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

2021 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 2022

This page intentionally blank

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

2021 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 31, 2022

This page intentionally blank

CONTENTS

TABLES

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, 2021.

1.1 Mitigation Plan

There were no changes to the Mitigation Plan (PCT 2015a) in 2021.

1.2 Weed Management Plan

There were no changes to the Weed Management Plan (PCT 2015b) in 2021. The Team is currently revising this plan in coordination with signatory management planning.

1.3 Livestock Grazing Management Plan

There were no changes to the Livestock Grazing Management Plan (PCT 2015c) in 2021. The Team is currently revising this plan in coordination with signatory management planning.

1.4 Surface Disturbance Plan

There were no changes the Surface Disturbance Plan (PCT 2015d) in 2021.

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, and again in May 2021. The second year (2021) range-wide population monitoring results are included in Appendix A and summarized in Section 7.1.

1.6 Seed Management Strategy

There were no changes to Seed Management Strategy in 2021.

1.7 Restoration Plan

The Restoration Plan Subcommittee developed an early draft Beardtongue Restoration Plan in late 2017. The Team is currently revising this plan.

2 IMPLEMENTATION OF CONSERVATION AGREEMENT IN BEARDTONGUE HABITATS

2.1 BLM Vernal Field Office (Utah)

In 2021, 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 2021, 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 did not issue any new leases within Penstemon conservation Areas in 2021. SITLA currently administers $19,592.00 in the Penstemon Mitigation Fund on behalf of the Conservation Team. SITLA provided $4,801.53 in FY2021 for support of the Penstemon Conservation Team and monitoring activities associated with the Agreement.

2.4 Uintah County

Uintah County actively participated as a Team member in 2021.

2.5 Rio Blanco County

Rio Blanco County had limited participation in the Team in 2021 due to changes to Rio Blanco County leadership and organizational structure. Rio Blanco County will actively participate as a Team member in 2022.

2.6 State of Utah/The Nature Conservancy

The State of Utah Department of Natural Resources ESMF provided $10,950.98 in FY2021 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 via conference call three times in 2021. The direct funds and in-kind contributions associated with these meetings and other Agreement-related activities are summarized in Table 1.

Table 1. 2021 Conservation Agreement Financial Contributions by Partner Agencies

Partner	Direct Funds	In-Kind (hours)
BLM - CO	--	280
BLM - UT	--	184
Utah DNR/Utah State University	$10,950.98	200
Manzanita Botanical Consulting	--	20
PLPCO	$10,000.00	20
Rio Blanco County, Colorado	--	--
SITLA	$4,801.53	20
Uintah County, Utah	--	8
USFWS - CO	--	20
USFWS - UT	--	90
TOTAL	**$25,752.51**	**842 hours**

A similar level of participation by the Agreement partner agencies is expected in 2022.

3 CONSERVATION AGREEMENT UPDATES

There were no changes to the Penstemon Conservation Agreement and Strategy in 2021.

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 2021 were submitted to the Penstemon Conservation Team for inclusion in this and future annual reports.

5 2021 FIELD SURVEY RESULTS

Surveys for Graham's beardtongue and White River beardtongue in 2021 were limited to efforts to identify additional monitoring sites for the Range-wide Population Monitoring Program.

5.1 BLM Vernal Field Office (Utah)

The BLM VFO surveyed approximately 200 acres for both Graham's and White River beardtongue as part of population monitoring plan reimplementation in 2021. A macroplot was installed on BLM lands in Weaver Canyon. The plot will be revisited in May 2022.

5.2 BLM White River Field Office (Colorado)

The BLM WRFO did not conduct any surveys in 2021.

5.3 State of Utah

The Utah State University rare plant team surveyed approximately 200 acres for Graham's beardtongue in Conservation Unit 4 and approximately 500 acres for White River beardtongue in Conservation Units 4 and 6 in 2021 as part of Range-wide Population Monitoring implementation.

5.4 SITLA

The Utah State University rare plant team surveyed approximately 300 acres for White River beardtongue in Conservation Unit 6 in 2021 as part of Range-wide Population Monitoring

implementation. A macroplot was installed and will be revisited in May 2022 to assess sample size and population condition.

6 2021 SEED COLLECTIONS

No known seed collections took place in 2021 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 Range-wide Population Monitoring

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. In May 2021, the Utah DNR, BLM VFO, and BLM Colorado botanists monitored 14 established monitoring plots (7 for each species) and established 2 additional macroplots: one each for Graham's and White River beardtongues in conservation unit 4. The 2021 population monitoring results are detailed in Appendix A and summarized for each species in the following sections.

7.1.1 White River Beardtongue 2021 Monitoring Results

Utah DNR, BLM VFO, and BLM Colorado botanists revisited six existing White River beardtongue macroplot monitoring sites in May 2021. The Utah FWS and Manzanita Botanical Consulting revisited the macroplot established in the Book Cliffs population in 2020 on June 9, 2021. Surveys were conducted in late May and early June to identify a second macroplot location in the Book Cliffs population, but a population of sufficient density was not identified. 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 2021 Monitoring Results

Utah DNR, BLM VFO, and BLM Colorado botanists revisited seven existing Graham's beardtongue macroplot monitoring sites and established one new macroplot monitoring sites in late May 2021. 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 2021, the BLM VFO worked with DNR and BLM Colorado botanists to continue range-wide monitoring at 15 monitoring sites and establishment of a new Graham's beardtongue macroplot monitoring site (summarized in Section 7.1).

7.3 BLM Colorado

In May 2021, annual monitoring for both Graham's and White River beardtongue was completed by the BLM Colorado State Office and researchers from University of Northern Colorado, the BLM VFO, and the Utah State University Rare Plant Team. The Colorado BLM monitored the single, long-term Graham's beardtongue study site at Mormon Gap, and the three White River beardtongue study sites established between 2017 and 2018. The Colorado BLM and UNC team also provided significant assistance in mapping and monitoring the macroplot monitoring sites in Utah (summarized in Section 7.1).

7.4 Utah DNR Endangered Species Mitigation Fund

Manzanita Botanical Consulting provided planning, study design, and field support for the ongoing implementation of range-wide population monitoring in May 2021. The population monitoring year two (2021) results are detailed in Appendix A and summarized in 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, FY2020, and FY2021. 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 May 2021 with FY2021 Utah Endangered Species Recovery program funding.

We revisited the PEGR-1 Red Leaf Seep Ridge experimental site during Graham's beardtongue flowering on May 20, 2021. Plant survival from 2015 to 2021 was 20.0%, with 20 of the original 100 seedlings transplanted in October 2015 surviving to May 2021. Of the surviving plants, 95.0% flowered and averaged 5.0 flowering stems and 22.5 flowers per plