Field Office. Any Colorado BLM survey data for the beardtongues is submitted to the Colorado Natural Heritage Program and Colorado Fish and Wildlife Service Field Office.

4.2 Manzanita Botanical Consulting

Any data collected by Manzanita Botanical Consulting in 2020 were submitted to the Penstemon Conservation Team for inclusion in this and future annual reports.

5 2020 FIELD SURVEY RESULTS

No surveys for Graham's beardtongue or White River beardtongue were conducted in 2020. Any new distribution information was acquired as part of Range-wide Population Monitoring Reimplementation (see Appendix A and Section 7.1).

5.1 BLM Vernal Field Office (Utah)

The BLM VFO surveyed approximately 552 acres for both Graham's and White River beardtongue as part of population monitoring plan reimplementation in 2020.

5.2 BLM White River Field Office (Colorado)

The BLM WRFO did not conduct any surveys in 2020.

5.3 State of Utah

No surveys for *P. grahamii* or *P. scariosus* var. *albifluvis* were performed by the Utah Department of Natural Resources or Utah State University in 2020.

5.4 SITLA

There were no surveys conducted on SITLA managed lands in 2020.

6 2020 SEED COLLECTIONS

No known seed collections took place in 2020 or were implemented under the 2017 Seed Management Plan (PCT 2017b).

7 ONGOING RESEARCH

Multiple research and monitoring activities have been implemented as part of the Agreement and are summarized by partner agency below.

7.1 Interagency Population Monitoring Reimplementation

In early 2020, the PCT worked with Colorado BLM to design a range-wide population monitoring program to replace the 2017 demographic monitoring plan. In May and June 2020, Utah DNR, BLM VFO, and BLM Colorado botanists reimplemented range-wide monitoring with the establishment of ten macroplot monitoring sites, six for Graham's beardtongue and five for White River beardtongue. BLM Colorado has five previously established sites (one for Graham's beardtongue and four for White River beardtongue) in conservation units 4 and 5. The 2020 results for the 15 established population monitoring sites are detailed in Appendix B and summarized for each species in the following sections.

7.1.1 White River Beardtongue 2020 Monitoring Results

Utah DNR, BLM VFO, and BLM Colorado botanists revisited the four existing White River beardtongue macroplot monitoring sites in May 2020 and established four new macroplot monitoring sites in May and June 2020. Disturbances included livestock hoof prints and droppings and native ungulate hoofprints and droppings. No direct damage to White River beardtongue plants was attributable to livestock or off-road vehicles.

7.1.2 Graham's Beardtongue 2020 Monitoring Results

Utah DNR, BLM VFO, and BLM Colorado botanists revisited the one existing Graham's beardtongue macroplot monitoring site in May 2020 and established six new macroplot monitoring sites in May 2020. Disturbances included livestock hoof prints and droppings, native ungulate hoofprints and droppings, and tire tracks. No direct damage to Graham's beardtongue plants was attributable to livestock or off-road vehicles.

7.2 BLM Vernal Field Office

In May and June 2020, the BLM VFO worked with DNR and BLM Colorado botanists to reimplement range-wide monitoring with the establishment of eleven new macroplot monitoring sites (summarized in Section 7.1).

7.3 BLM Colorado

In May 2020, annual monitoring activities for both Graham's and White River beardtongue were completed by the BLM Colorado State Office and researchers from University of Northern Colorado, the BLM VFO, and Utah DNR. Sites monitored included the single, long-term Graham's beardtongue study site in Colorado at Mormon Gap, and the three White River beardtongue study sites established between 2017 and 2018. Researchers from UNC also collected leaf tissue from both species to be used in phylogenetic analysis. BLM Colorado also provided significant assistance in mapping and monitoring new macroplot monitoring sites (summarized in Section 7.1)

The Interagency 2020 Penstemon Population Monitoring Report is attached as Appendix B.

7.4 Red Butte Garden/Utah Nature Conservancy/DNR

The Red Butte Conservation Program initiated a study of pollinator visitation and reproductive success relative to surface disturbance (roads) for White River beardtongue in 2018 and a parallel study for Graham's beardtongue in 2019. Data analysis was completed in 2020 (Barlow and Pavlik 2020). The aim of the project was to determine the effect of beardtongue population location, road density, and pollinator activity on reproductive output (seed production). Barlow and Pavlik (2020) used Rana video monitoring technology to record 1,373 hours (24,470 pollinator visits) to White River beardtongue at five sites over 12 days, and 2,300 hours (2,771 insect and 6 hummingbird visits) to Graham's beardtongue at five sites over 18 days. Osmia bees were the principal pollinators for both species. The pollen specialist Masarid wasp, *Pseudomasaris vespoides* was also a frequent visitor to White River beardtongue. Red Butte Garden collected 104,807 and 20,532 seeds for White River and Graham's beardtongue, respectively. The seed collections have been curated at the Red Butte Garden Conservation Program and other germplasm storage facilities.

Barlow and Pavlik (2020) evaluated the study data with Structural Equation Modelling (SEM) analyses of site position, population size and density, flower and stem density, pollinator visitation, road density, and time and temperature variables to quantify relationships between pollinator activity and surface disturbance. They found significant positive causal relationships between pollinator visitation rate and linear road density within 400 meters of the White River beardtongue study sites. There were also significant relationships between pollinator visitation and number of flowers and between visitation and density of flowering plants. For Graham's beardtongue, they found significant negative relationships between roads within 200 meters and pollinator visitation, but there was no effect beyond 200 meters. Their results suggest that surface disturbance effects on pollinator visitation and associated seed output are associated with spatial scale (site) and that Graham's and White River beardtongue respond differently. Positive

relationships with road density could reflect increased pollinator nesting sites in disturbed soil and roadside berms, while negative effects could be due to change in surface runoff and hydrology from roads. The authors recommend limiting new roads and surface disturbance within 200 meters of Graham's beardtongue populations. They also recommend conservation of larger, denser, or more robust beardtongue populations in washes with intact hydrology to mitigate negative effects from nearby road disturbance. The study results are expected to be published in 2021. Please contact the authors for information about the study results or publication (sarah.barlow@redbutte.utah.edu).

7.5 Utah DNR Endangered Species Mitigation Fund

Manzanita Botanical Consulting provided planning, study design, and field support for the reimplementation of range-wide population monitoring in May and June 2020. The population monitoring methods and year one results are summarized in Appendices A and B and Section 7.1.

Transplant experiments for Graham's and White River beardtongue were carried out in 2014 and 2015 and monitored through ESMF and partner funding in fiscal years (FY) 2014 through FY2017 and in FY2019 and FY2020. The objective of ongoing monitoring is to assess 1) transplant longevity, 2) the ability of transplanted individuals to recruit offspring and potentially function as a natural population, and 3) suitable habitat conditions and potential treatments for enhancing the survival of restored populations. Transplant success monitoring was continued in June 2020 with FY2020 Utah Endangered Species Recovery program funding.

We revisited the PESCAL-1 Enefit North transplant site on June 19, 2020. The seedlings that became established early in the transplant study have grown quite large and have mostly flowered annually. Of the original 64 seedlings transplanted in October 2014, 24 (37.5%) survived to June 2020. Of the surviving plants, 10 (41.7%) flowered and averaged 1.8 flowering stems and 5.1 flowers per plant, which is less than 10% of the reproductive effort observed in 2019. Most of the flowers were aborted with few developing fruits. We documented two seedlings in excellent condition near large reproductive transplants at the PESCAL-1 site.

We revisited the PEGR-1 Red Leaf Seep Ridge experimental site during Graham's beardtongue flowering on June 18, 2019. Plant survival at the experimental site appears to have stabilized, with 21 (21.0%) of the original 100 seedlings transplanted in October 2015 surviving to June 2020. Of the surviving plants, 66.7% flowered and averaged 5.0 flowering stems and 21.2 flowers per plant. Like 2019, there were large numbers of aborted flowers apparently due to the cool, wet spring and early summer conditions. There have been significant differences in caudex diameter, rosette, diameter, stem height, and flower number between the Shale + Utelite and Soil + Utelite treatments for all years of the study (ANOVA; $p < 0.001$). No recruitment of seedlings has been observed to date, but the continued successful flowering and seed set in the Shale + Utelite treatment suggests that recruitment is possible. Surviving plants continue to be stressed by competition from dense invasive annual weeds, with 43.5% and 33.3% weed cover in the soil and shale treatments, respectively. The results to date at the PEGR-1 site indicate that transplant, translocation, and restoration efforts for this species should be performed using native shale and Utelite or a similar soil amendment. The shale soil treatments excluded invasive weeds early in

the study but are now also becoming dominated by invasive annual weeds and by the neighboring seed mix forage species. Future restoration efforts should reduce the potential for weed invasion by minimizing soil mixing and proximity of potentially invasive species.

Successful White River beardtongue seedling recruitment at the Enefit North site demonstrates that establishment of a restored population may be feasible; however, seedling survival and additional recruitment will be required to quantitatively demonstrate restoration success with the establishment of a viable population. Monitoring of the Enefit North White River beardtongue and the Seep Ridge Graham's beardtongue experimental sites will continue in 2021.

8 FUTURE SUBCOMMITTEE WORK

The Penstemon Conservation Team has developed six management plans to date. Ongoing and expected future activities associated with these plans are summarized below.

8.1 Demographic/Population Monitoring Plan

Utah DNR, BLM VFO, and BLM Colorado botanists plan to revisit and monitor the 15 existing Penstemon macroplot monitoring sites and establish at least five new macroplot sites in May and June 2021. The addition of five macroplot monitoring locations will meet the plan target of two macroplots per species per conservation unit or a total of 20 monitoring sites.

8.2 Livestock Grazing Management Plan

Disturbance monitoring was reimplemented in 2020 as part of the revised population monitoring program. The revised methods comprise frequency monitoring of species composition, ground cover, disturbance, and invasive weeds using a nested quadrat approach. The methods are detailed in the attached plan (Appendix A). The revised disturbance monitoring methods will be tiered to a revised Livestock Grazing Management Plan in 2021.

8.3 Weed Management Plan

Weed monitoring was reimplemented in 2020 as part of the revised population monitoring program. The revised methods comprise frequency monitoring of species composition, ground cover, disturbance, and invasive weeds using a nested quadrat approach. The methods are detailed in the attached plan (Appendix A). The revised weed monitoring methods will be tiered to a revised Weed Management Plan in 2021.

8.4 Restoration Plan

The Restoration Plan Subcommittee drafted an outline restoration plan in 2017. The plan is in revised and is expected to be finalized in 2021.

8.5 Other Future Activities

Ongoing conservation-related research and activities are being conducted by the Agreement partner agencies. Expected 2021 activities include the following:

8.5.1 Climate Monitoring

Range-wide penstemon habitat climate monitoring will be conducted remotely using spatially explicit precipitation and temperature data (PRISM) for the macroplot monitoring locations. Use of historical and current climate data from the species' ranges and spatially explicit modeled climate data will maximize efficiency and use of available resources.

8.5.2 Seed Collections

Seed collections will continue in 2021 as climate-linked flowering and fruiting permits.

9 LITERATURE CITED

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Barlow, S. E., and B. M. Pavlik. 2018. Effects of distance to disturbance and population density on pollinator visitation and reproductive output of White River penstemon (*Penstemon scariosus* var. *albifluvis*) and Graham's penstemon (*P. grahamii*). Interim report prepared October 2018 for The Nature Conservancy. 12 pages.

Barlow, S. E., and B. M. Pavlik. 2020. Understanding the relationships between roads, pollinator visitation and reproductive output of White River penstemon (Penstemon albifluvis) and Graham's penstemon (P. grahamii) FINAL REPORT. Prepared by Red Butte Garden and Arboretum, University of Utah for the Endangered Species Mitigation Fund, Utah Department of Natural Resources and The Nature Conservancy. 43 pages.

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———. 2017a. *Conservation Agreement and Strategy for Graham's Beardtongue (*Penstemon grahamii) *and White River Beardtongue (*P. scariosus *var.* albifluvis*): Demographic Monitoring Plan*. Prepared by the Penstemon Conservation Team. March 31, 2017.

———. 2017b. *Conservation Agreement and Strategy for Graham's Beardtongue (*Penstemon grahamii*) and White River Beardtongue (*P. scariosus *var.* albifluvis*): Seed Management Strategy*. Prepared by the Penstemon Conservation Team. May 30, 2017.

Appendix A

Penstemon Population Monitoring Plan

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Conservation Agreement and Strategy for Graham's Beardtongue (*Penstemon grahamii*) and White River Beardtongue (*P. scariosus* var. *albifluvis*)

POPULATION MONITORING PLAN

Prepared by the Penstemon Conservation Team

State of Utah School and Institutional Trust Lands Administration
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PREFACE

This monitoring plan supersedes the 2017 Demographic Monitoring Plan for Graham's beardtongue (*Penstemon grahamii*) and White River beardtongue (*Penstemon scariosus var. albifluvis*) (PCT 2017). The purpose of this updated monitoring plan is to improve monitoring outcomes and streamline data collection by incorporating information obtained during the first three years of the monitoring program, and to allow feasible implementation with limited staffing and resources. This updated range-wide population trend monitoring study design consists of twenty permanent, long-term, trend monitoring sites (two monitoring sites per beardtongue species per conservation area) to document population trends of both species range-wide. In addition to population trend, supplemental information gathered at each study site - including the frequency of invasive weeds, vegetation composition, and evidence of disturbance - will be used to evaluate relative habitat condition. The purpose of the supplemental data collection is to meet monitoring objectives stated in the 2015 Weed Management and Livestock Grazing Management Plans (PCT 2015b, 2015c). Demographic monitoring will occur at a subset of the twenty monitoring sites. Adding to five previously established monitoring sites, ten new sites were established by the Penstemon Conservation Team (PCT) in May 2020. Five additional sites are to be added to the study system during the 2021 field season. Throughout the life of the plan, changes in the strategy will be made when necessary (new information, etc.) and as approved by the PCT using principles of adaptive management. If any problems are identified during monitoring, more intensive monitoring may be implemented in those areas.

INTRODUCTION

The 2014 Conservation Agreement and Strategy for Graham's beardtongue (*Penstemon grahamii*) and White River beardtongue (*Penstemon scariosus* var. *albifluvis*) includes a requirement that a long-term population monitoring plan be developed and implemented (Penstemon Conservation Team [PCT] 2014). Specifically, the Agreement calls for the development and implementation of "a species monitoring plan to determine trends in plant populations across their ranges and to identify significant threats to the species" (PCT 2014). A deliberative process beginning in 2016 resulted in the issuing of a Demographic Monitoring Plan for the two species the following year (PCT 2017). This monitoring plan employed a two-phase sample design at 25 randomly generated sample points per species. At the center of each sample point was a 1-meter square demography plot with three 25-meter transect lines radiating from the center. Along each of the three transect lines, nested frequency plots were measured at 5-meter intervals to quantify the change in *Penstemon* frequency (%) from year to year. Based on pilot data collected in 2017, 2018, and partial data collected in 2019, it was determined that the monitoring methods should be amended to alleviate issues related to insufficient sample size and staffing resources associated with the original study design.

Pursuant to Section 6.5 of the Conservation Agreement – Monitoring and Adaptive Management, in 2019 the PCT began a process of exploring options for adapting and improving the Demographic Monitoring Plan. Over the course of several meetings occurring between November 2019 and February 2020 the study design and updated range-wide population trend monitoring plan was developed and approved by consensus of the PCT for implementation beginning during the 2020 field season. The updated methods, summarized here, will help to streamline data collection and strengthen results – ensuring that monitoring is both efficient and robust. This range-wide Population Monitoring Plan supersedes the 2017 Demographic Monitoring Plan. The 2014 Agreement does not contain an explicit requirement for demographic monitoring. Nevertheless, recent demographic studies of both species (McCaffery et al.

2014) meet current needs for understanding population processes. Limited demographic monitoring is ongoing at a limited number of sites across both species ranges. Additional demographic monitoring may be implemented on an as needed basis as determined by the Penstemon Conservation Team.

The updated monitoring plan employs a series of permanent macroplots (i.e., large rectangular study sites) located at discrete *Penstemon* occurrences that are stratified by species (Graham's & White River) and conservation unit, in order to obtain a representative range-wide sample. Each *Penstemon* trend monitoring macroplot is sampled via a series of permanent 1m wide belt transects positioned at randomly selected locations within the plot. Population trend is determined by the change in mean plant density (*Penstemon* plants/m^2) from year to year. Invasive weed and disturbance monitoring is assessed at each site within a series of 30 to 50 $1m^2$ frequency quadrats nested within the belt transects at each plot (5 quadrats per transect to a maximum of 50 quadrats per macroplot). These additional monitoring components will help support the implementation of the Livestock Grazing and Weed Management Plans (PCT 2015b, 2015c). Demographic monitoring will occur at a subset of sites where all individual *Penstemon* plants occurring in the transect lines will be tagged and followed from year to year to quantify survivorship and recruitment rates.

The rationale for using permanent macroplots, rather than randomly selected sample points is based, in part, on precedent. Previous trend monitoring studies of the two *Penstemon* species have utilized macroplots rather than randomly placed transects. BLM Colorado has maintained a single long-term demographic monitoring macroplot of Graham's beardtongue at Mormon Gap in the White River Field Office since 2005 (BLM 2019). Since 2016, three additional demographic monitoring macroplots have been established at White River beardtongue populations in Colorado. Similar demographic monitoring studies using macroplots have been conducted on both *Penstemon* species in Utah by Red Butte Garden and Arboretum (McCaffrey 2014; Barlow and Pavlik 2020). Subjectively placed macroplots also ensure monitoring is efficient by eliminating sample size shortcomings based in the uncertainty of plant detection associated with a random selection of monitoring locations. Additionally, this new study design will allow for an assessment of populations relative to management objectives outlined by the Conservation Agreement and provide for a consistency in approach with previously established methods.

MANAGEMENT OBJECTIVES

This plan consists of three management objectives and three associated sampling objectives. The primary intent of the Agreement is to promote the long-term persistence of the two *Penstemon* species. Objective 3, as defined by the Conservation Agreement at pg. 3, is to "promote stable or increasing populations within identified conservation areas and across the range of the two species" (PCT 2014). Supplemental to this goal are two additional objectives that relate to the frequency of invasive plant species and disturbance at each monitoring site. The management and sampling objectives associated with this plan are:

Management Objective 1:

Maintain stable or increasing density *of Penstemon grahamii* and *Penstemon scariosus* var. *albifluvis* within the six conservation units designated by the Penstemon Conservation Agreement for the duration of the agreement (2020 – 2034).

Sampling Objective 1:

To be 80% confident of detecting at least a 20% change in mean *Penstemon grahamii* and *Penstemon scariosus* var. *albifluvis* density while maintaining the possibility of observing a false change or missed change error at ≤ 20%.

Management Objective 2:

Minimize the frequency of invasive weeds within occupied *Penstemon grahamii* and *Penstemon scariosus* var. *albifluvis* habitats. Monitoring will help detect invasive weed species incursions into, or increased weed frequency within, monitored *Penstemon* habitats for the duration of the agreement (2020-2034).

Sampling Objective 2:

To be 80% confident of detecting at least a 20% change in mean invasive weed species frequency while maintaining the possibility of observing a false change or missed change error at ≤ 20%.

Management Objective 3:

Minimize the frequency of domestic livestock related impacts to *Penstemon grahamii* and *Penstemon scariosus* var. *albifluvis* plants and occupied habitats. Monitoring will quantify the frequency of livestock trampling and other forms of disturbance and any changes in disturbance frequency within monitored penstemon habitats for the duration of the agreement (2020-2034).

Sampling Objective 3:

To be 80% confident of detecting at least a 20% change in mean disturbance frequency while maintaining the possibility of observing a false change or missed change error at ≤ 20%.

METHODS

The monitoring methods described here were adapted from the BLM technical references: *Measuring and Monitoring Plant Populations* (Elzinga et al. 1998) and the *Monitoring Manual for Grassland, Shrubland, and Savanna Ecosystems* (Herrick et al. 2005). Population trend monitoring is designed to assess whether *Penstemon* populations are increasing, decreasing, or stable by comparing differences in mean plant density across years. Understanding the trend of monitored populations can then be used to inform land management decisions / interventions aimed at reducing or eliminating threats to the species and minimize the likelihood of, and need for, their listing under the Endangered Species Act (BLM 2008).

Study Design

Monitoring will occur at a series of twenty permanent macroplots established at occurrences of both *Penstemon* species across their respective ranges (Figure 1). Conservation Units 2 (Seep Ridge), 3 (Evacuation), 4 (White River), and 5 (Raven Ridge) include occurrences of both *Penstemon* species and will each have four study sites – two per species. Units 1 (Sand Wash) and 6 (Book Cliffs) include just one species – *Penstemon grahamii* in Unit 1 and *Penstemon scariosus* var. *albifluvis* in Unit 6 – each of these units will have two study sites.

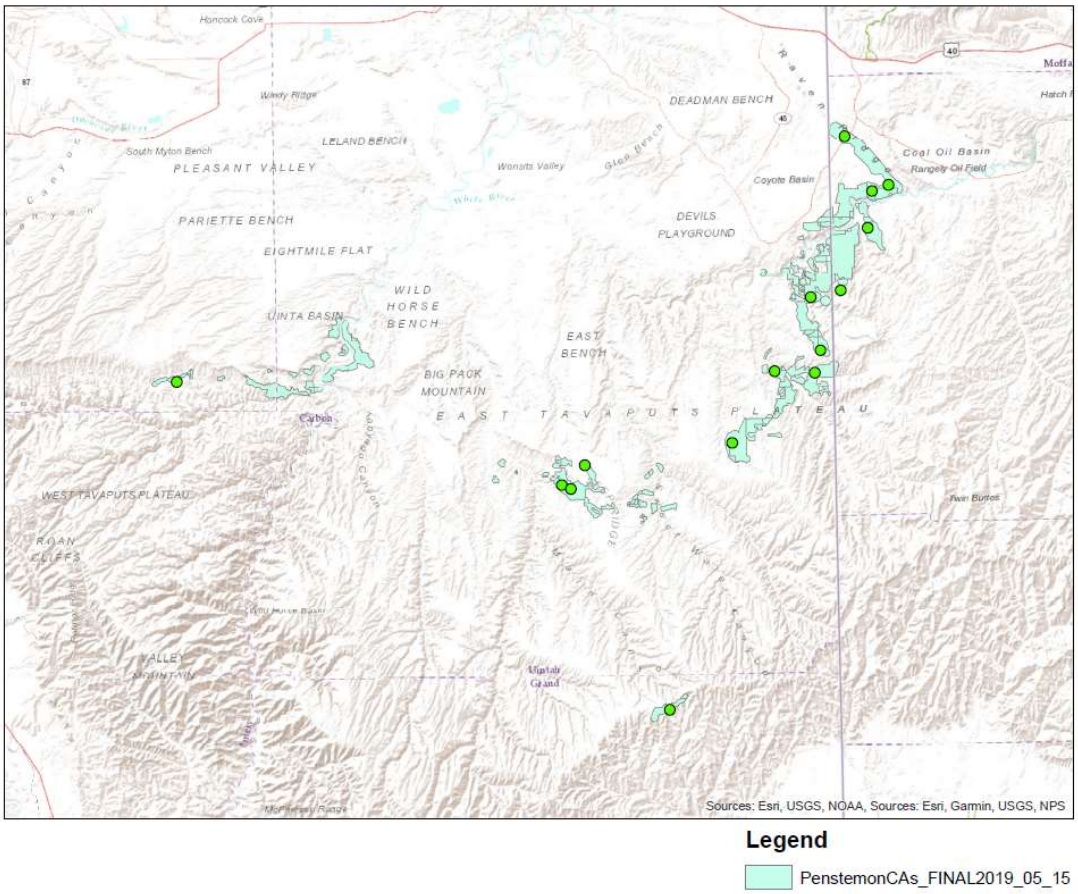

Figure 1. Distribution of *Penstemon* monitoring sites within the 6 Conservation Units as of February 2021.

Populations were selected for trend monitoring from PCT aggregated spatial occurrence data. Consideration related to the spatial distribution of study populations and variation in habitat and other bioclimatic variables of occupied sites were taken into account when selecting study sites. Populations were identified for sampling based on BLM surface management responsibility, the relative importance of the population for the conservation of the species overall, and in areas where certain management questions can be assessed. One *Penstemon scariosus* var. *albifluvis* study site established in 2020 is located on conservation area private land held by Enefit American Oil ("Enefit").

It is important to note, that since the macroplots were subjectively located the extent to which inferences can be drawn to the larger landscape from our study sites ultimately represents a subjective assessment (Karl 2014).

Study Site Establishment

A permanent rectangular macroplot is established at each occurrence selected for sampling. Each macroplot is oriented to capture a portion of the target population considered to be representative of the site. Macroplot dimensions vary among sites based on population size and structure at location of occurrence. Plot corners are monumented with rebar and marked with GPS to aid in relocation.

Within each macroplot permanent sampling units (1m wide belt transects) are established. In order to limit observer bias, transect locations are selected using a restricted random method (Elzinga et al. 1998). Ten-inch steel stakes are placed in the middle and at both ends of each transect. When transect length exceeds 25 meters, quarter points are established to aid in the accuracy of data collection.

Data Collection Procedure

Monitoring data will be collected during the spring (approximating peak phenology) as a collaborative effort organized by the PCT monitoring sub-committee. After at least two sampling intervals at each monitoring site, monitoring intensity may be decreased to biannually. A decision to decrease sampling interval frequency will be subject to the discretion of the PCT and based on observed stable to increasing trends and available resources.

Population Trend Monitoring

Population trend monitoring data is collected on site-specific paper field data forms. At each monitoring site a group of observers establishes the macroplot perimeter and then strings the series of transect lines within the macroplot using 50m survey tapes attached at either end to the permanent nails marking the transect locations. Using a metal carpenters tape measure, the researcher walks the length of the transect recording the number of *Penstemon* plants occurring in the 1m wide transect belt on their data sheet. The resulting data consists of a total number of plants/m^2 for each transect. The average of all the transects are taken to calculate the mean density of the entire macroplot. Population estimates can be extrapolated for each plot by multiplying the average density by the area of the macroplot.

For both species, the researcher will document whether each plant detected was in a reproductive or vegetative stage at the time of sampling. Plants are classified as reproductive if they possess sampling year reproductive structures (either flowers or fruits), vegetative individuals either lack reproductive structures or possess a previous year's flowers or fruits. Additional information gathered for each detected *Penstemon grahamii* plant consists of the number of rosettes per individual plant. For White River beardtongue the number of flowering stems per reproductive individual is recorded. Notes will also be taken indicating evidence of browsing or herbivory and the general condition of the plant.

Individual plants are usually discrete and easily identifiable on sparse shale barrens. Though, in situations where plants occur in dense clumps (more frequently observed in *Penstemon scariosus* var. *albifluvis*) a general rule is that if a mature clump is separated from another by >10cm of soil it is considered a separate individual. In situations where there are many seedlings (or very young plants) occupying a small space, the 10cm rule does not apply and each is counted individually.

Disturbance and Invasive Plant Species Monitoring

Disturbance and invasive plant species frequency data will be collected on site-specific paper field data forms. At each macroplot, researchers will place a one-meter square quadrat frame at five randomly selected intervals along the transect lines for a minimum of 30 and maximum of 50 quadrats per macroplot. At each quadrat, the observer records the presence (frequency) of all native plant species, invasive plant species, ground cover, and any disturbance by type (hoof print, tire track, erosion, etc.). The resulting data is nested frequency of all plant cover, ground cover, and disturbance, where the total frequency of species by functional groups, invasive species, ground cover, or disturbance across all quadrates divided by the total number of quadrats sampled provides a mean frequency value for the entire

macroplot. The nested frequency quadrat locations will be selected annually using a random number generator prior to monitoring.

Demographic monitoring

In order to address questions related to the life history and vitality of population's, demographic metrics will be recorded at a subset of monitoring sites. At demographic monitoring sites, plants detected in each 1m wide transect belt will be tagged with an 8" nail and individually numbered aluminum tag. Tags will be placed ca. 5-10cm from the plant in the direction of the macroplot origin. In order to relocate individuals from year to year, X / Y coordinates are recorded for each nail in order to assist with relocation. Demographic metrics include but are not limited to: reproduction, recruitment, and longevity of individuals. In addition to the stage of each plant (reproductive or vegetative), for each detected *Penstemon grahamii* plant the number of rosettes per individual plant is recorded. For *Penstemon scariosus* var. *albifluvis* the number of flowering stems per reproductive individual is recorded.

Survivorship and transition rates:

Raw data from our tagged sample can be easily transformed to determine survival and transition rates for various life stages (*e.g.,* seedlings, vegetative adults, reproductive adults). McCaffrey 2014 describes the procedure for performing naïve survival analysis from raw data. Survivorship is determined by the proportion of plants in a certain life stage that survive to the following year. [(# of plants alive in year t+1)-(new plants marked in year t+1)]/# of plants alive in year t).

Reproduction and recruitment:

A commonly used method of quantifying plant reproduction is to calculate the ratio of the number of seedlings counted in year $t + 1$ to the number of flowering plants in year t. (# of new plants in year t+1 / the number of reproductive plants in year t). This method assumes that all new seedlings present in year $t + 1$ were a product of the previous year's flowering individuals. This method does not account for the effect of a soil seedbank, plant dormancy, or imperfect detection. This method has been used previously in demographic studies of the two *Penstemon* species and eliminates the need to visit each monitoring site on two different occasions per monitoring season. Allowing for easy interpretation of reproductive success.

Climate monitoring

Interactions between climate (precipitation and temperature) and population trend will be evaluated using spatially explicit climate data. Data sources will comprise the PRISM database (PRISM 2021) or other available climate datasets.

Power Analysis

Population trend:

Two years of data are required to perform sample size calculations. If necessary, the number of sampling units within the macroplot will be adjusted following the second sampling interval to accommodate the necessary number of samples required to obtain statistically meaningful results. The calculation used to

determine the necessary number of samples to detect a specified amount of change in plant density between two time periods using permanent sample units is:

$$n = \frac{(s)^2(Z_\alpha + Z_\beta)^2}{(MDC)^2}$$

Where n is the necessary number of transects needed to detect a specified amount of change between two samples according to a specified power (Elzinga et al., 1998; Sample Size Equation 3). Calculations are performed to meet a sampling objective that maximizes statistical power (≥ 0.8) of detecting at least a 20% change in mean plant density, while maintaining the possibility of committing either a type 1 or 2 error at ≤ 20%.

A finite population correction factor (fpc) is applied when sampling > 5% of the within-plot population:

$$n' = \frac{n}{(1 + \left(\frac{n}{N}\right))}$$

Disturbance and invasive plant species:

A similar sample size estimation approach will be used to determine the minimum number of nested quadrats needed at each monitoring location (Elzinga et al. 1998, 2001; Sample Size Equation 5). The number of nested quadrats will be adjusted following the second sampling interval using the following sample size equation (equation 5, Elzinga et al. 2001):

$$n = \frac{\left[Z_\alpha + Z_\beta\right]^2 [p_1 q_1 + p_2 q_2]}{[p_2 - p_1]^2}$$

Preliminary sample size estimations based on the 2020 data indicate that our sampling approach is more than adequate to capture interannual changes in nested disturbance frequency.

Statistical analysis

Population trend:

Each transects sampling results are compared from year to year using a two-tailed paired t-test analysis to determine the significance ($p \leq 0.05$) of changes in mean density over time. As with determining sample size, if more that 5% of a population has been sampled you must apply the fpc to the results of the significance test (Elzinga et al., 1998).

Range-wide trends are determined by assessing the mean change in plant density across all monitoring plots between years.

All statistical transformations can be completed using Microsoft Excel.

Disturbance and invasive plant species:

Nested quadrat-level frequency of invasive species and disturbance will be compiled for each monitoring macroplot. Average frequency of invasive species or disturbance (by type) will be analyzed using chi-

square test for between-year or between-site analyses and McNemar's test for within-site analyses (Elzinga et al. 2001).

Reporting

Monitoring results will be summarized in the PCT annual reports and as part of regular progress reports.

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PRISM. 2021. PRISM Climate Group ©2021, Northwest Alliance for Computational Science & Engineering, Oregon State University, Corvallis, Oregon. http://www.prism.oregonstate.edu.

Appendix B

2020 Penstemon Population Monitoring Report

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Graham's Beardtongue (*Penstemon grahamii*) and White River Beardtongue (*Penstemon scariosus* var. *albifluvis*)

2020 Population Monitoring Report

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June 30, 2021

Introduction

The aim of the penstemon population monitoring program is to document range-wide population trends for both species as required in the 2014 Penstemon Conservation Agreement and Strategy (PCT 2014). In addition, the revised monitoring methods implemented in 2020 (PCT 2021) and results reported here include quantification of disturbance (livestock, human activity, native herbivores), habitat composition, and invasive weeds. The revised Penstemon Population Monitoring Plan was finalized in March 2021 (PCT 2021) concurrently with this report.

The Colorado BLM Threatened and Endangered Species Program established five population monitoring sites from 2005 to 2018 within the Colorado portions of the species' ranges. In May and June 2020, the Colorado BLM, BLM Vernal Field Office, Uintah County, Utah, and Utah Division of Natural Resources established ten new macroplot monitoring sites ((Figure 1). Five additional macroplots will be added to the study system during the 2021 field season for a total of ten population monitoring sites for each species, or two macroplots per species in each of the species' five conservation units.

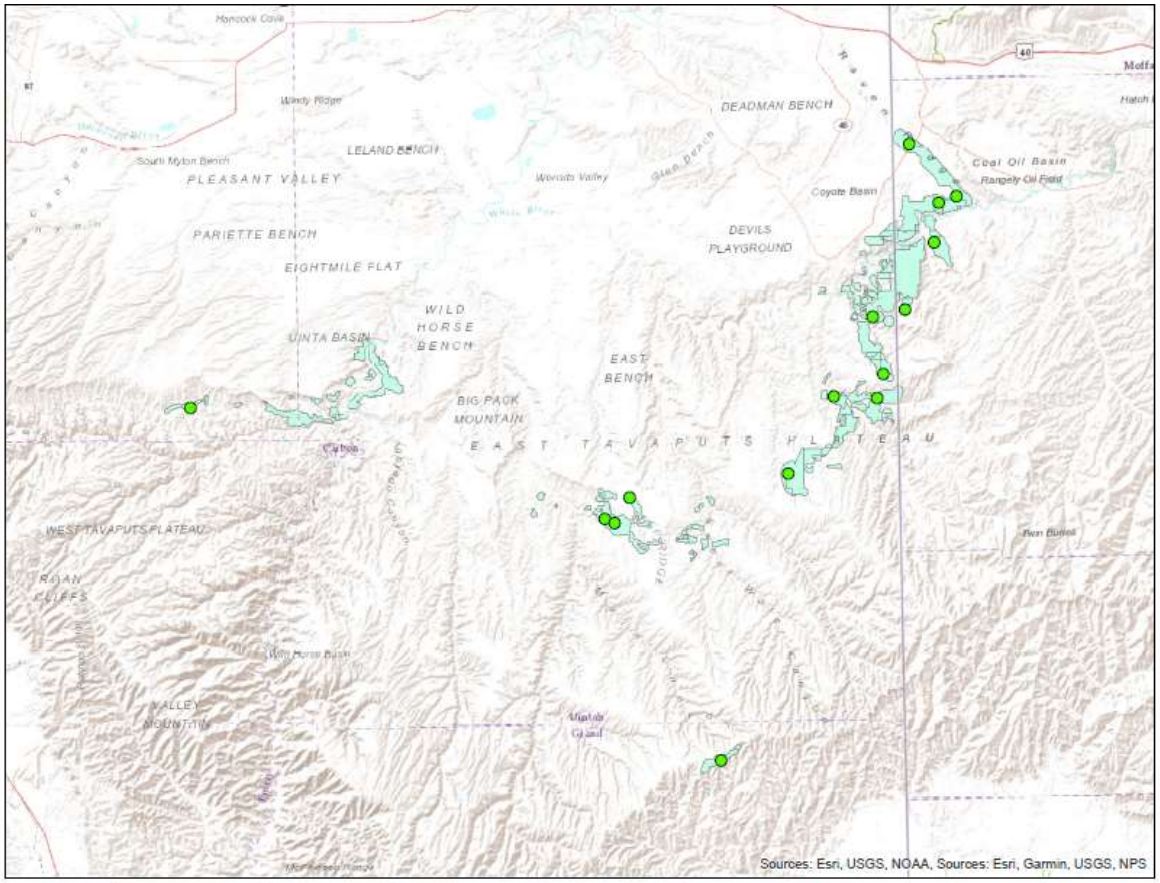

Figure 1. 2020 distribution of 15 established beardtongue macroplot monitoring sites in the Penstemon conservation areas.

This report summarizes the methods and population trend and habitat monitoring results for the 15 macroplots distributed across the ranges of both species in 2020. We also include a brief discussion and management implications and recommendations based on the 2020 results.

Methods

Implementation of the updated Penstemon range-wide monitoring plan began in May 2020. A total of ten monitoring sites (six *Penstemon grahamii* and four *Penstemon scariosus* var. *albifluvis*) were added to the range-wide monitoring program during the 2020 field season. Additionally, data was collected at four previously established long-term monitoring sites: *Penstemon grahamii* – Mormon Gap; and *Penstemon scariosus* var. *albifluvis* – Raven Ridge 1, Raven Ridge 2, and Weaver Canyon. No data was collected at the Cottonwood Creek (*P. scariosus* var. *albifluvis*) study site in 2020. The addition of 10 monitoring sites leaves five monitoring sites yet to be established to reach the objective of maintaining a total of 20 monitoring sites for the two species among the six Conservation Units.

The population monitoring methods are detailed in the Penstemon Population Monitoring Plan (PCT 2021). Any changes to or deviations from the methods given in the 2021 Penstemon Population Monitoring Plan are addressed here.

Management Objectives

The Penstemon Population Monitoring Program addresses three management objectives:

Management Objective 1

Maintain stable or increasing density of *Penstemon grahamii* and *Penstemon scariosus* var. *albifluvis* within the six conservation units with 80% confidence of detecting a 20% or greater change in mean beardtongue density. The objective was addressed by tallying seedlings, nonflowering, and flowering individuals within a set of one meter wide transects randomly positioned along the baseline of each macroplot.

Management Objective 2

Minimize the frequency of invasive weeds within occupied *Penstemon grahamii* and *Penstemon scariosus* var. *albifluvis* habitats with 80% confidence of detecting a 20% or greater change in mean invasive weed species frequency. This objective was addressed by recording the presence of invasive weed species in 50 nested frequency one-meter square quadrats systematically placed within the belt transects in each macroplot. The position of the nested frequency quadrats will be selected randomly at each monitoring site in future years.

Management Objective 3

Minimize the frequency of domestic livestock related impacts to *Penstemon grahamii* and *Penstemon scariosus* var. *albifluvis* plants and occupied habitats with 80% confidence of detecting a 20% or greater change in mean disturbance frequency. This objective was addressed by recording the presence of livestock and native ungulate sign (hoof prints, droppings), human activity (footprints, tire tracks), or herbivore sign (droppings) in 50 nested frequency one-meter square quadrats systematically placed within the belt transects in each macroplot. The position of the nested frequency quadrats will be selected randomly at each monitoring site in future years.

Disturbance and invasive weed species monitoring methods were piloted in May 2020. We did not collect disturbance or habitat composition data at the Graham's beardtongue Mormon Gap site or the White River beardtongue Weaver Canyon or Cottonwood Creek sites.

In establishing trend monitoring, the first year of data establishes the benchmark for the subsequently documented trend. Therefore, the conditions present during the first year of data collection may impact sample size calculations (performed using the difference between the first two years of data), and whether the trend appears to be increasing or decreasing over the short term. Ideally, plot establishment and the first year of data collection would occur during an "average" year. The twelve months preceding 2020 data collection featured below average precipitation across the range of the two *Penstemon* species. During the year preceding 2020 monitoring, total precipitation ranged between 50-90% across the Uinta Basin relative to the 30-year average (1981-2010; PRISM Climate Group 2020). Long-term monitoring datasets from both species in northwestern Colorado indicated that there was not a significant difference in plant density relative to 2019. However, reproduction rates and the number of flowering stems per reproductive individual (*P. scariosus* var. *albifluvis*) and total rosettes (*P. grahamii*) were both notably lower in 2020 than in previous years. A portion of the impact to the reproductive output documented in *P. scariosus* var. *albifluvis* was due to insect herbivory. Rates of insect damaged plants averaged 40% (0.12, 0.90) across the seven *P. scariosus* var. *albifluvis* monitoring sites visited in 2020.

Results

Population trend and disturbance and habitat composition results are summarized for each species and detailed for each monitoring site in the sections below.

Graham's Beardtongue Population Trend

The Graham's beardtongue macroplots were monitored from May 17 to May 21, 2020. Six new macroplot monitoring sites were established in 2020 in Conservation Unit 1 (Wrinkles Road), Unit 2 (E. Sand Wash, Sunday School 1), Unit 3 (Dragon, Wolf's Den), and Unit 4 (Hell's Hole). Mormon Gap (Unit 5) is the only *Penstemon grahamii* monitoring site with relevant trend data to report in 2020. (Table 1).

Table 1. 2020 Summary Statistics for the *Penstemon grahamii* Monitoring Sites

2020	Mormon Gap	Dragon	E. Sand Wash	Hell's Hole	Sunday School 1	Wolf's Den	Wrinkles Road
Date Established with Sample Size	2009	N/A	N/A	N/A	N/A	N/A	N/A
Macroplot area (m^2)	700	800	1500	240	1200	1200	1200
Transects (m)	15 (1x35m)	12 (1x20m)	12 (1x30m)	6 (1x20m)	12 (1x30m)	12 (1x40m)	12 (1x30m)
Est. plant total in 2020	60	107	203	34	540	373	77
% reproductive	13%	13%	5%	59%	9%	26%	0%
Significant increase or decrease in 2020 since initiation	sig. decrease	N/A	N/A	N/A	N/A	N/A	N/A
p	0.02	N/A	N/A	N/A	N/A	N/A	N/A
Mean density 2020 (plants/m^2)	0.09	0.09	0.14	0.14	0.45	0.31	0.06

Table 1 lists N/A for newly established sites where two years of data are not yet available for comparisons. The *p-value* is the result of a two-tailed paired t-test performed between 2020 and the first year of data collection at each site (*p* values of < 0.05 are considered statistically significant). For conservation units 1 through 4 population trend results will be reported following the second year of monitoring in 2021. Graham's beardtongue does not occur in Conservation Unit 6.

Graham's Beardtongue Disturbance and Habitat Composition

In May 2020, we collected pilot disturbance and habitat composition data at the six newly established Wrinkles Road (CU1), East Sand Wash and Sunday School 1 (CU2), Dragon and Wolf's Den (CU3), and Hell's Hole (CU4) macroplot monitoring sites. In general, this species occurs on gentle slopes or ledges in shale barrens that contain sparsely distributed shrubs, forbs, and grasses. Common species associates comprise a suite of shale-tolerant species: ephedra buckwheat (*Eriogonum ephedroides* [CO BLM Sensitive], Dragon milkvetch (*Astragalus lutosus*), Barneby's cryptanth (*Cryptantha barnebyi*), and ephedra buckwheat (*Eriogonum ephedroides*).

Total frequency is given as a proportion for four disturbance classes (human, livestock, native ungulate, other), three ground cover classes (shale, bare ground, litter), four vegetation classes (shrubs, forbs,

grasses, invasive species), and for the target species. Frequency of Graham's beardtongue is also included in the forbs class. Year 1 results are summarized for each monitoring macroplot following the population trend results, where available.

Conservation Unit 1 (Sand Wash)

We established one Graham's beardtongue macroplot near Wrinkles Road in conservation unit 1 in May 2020. We plan to establish a second macroplot monitoring location in conservation unit 1 in 2021.

Wrinkles Road Population Trend

Population trend will be reported following the second year of data collection in 2021.

Wrinkles Road Disturbance and Habitat Composition

The Wrinkles Road monitoring site comprises a relatively small Graham's beardtongue population on a west-south-west facing slope with soft shale soils. Frequency by cover class is illustrated in Figure 2.

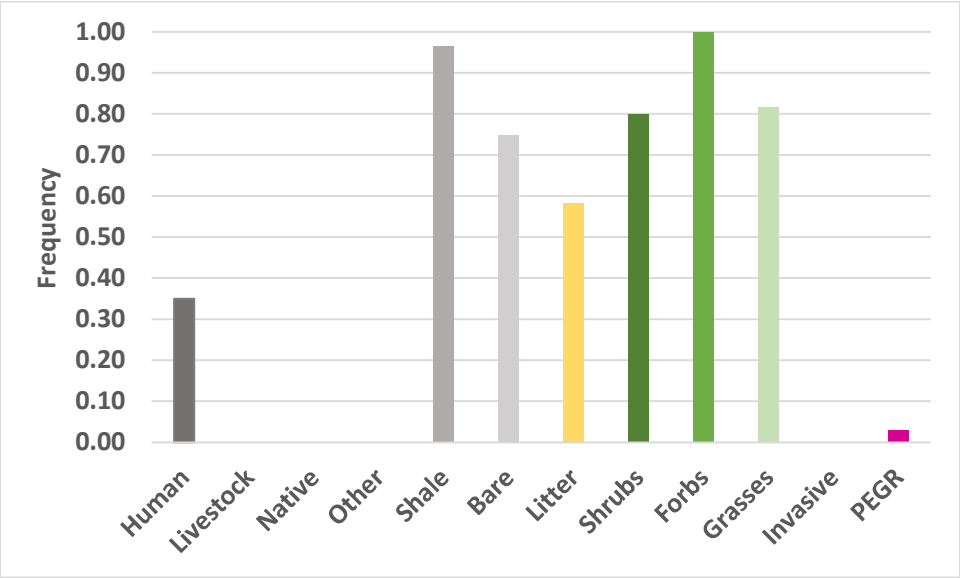

Figure 2. Frequency of disturbance, ground cover, vegetation, and Graham's beardtongue at the Wrinkles Road monitoring site.

The site is dominated by surface shale, stemless four-nerve daisy (*Tetraneuris* [*Hymenoxys*] *acaulis*), and salina wild rye (*Leymus salinus*). No livestock disturbance or invasive species were recorded in the macroplot. Frequency of human disturbance by the monitoring crew was relatively high due to the soft soils at the site.

Conservation Unit 2 (Seep Ridge)

We established two Graham's beardtongue macroplot monitoring sites at East Sand Wash and Sunday School Canyon in conservation unit 2 in May 2020. No additional monitoring locations are planned for 2021.

East Sand Wash Population Trend

Population trend will be reported following the second year of data collection in 2021.

East Sand Wash Disturbance and Habitat Composition

The East Sand Wash monitoring site contains a large but sparsely distributed population on a flat-topped knoll. Frequency by cover class is illustrated in Figure 3.

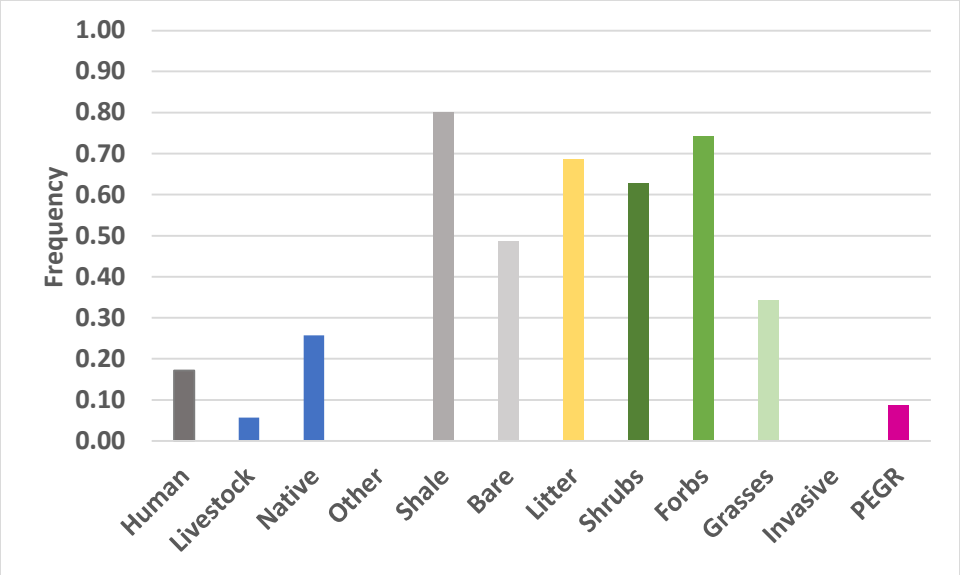

Figure 3. Frequency of disturbance, ground cover, vegetation, and Graham's beardtongue at the East Sand Wash monitoring site.

The site is dominated by shale, slender and ephedra buckwheat (*Eriogonum microthecum* and *E. ephedroides*, respectively), and a diverse community of shrubs and forbs. There was evidence of vehicle tire tracks and livestock activity within the plot. Native ungulate sign was also present.

Sunday School Canyon 1 Population Trend

Population trend will be reported following the second year of data collection in 2021.

Sunday School Canyon 1 Disturbance and Habitat Composition

The Sunday School Canyon 1 monitoring site contains a sparsely distributed population. Frequency by cover class is illustrated in Figure 4.

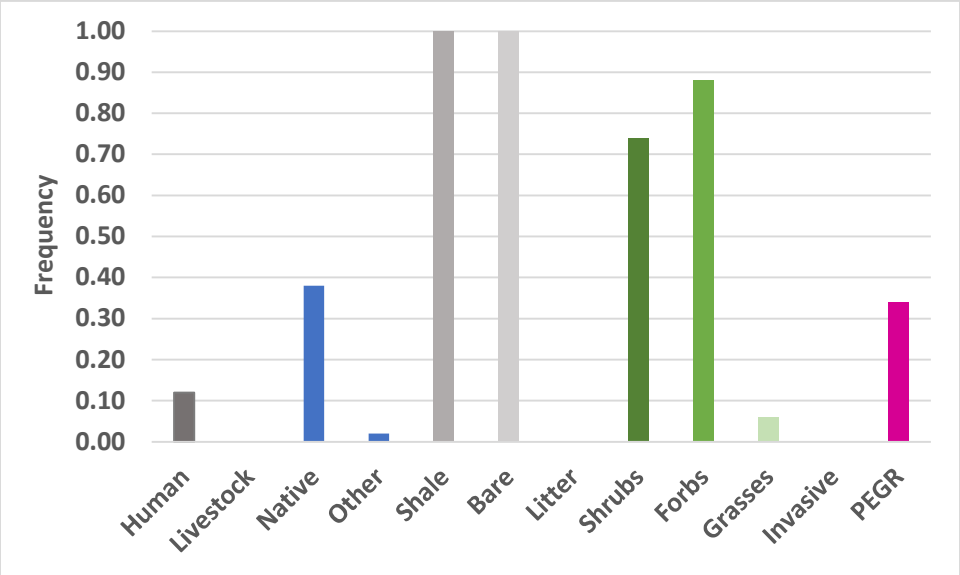

Figure 4. Frequency of disturbance, ground cover, vegetation, and Graham's beardtongue at the Sunday School Canyon 1 monitoring site.

The site is dominated by shale, a diverse community of mat-forming forbs and shrubs. There was evidence of vehicle tire tracks within the plot, but no livestock sign was present. Native ungulate sign was scattered throughout the plot.

Conservation Unit 3 (Evacuation Creek)

We established two macroplot monitoring sites at Dragon and Wolf's Den in conservation unit 3 in May 2020. No additional monitoring locations are planned for 2021.

Dragon Population Trend

Population trend will be reported following the second year of data collection in 2021.

Dragon Disturbance and Habitat Composition

The Dragon monitoring site comprises a Graham's beardtongue population on a steep north-facing slope with intact shale. Frequency by cover class is illustrated in Figure 5.

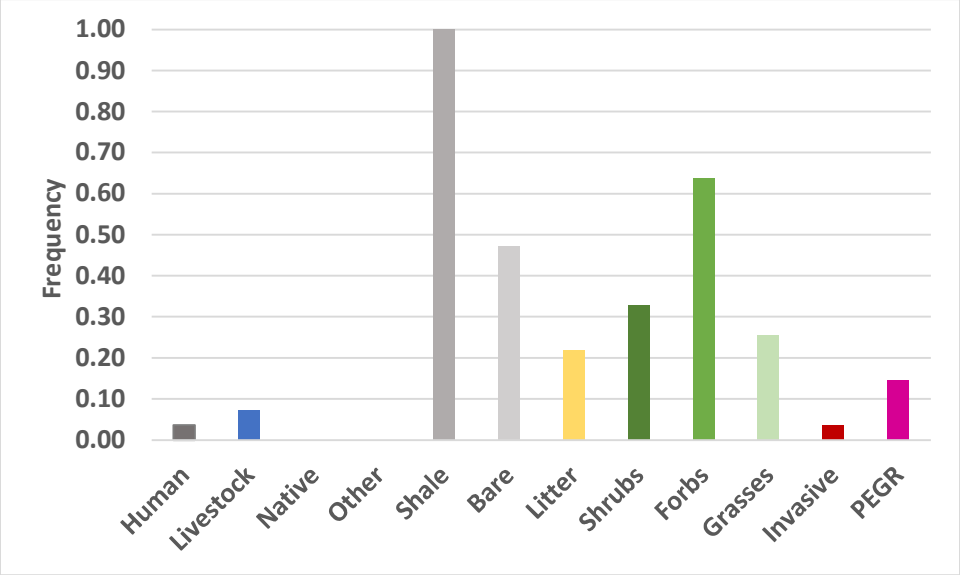

Figure 5. Frequency of disturbance, ground cover, vegetation, and Graham's beardtongue at the Dragon monitoring site.

The site is dominated by shale with sparsely distributed shrubs and forbs and occasional grasses. Cheatgrass (*Bromus tectorum*) is present at low frequency. There was evidence of sheep activity in and near the macroplot.

Wolf's Den Population Trend

Population trend will be reported following the second year of data collection in 2021.

Wolf's Den Disturbance and Habitat Composition

The Wolf's Den monitoring site comprises a dense Graham's beardtongue population on a shallow toe slope with intact shale. Frequency by cover class is illustrated in Figure 6.

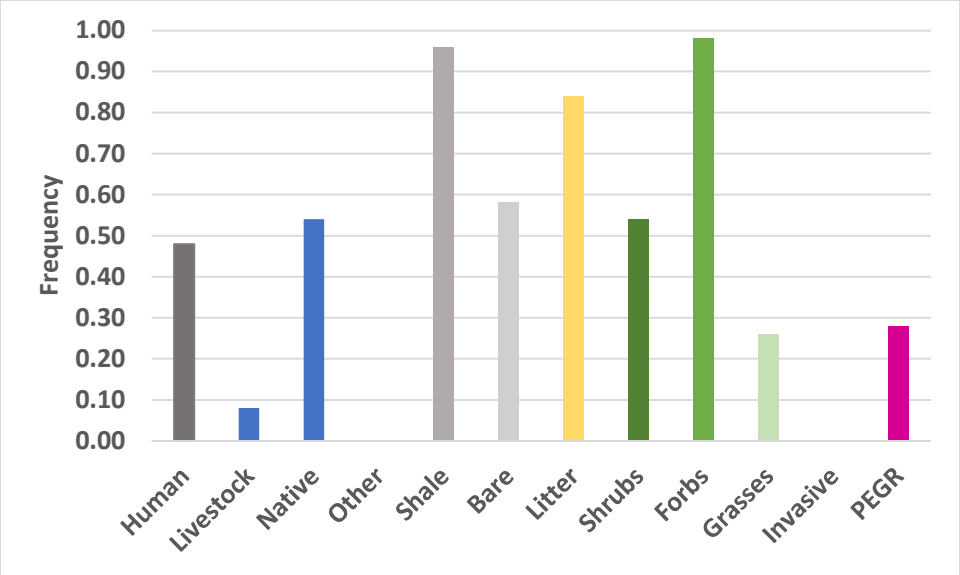

Figure 6. Frequency of disturbance, ground cover, vegetation, and Graham's beardtongue at the Wolf's Den monitoring site.

The site is dominated by shale with sparsely distributed shrubs and forbs and occasional grasses. Cheatgrass (*Bromus tectorum*) is present at low frequency. There was evidence of sheep activity in and near the macroplot.

Conservation Unit 4 (White River)

We established one macroplot monitoring site in Hell's Hole Canyon in conservation unit 4 in May 2020. We plan to establish a second macroplot monitoring location in conservation unit 4 in 2021.

Hell's Hole Population Trend

Population trend will be reported following the second year of data collection in 2021.

Hell's Hole Disturbance and Habitat Composition

The Hell's Hole monitoring site comprises a small Graham's beardtongue population distributed above and below a shale ledge. Frequency by cover class is illustrated in Figure 7.

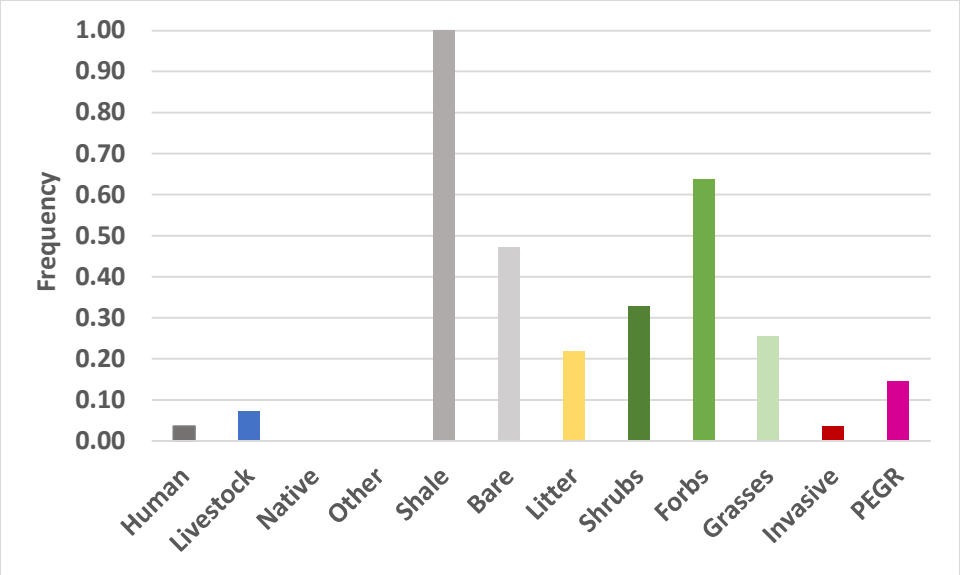

Figure 7. Frequency of disturbance, ground cover, vegetation, and Graham's beardtongue at the Hell's Hole monitoring site.

The site is dominated by shale and saline wild rye with a diverse assemblage of native forbs and shrubs. Cheatgrass (*Bromus tectorum*) is present at low frequency. There was evidence of sheep activity in the macroplot.

Conservation Unit 5 (Raven Ridge)

No additional macroplot monitoring sites were established for Graham's beardtongue in conservation unit 5 in 2020.

Mormon Gap Population Trend 2005-2020

Data collection has occurred at the Mormon Gap site for eleven of the fifteen years since the site was established (no data collected in 2006, 2007, 2008, and 2013). The population has experienced a statistically significant decrease since monitoring began at the site ($p = 0.02$). Since monitoring was established at the site, the Mormon Gap population has ranged from an estimated 19 to 101 plants – correlating to an average estimated plant density of 0.09 plants/square meter (m^2) over the same period (Figure 8).

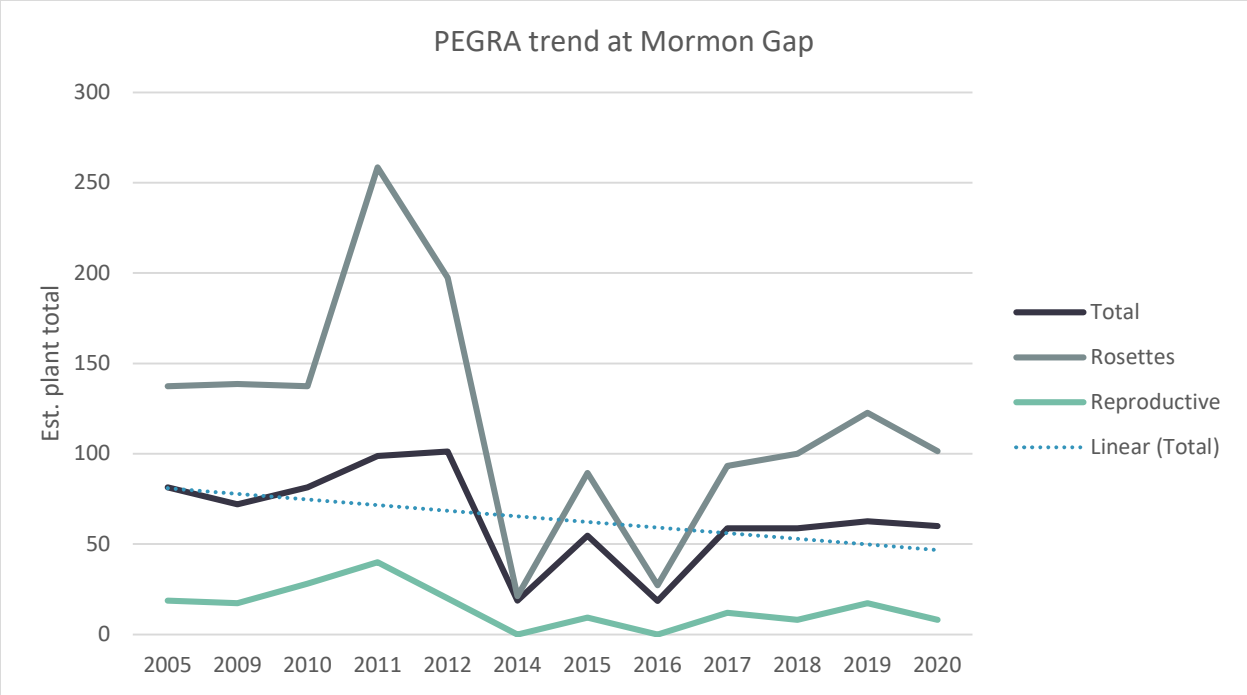

Figure 8. Total, reproductive, and rosette PEGRA trend at Mormon Gap. Trend is defined by the change in the estimated population total between 2005 and 2020.

The population has experienced a significant decrease in plant density (p = 0.02) since monitoring was established – the result of livestock impacts which occurred between the 2012 and 2014 sampling intervals (Figures 9 and 10). Despite being smaller than when monitoring was established, the population has been stable to increasing over the last six monitoring intervals (2014 - 2020). Since 2017 the population has exhibited very little change in size, the standard deviation in the total number of plants from 2017 – 2020 is σ = 1.41. Despite the stability in its current trend, the Mormon Gap population remains a conservation priority due to its isolation from other populations, its small size, and sluggish growth rate.

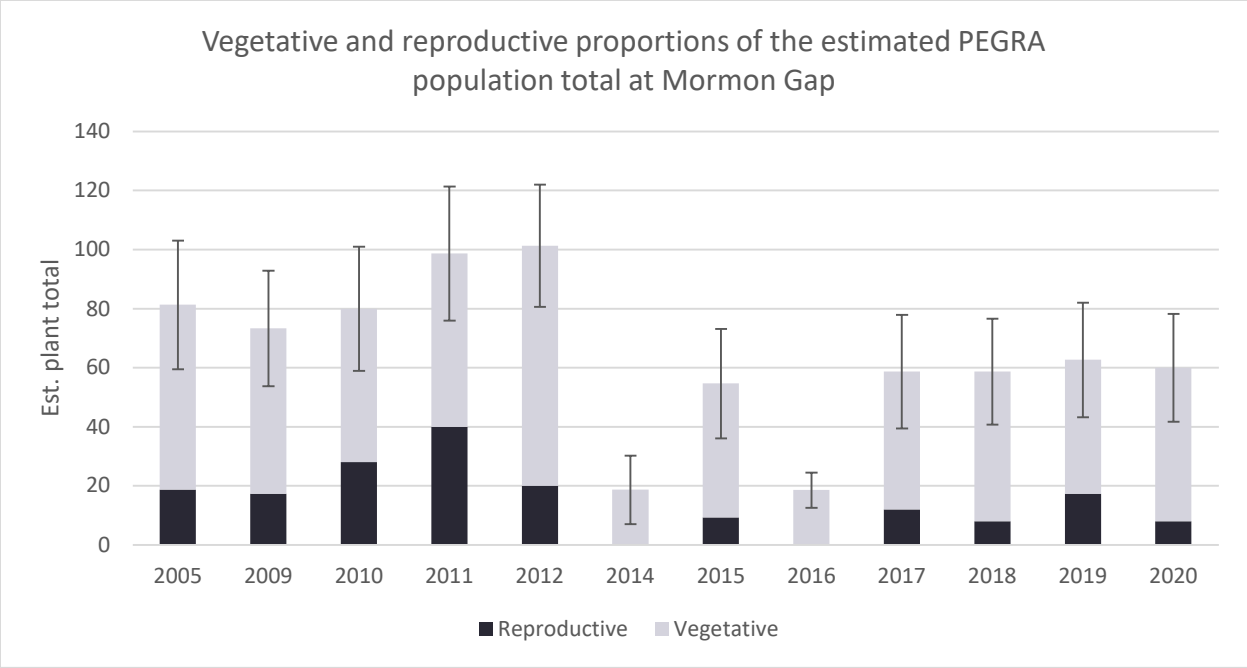

Figure 9. Estimated PEGRA totals per year at Mormon Gap broken down by life stage. 95% confidence interval are displayed around the estimated plant total.

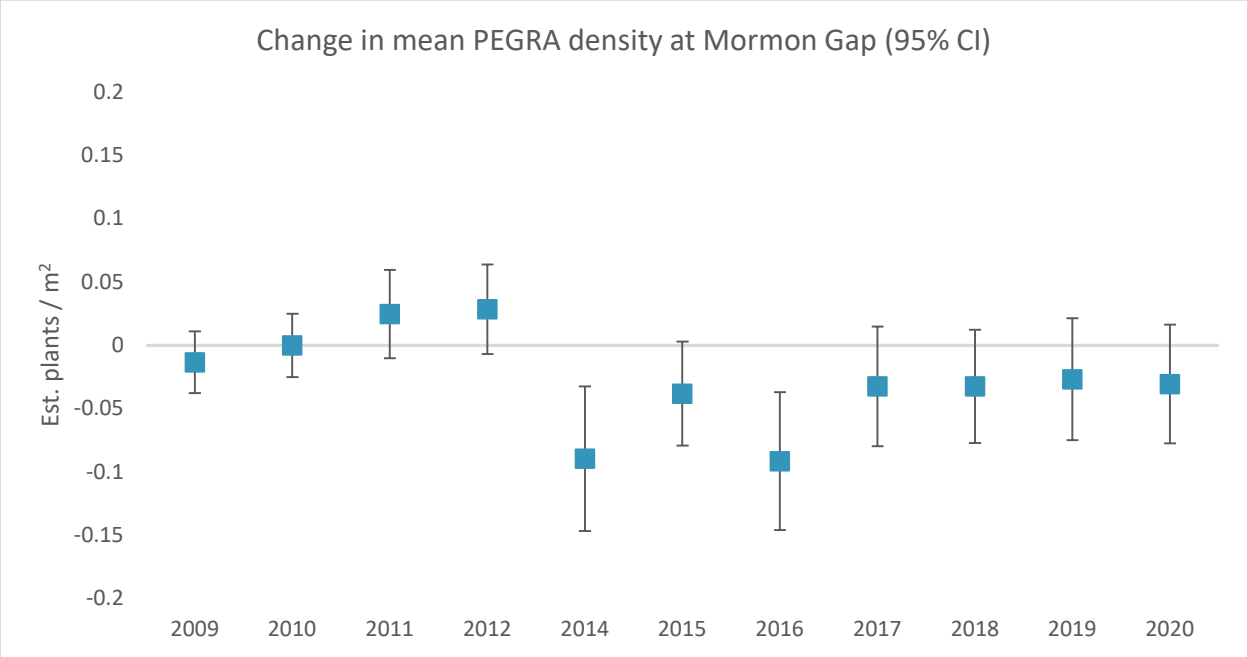

Figure 10. Population change at Mormon Gap as defined by the change in mean PEGRA plant density (plants/m^2) between 2005 and 2020. 95% confidence intervals are displayed on either side of the mean value.

Mormon Gap Disturbance and Habitat Composition

No disturbance or habitat composition data were collected at the Mormon Gap site in 2020. However, these monitoring methods will be implemented at the site in 2021. A second macroplot monitoring location in conservation unit 5 has not been identified to date.

Two years of disturbance and habitat data will be required to evaluate sample size adequacy and to evaluate differences between years for all monitoring locations.

White River Beardtongue Population Trend

Monitoring year 2020 marked the fourth year of data collection at Raven Ridge 1 (CU5) and the third year of monitoring at both Raven Ridge 2 (CU5) and Weaver Canyon (CU4). Since their establishment Raven Ridge 1 exhibited a significant increase, Raven Ridge 2 remained stable, and Weaver Canyon exhibited a significant decrease (Table 2).

Table 2. 2020 Summary Statistics for the *Penstemon scariosus* var. *albifluvis* Monitoring Sites

2020	Raven Ridge 1	Raven Ridge 2	Weaver Canyon	Sunday School 2	Rabbit Mtn.	Enefit	Cottonwood Creek	Book Cliffs
Date Established with Sample Size	2017	2019	2019	N/A	N/A	N/A	N/A	N/A
Macroplot area (m^2)	800	800	720	840	1800	800	800	360
Transects (m)	12 (1x20m)	12 (1x20m)	12 (1x20m)	15 (1x20m)	12 (1x50m)	13 (1x20m)	12 (1x40)	12 (1x15m)
Est. plant total in 2020	507	433	387	434	651	517	N/A	846
% reproductive	44%	29%	41%	27%	24%	12%	N/A	36%
Significant increase or decrease in 2020 since initiation	sig. increase	no / stable	sig. decrease	N/A	N/A	N/A	N/A	N/A
p	0.02	0.17	< 0.01	N/A	N/A	N/A	N/A	N/A
Mean density 2020 (plants/m^2)	0.63	0.54	0.54	0.52	0.36	0.65	N/A	1.57

Table 2 lists N/A for newly established sites where two years of data are not yet available for comparisons. The *p-value* is the result of a two-tailed paired t-test performed between 2020 and the first year of data collection at each site (*p* values of < 0.05 are considered statistically significant).

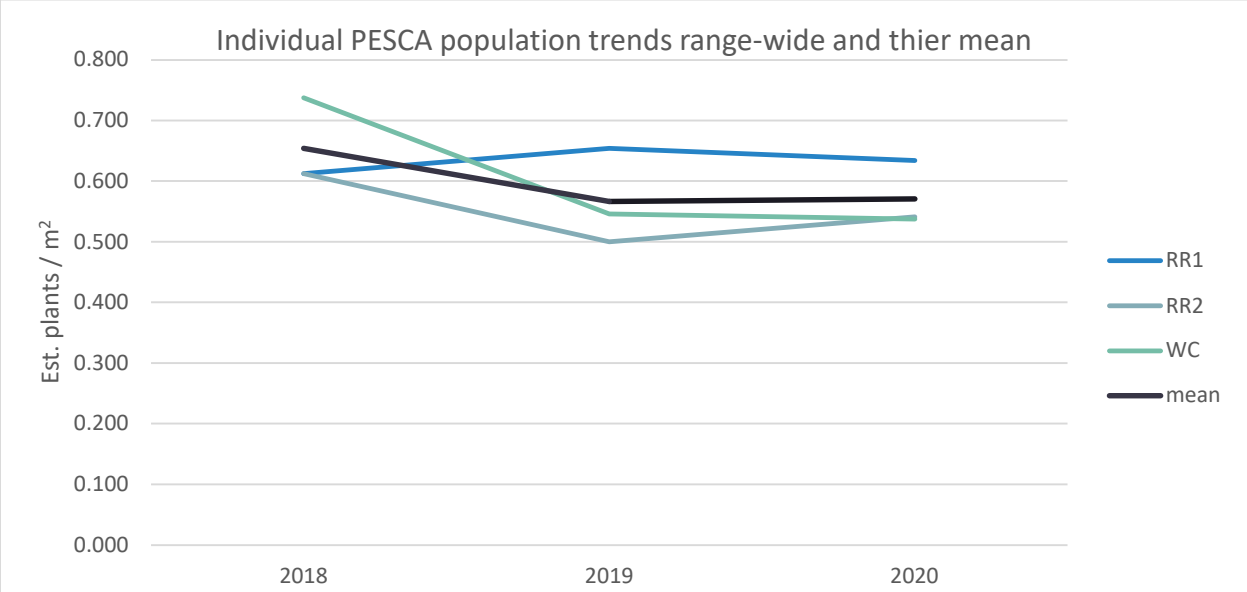

Figure 11. White River beardtongue population trends range-wide and their mean (change in average plants/m^2).

More years of data will help to clarify the range of variability present in observed trends. Reproductive rates were significantly lower in 2020 at the Weaver Canyon and Raven Ridge 2 study sites. One explanation for the decreased rate of flowering is that insect herbivory to flowering stems inhibited mature plants from flowering. Insect herbivory was documented at all White River beardtongue study sites.

For conservation units 2, 3, and 6 population trend results will be reported following the second year of monitoring in 2021. White River beardtongue does not occur in Conservation Unit 1.

White River Beardtongue Disturbance and Habitat Composition

In May and June 2020, we collected pilot disturbance and habitat composition data at four newly established macroplot monitoring sites at Sunday School Canyon 2 (CU2), Enefit Don Holmes Road 9CU3), Rabbit Mountain (CU3), and Book Cliffs (CU6). We also collected disturbance and habitat data using line intercept methods at the Raven Ridge 1 (CU5) site. In general, this species occurs on gentle slopes or ledges in shale barrens that contain sparsely distributed shrubs, forbs, and grasses. Common species associates comprise a suite of shale-tolerant species: ephedra buckwheat (*Eriogonum ephedroides* [CO BLM Sensitive], Dragon milkvetch (*Astragalus lutosus*), Barneby's cryptanth (*Cryptantha barnebyi*), and ephedra buckwheat (*Eriogonum ephedroides*).

Total frequency is given as a proportion for four disturbance classes (human, livestock, native ungulate, other), three ground cover classes (shale, bare ground, litter), four vegetation classes (shrubs, forbs, grasses, invasive species), and for the target species. Frequency of White River beardtongue is also included in the forbs class. Year 1 results are summarized for each monitoring macroplot following the population trend results, where applicable.

Conservation Unit 2 (Seep Ridge)

We established one macroplot monitoring site at Sunday School Canyon in conservation unit 2 in May 2020. We plan to establish one additional White River beardtongue macroplot monitoring location in 2021.

Sunday School Canyon 2 Population Trend

Population trend will be reported following the second year of data collection in 2021.

Sunday School Canyon 2 Disturbance and Habitat Composition

The Sunday School Canyon 2 monitoring site comprises a concentrated White River beardtongue population. Frequency by cover class is illustrated in Figure 12.

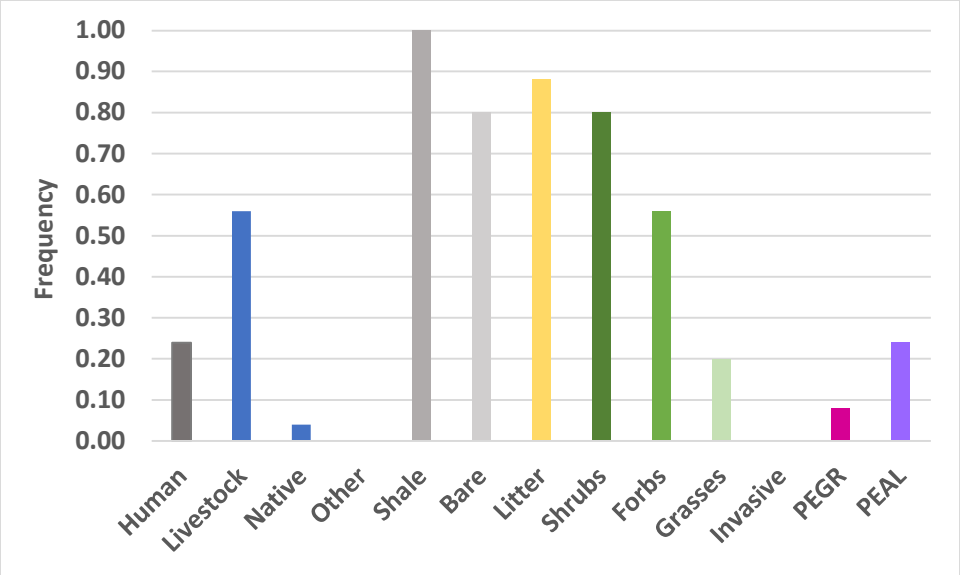

Figure 12. Frequency of disturbance, ground cover, vegetation, and White River beardtongue at the Sunday School Canyon 2 monitoring site.

The site is dominated by shale with scattered native forbs and shrubs. Graham's beardtongue is also present within the macroplot. Sheep hoof prints and droppings were present throughout the macroplot. No invasive species were detected.

Conservation Unit 3 (Evacuation Creek)

We established two macroplot monitoring sites at Don Holmes Road and Rabbit Mountain in conservation unit 3 in May 2020. No additional monitoring locations are planned for 2021.

Enefit Don Holmes Road Population Trend

Population trend will be reported following the second year of data collection in 2021.

Enefit Don Holmes Road Disturbance and Habitat Composition

The Don Holmes Road monitoring site is in a private Penstemon conservation area on Enefit American Oil property. The site comprises a concentrated White River beardtongue population on a shallow slope. Frequency by cover class is illustrated in Figure 13.

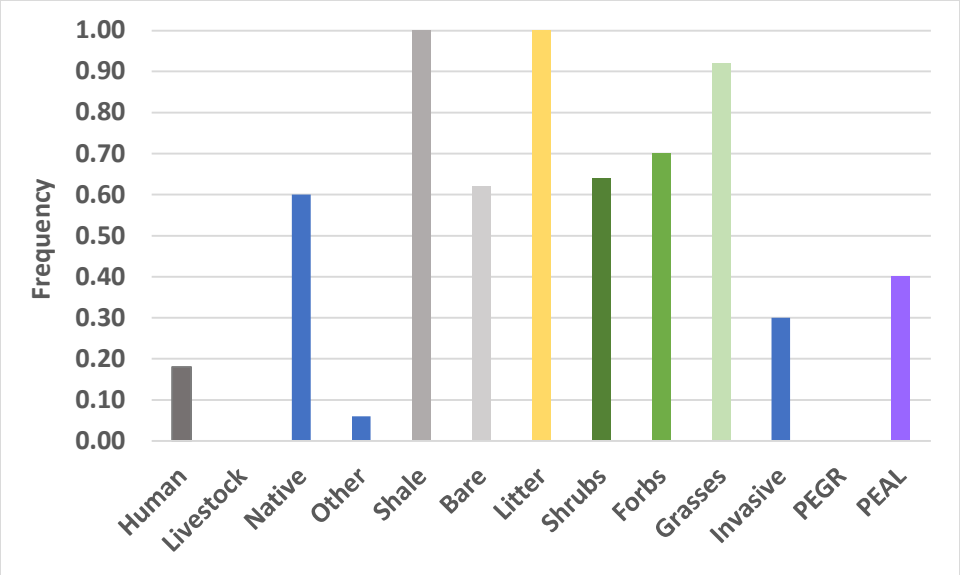

Figure 13. Frequency of disturbance, ground cover, vegetation, and White River beardtongue at the Enefit Don Holmes Road monitoring site.

The site is dominated by shale and salina wild rye with scattered native forbs and shrubs. The site also contains relatively high frequency of African mustard (*Strigosella africana*). Native ungulate hoof prints and droppings were present throughout the macroplot.

Rabbit Mountain Population Trend

Population trend will be reported following the second year of data collection in 2021.

Rabbit Mountain Disturbance and Habitat Composition

The Rabbit Mountain monitoring site comprises a very large White River beardtongue population distributed across a wide shale barren. Frequency by cover class is illustrated in Figure 14.

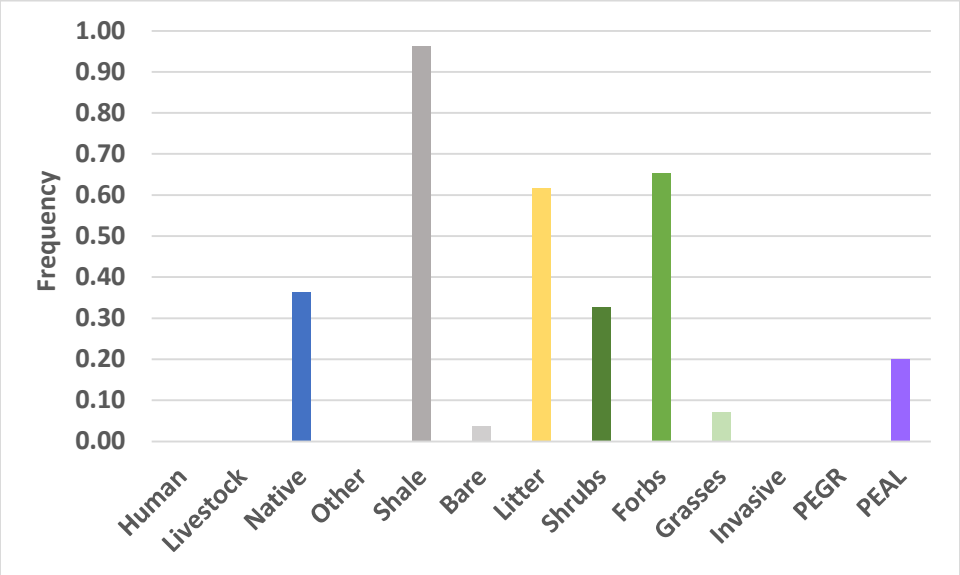

Figure 14. Frequency of disturbance, ground cover, vegetation, and White River beardtongue at the Rabbit Mountain monitoring site.

The site is dominated by shale with scattered native forbs and shrubs, and occasional very large Pinon pines (*Pinus edulis*). The site also contains relatively high frequency of African mustard (*Strigosella africana*). Native ungulate hoof prints and droppings were present throughout the macroplot.

Conservation Unit 4 (White River)

No new macroplot monitoring sites were established for White River beardtongue in conservation unit 4 in 2020. We plan to establish one additional macroplot monitoring location in 2021.

Weaver Canyon Population Trend 2018-2020

The Weaver Canyon monitoring site has experienced a statistically significant decrease ($p < 0.01$) since the site was established in 2018 - a decline equivalent to a loss of 0.23 plants/m^2 or 31% of the population (Figure 15).

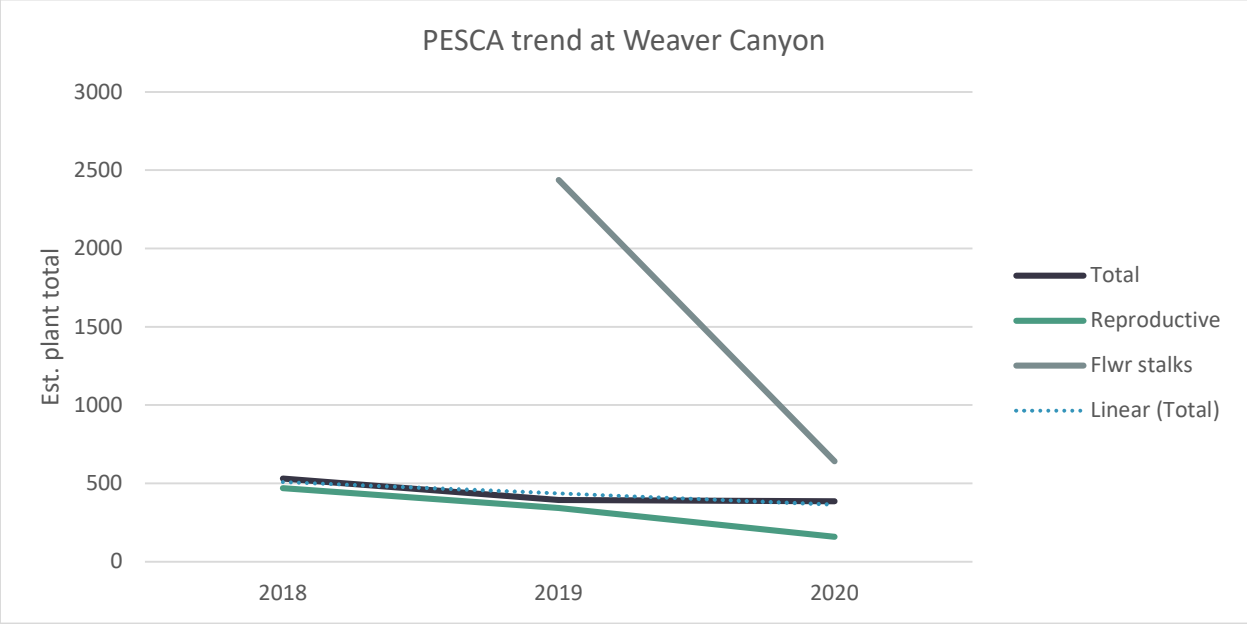

Figure 15. Total, reproductive, and flowering stalk White River beardtongue trend at Weaver Canyon. Trend is defined by the change in the estimated population total between 2018 and 2020.

The observed decline in plant density, reproductive frequency, and number of flowering stems per reproductive individual all appear to be related, at least in part, to insect herbivory (Figures 16 and 17). The Weaver Canyon monitoring site had the highest rate of insect herbivory documented in 2020. Of plants sampled at the site 90% were coded as insect damaged. No insects were observed at the time of data collection therefore no identification was made.

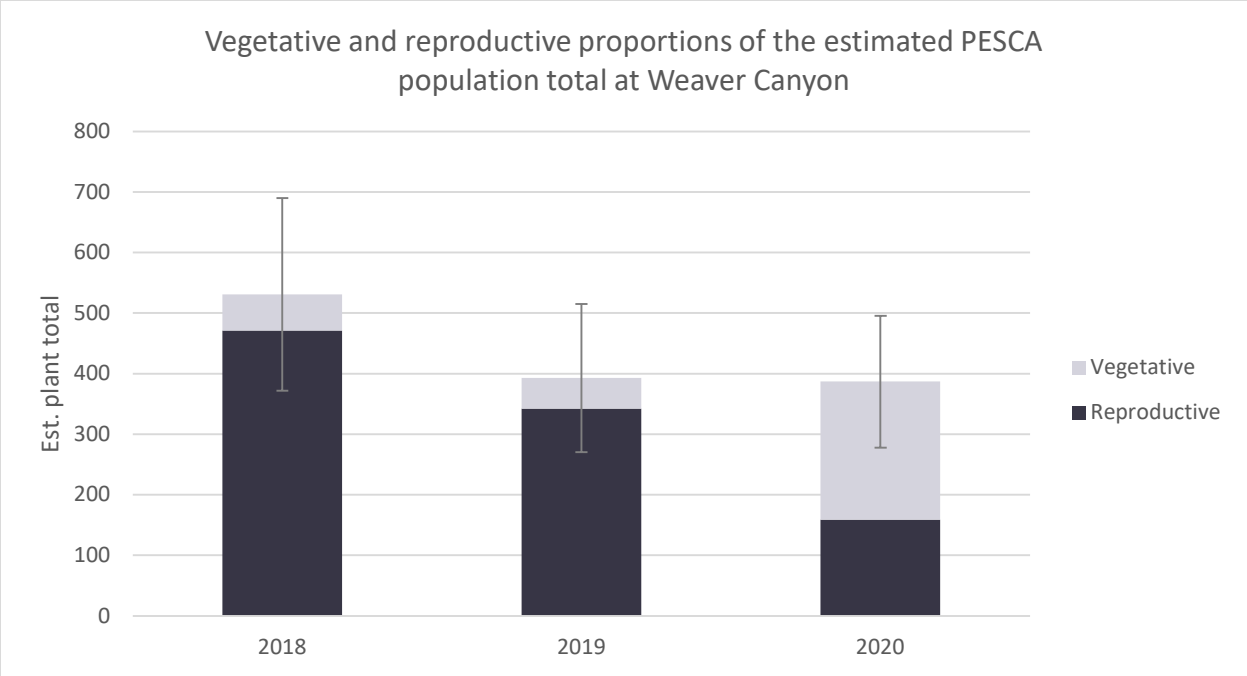

Figure 16. Estimated White River beardtongue totals per year at Weaver Canyon broken down by life stage. 95% confidence interval are displayed around the estimated plant total.

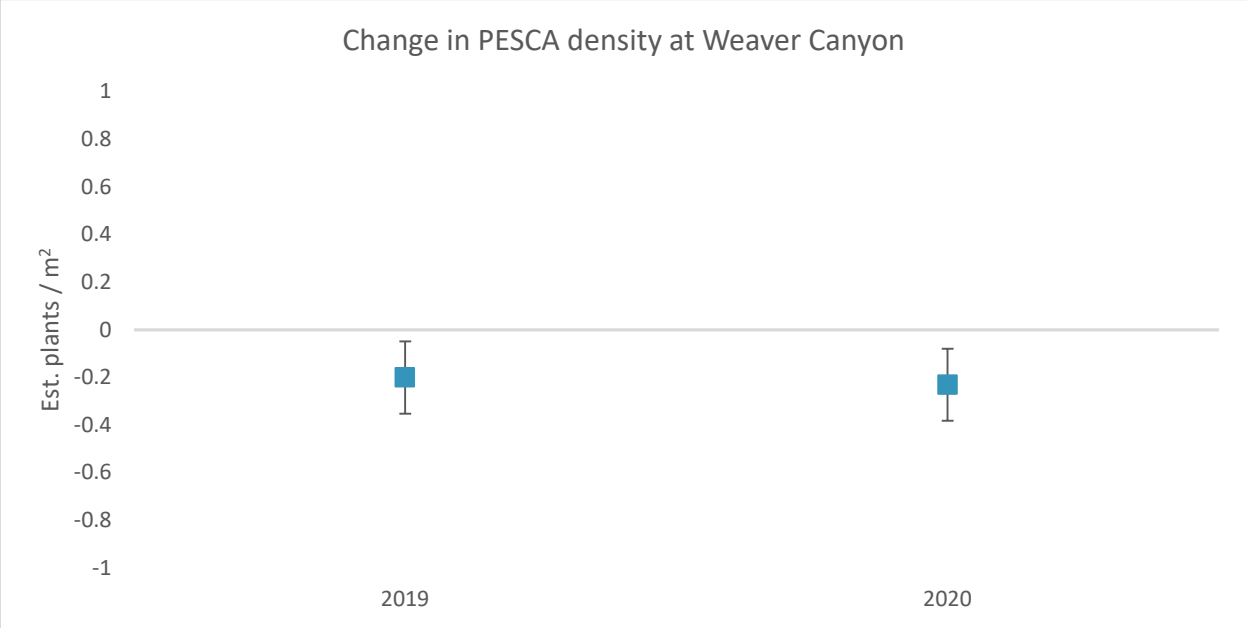

Figure 17. Population change at Weaver Canyon as defined by the change in mean White River beardtongue pant density (plants / m2) between 2018 and 2020. 95% confidence intervals are displayed on either side of the mean value.

Weaver Canyon Disturbance and Habitat Composition

No disturbance or habitat composition data were collected at the Weaver Canyon site in 2020. However, these monitoring methods will be implemented at the site in 2021.

Conservation Unit 5 (Raven Ridge)

No new macroplot monitoring sites were established for White River beardtongue in conservation unit 5 in 2020. No additional macroplot monitoring locations are planned for 2021.

Raven Ridge 1 Population Trend 2017-2020

The Raven Ridge 1 population has exhibited a statistically significant increase since monitoring was established at the site in 2017. Consistent with other monitoring sites, the number of flowering stalks per reproductive individual was significantly lower than in previous years (Figure 18).

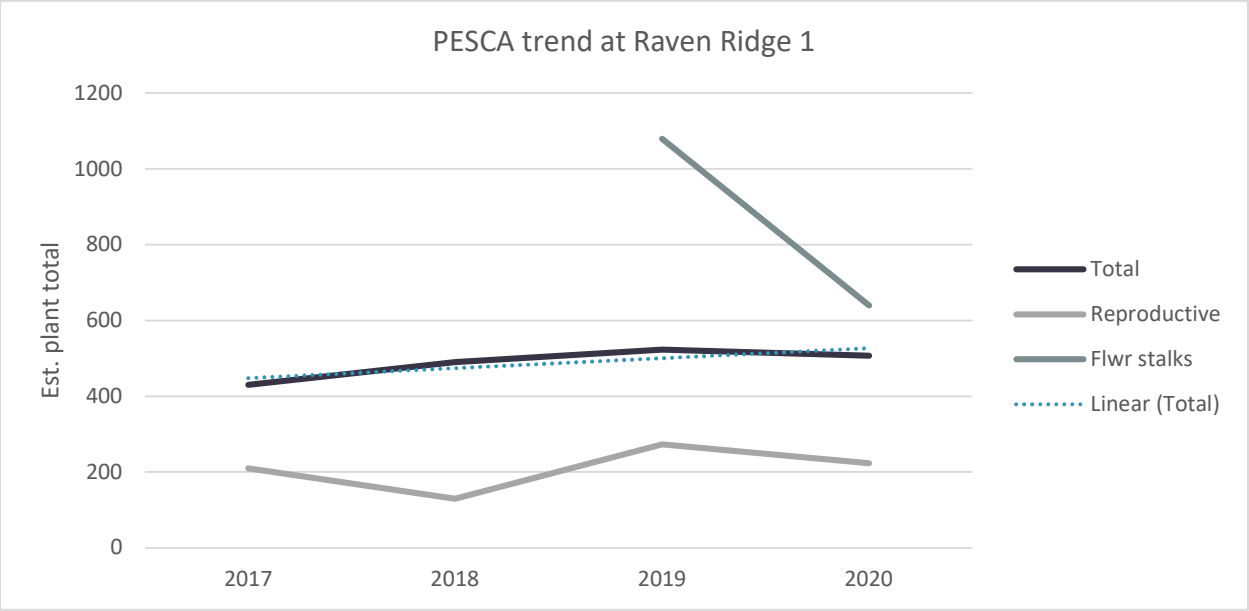

Figure 18. Total, reproductive, and flowering stalk White River beardtongue trend at Raven Ridge 1. Trend is defined by the change in the estimated population total between 2017 and 2020.

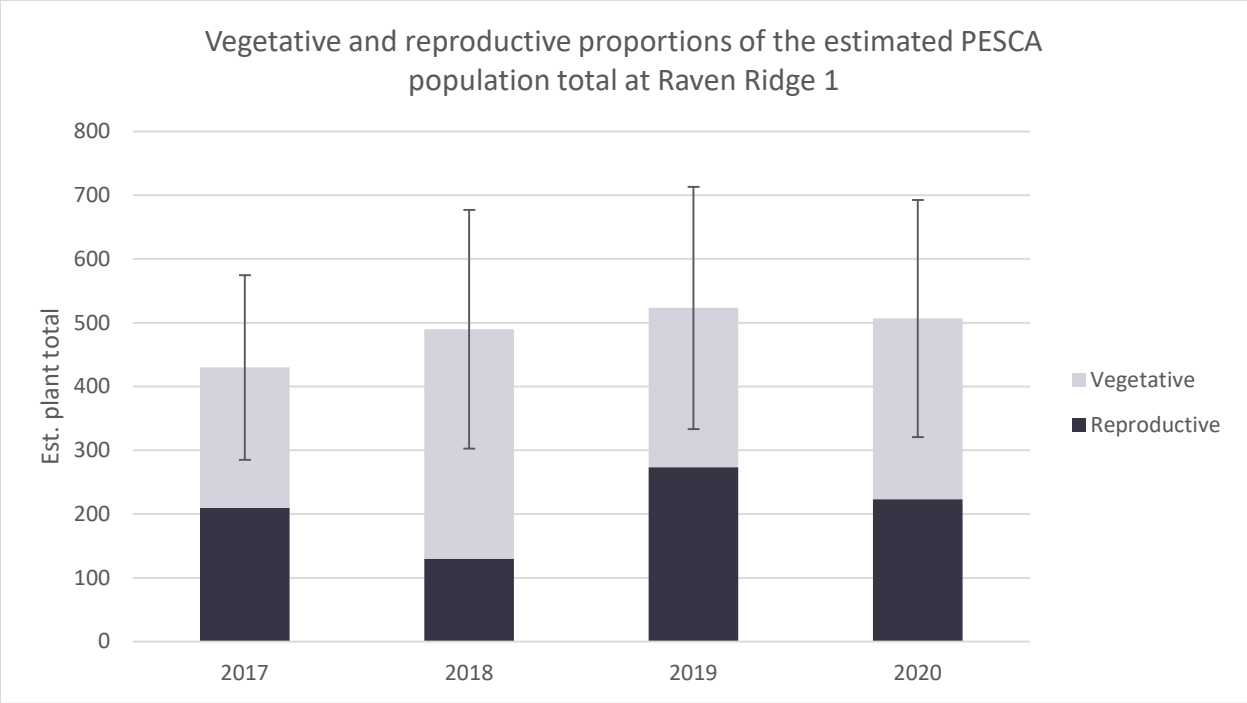

Figure 19. Estimated White River beardtongue totals per year at Raven Ridge 1 broken down by life stage. 95% confidence intervals are displayed around the estimated plant total.

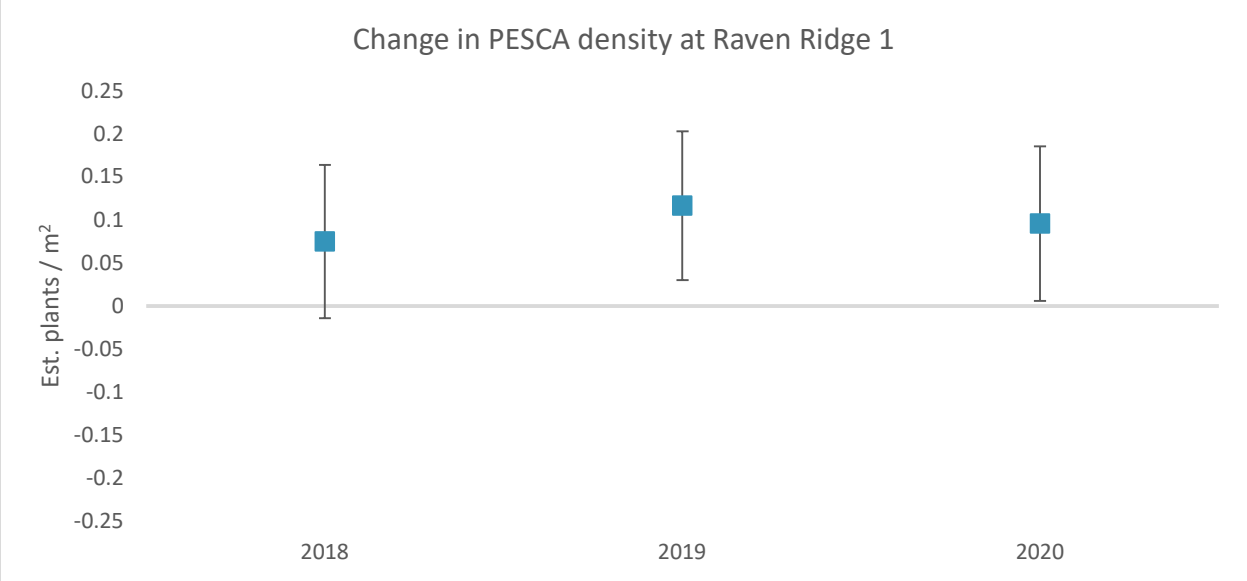

Figure 20. Population change at Raven Ridge 1 as defined by the change in mean White River beardtongue plant density (plants/m2) between 2017 and 2020. 95% confidence intervals are displayed on either side of the mean value.

Raven Ridge 1 Disturbance and Habitat Composition

No disturbance or habitat composition data were collected at the Raven Ridge 1 site in 2020. However, these monitoring methods will be implemented at the site in 2021.

Raven Ridge 2 Population Trend 2018-2020

The Raven Ridge 2 population has remained stable since monitoring was established at the site in 2018. Consistent with other populations, Raven Ridge 1 experienced a significant reduction in reproductive frequency and number of flowering stalks per reproductive individual in 2020 (Figure 21).

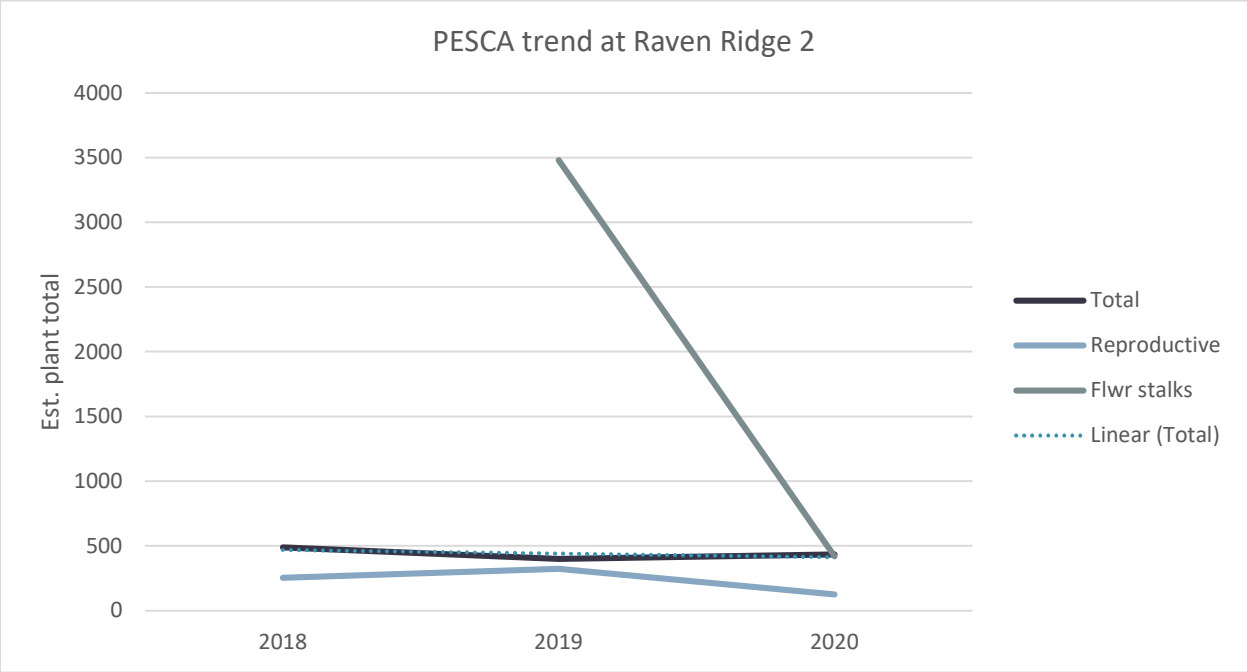

Figure 21. Total, reproductive, and flowering stalk White River beardtongue trend at Raven Ridge 2. Trend is defined by the change in the estimated population total between 2018 and 2020.

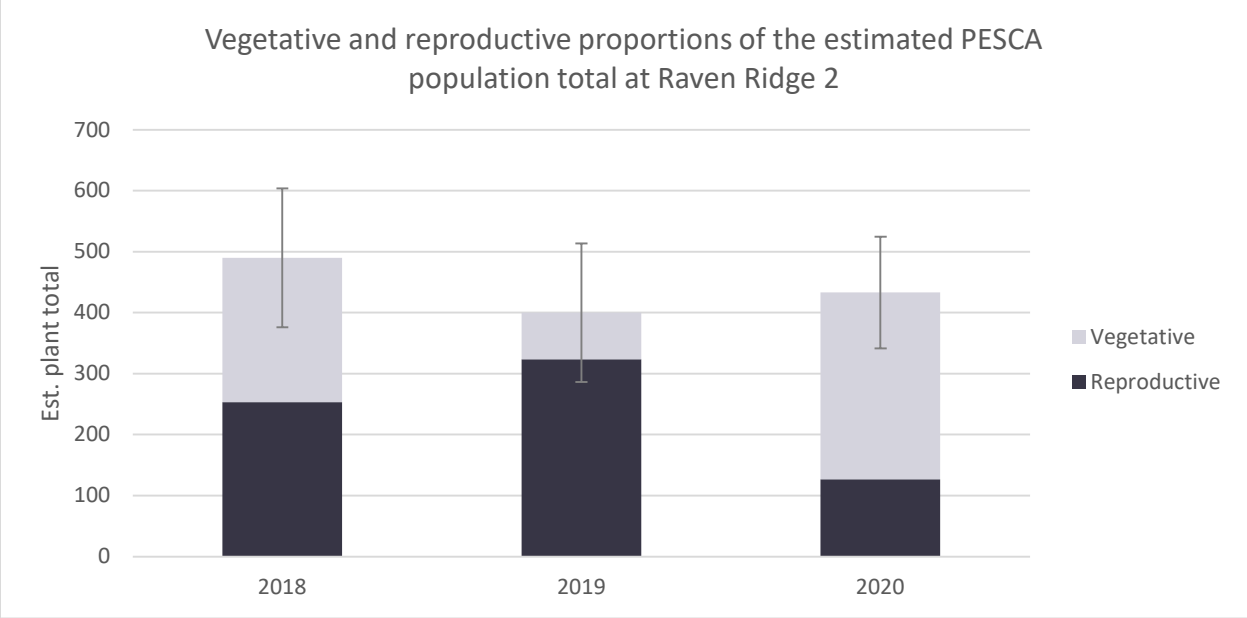

Figure 22. Estimated White River beardtongue totals per year at Raven Ridge 2 broken down by life stage. 95% confidence interval displayed around the estimated plant total.

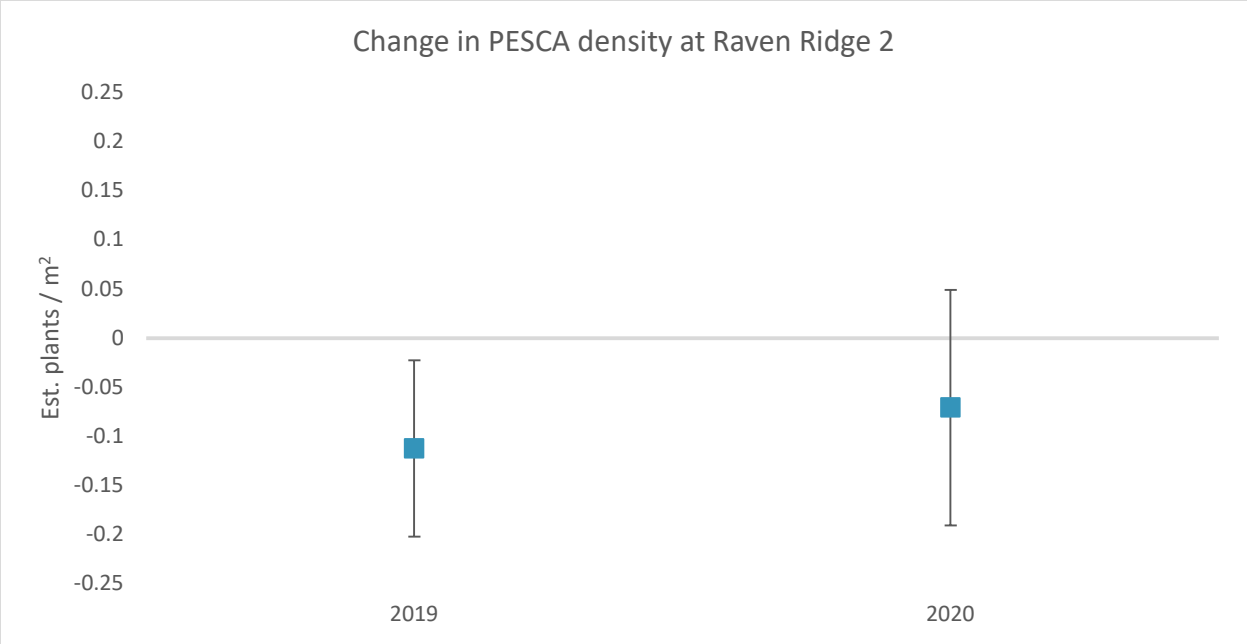

Figure 23. Population change at Raven Ridge 2 as defined by the change in mean White River beardtongue plant density (plants / m2) between 2018 and 2020. 95% confidence intervals are displayed on either side of the mean value.

Raven Ridge 2 Disturbance and Habitat Composition

The Raven Ridge 2 monitoring site comprises a White River beardtongue population on a sloped shale barren. Frequency by cover class is illustrated in Figure 24.

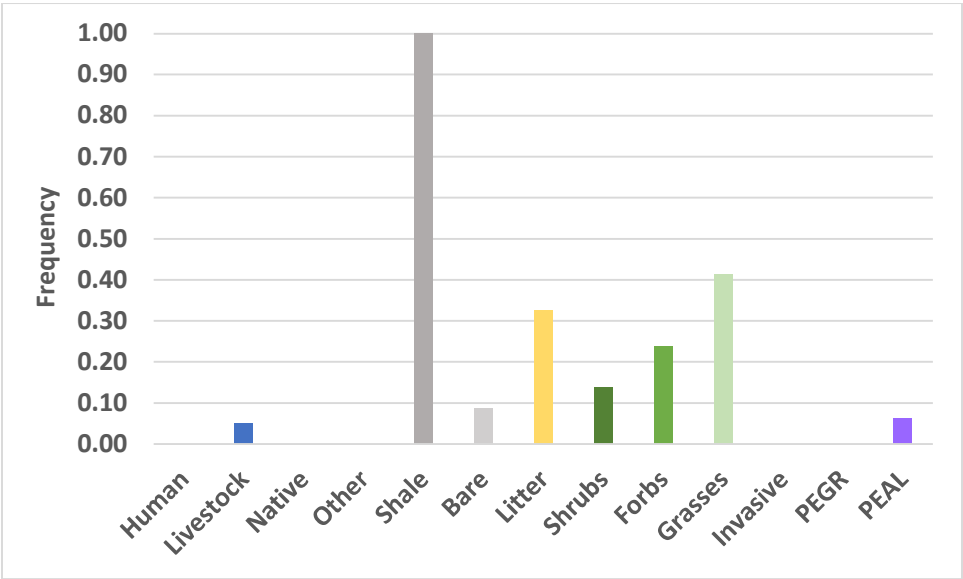

Figure 24. Frequency of disturbance, ground cover, vegetation, and White River beardtongue at the Raven Ridge 2 monitoring site.

The site is dominated by shale with scattered native forbs and shrubs. African mustard was noted in the

plot but was not detected in the nested quadrats. Sheep hoof prints and droppings were present at low frequency in the macroplot.

Conservation Unit 6 (Book Cliffs)

We established one macroplot monitoring site, Book Cliffs 1, in conservation unit 4 in June 2020. We plan to establish a second macroplot monitoring location in 2021.

Book Cliffs 1 Population Trend

Population trend will be reported following the second year of data collection in 2021.

Book Cliffs 1 Disturbance and Habitat Composition

The Book Cliffs 1 monitoring site comprises a very dense White River beardtongue population distributed on a steep shale barren. Frequency by cover class is illustrated in Figure 24.

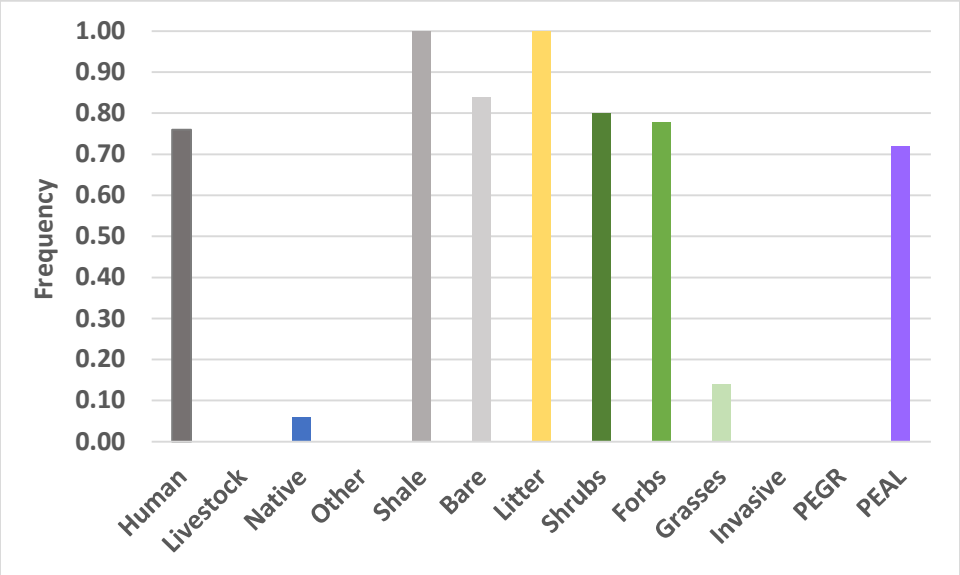

Figure 25. Frequency of disturbance, ground cover, vegetation, and White River beardtongue at the Book Cliffs 1 monitoring site.

The site is dominated by shale and Gambel oak (*Quercus gambellii*) and a diverse assemblage of native shrubs and forbs. Native ungulate hoof prints and droppings were present at low frequency in the macroplot.

Discussion

The purpose of the March 2021 Penstemon Population Monitoring Plan revision is to improve monitoring outcomes while increasing data collection efficiency to ensure that monitoring can be continued throughout the life of the 2014 Penstemon Conservation Agreement (PCT 2014) with limited staffing and resources. In 2020, we established ten new macroplot monitoring sites, and collected population trend and habitat condition data at the ten new sites and five existing macroplots, with the goal of a total of 20 permanent macroplots, or ten per beardtongue species. These revised methods will allow statistical comparisons between years and between different portions of the species' ranges.

The 2020 monitoring results demonstrate that shale habitats across all six conservation units are largely intact, but that livestock activity and invasive plant species are a potential threat in some locations.

Management Implications

The purpose of the nested quadrat disturbance and habitat composition data collection is to meet monitoring objectives stated in the 2015 Weed Management and Livestock Grazing Management Plans (PCT 2015b, 2015c). These data will allow explicit quantification of relationships between habitat condition and population trend at the monitoring locations.

Further, the population trend and habitat condition will also be intermittently evaluated using spatially explicit climate data from the PRISM database (PRISM 2021) or other available climate datasets.

Recommendations

We recommend the addition of a minimum of five more macroplot monitoring locations in 2021 to achieve the plan target of two macroplots for each species per conservation unit.

We also recommend statistical evaluation of the nested quadrat sample sizes needed at each monitoring site following the second and third years of data collection to maximize efficiency and minimize resource requirements for ongoing monitoring.

Literature Cited

Penstemon Conservation Team. 2014. Conservation Agreement and Strategy for Graham's Beardtongue (*Penstemon grahamii*) and White River Beardtongue (*Penstemon scariosus* var. *albifluvis*). Prepared for the State of Utah School and Institutional Trust Lands Administration; Uintah County, Utah; Utah Public Lands Coordination Office; Utah Division of Wildlife Resources; Rio Blanco County, Colorado; Bureau of Land Management; and U.S. Fish and Wildlife Service. Prepared by SWCA Environmental Consultants, Salt Lake City, Utah: 86 pages.

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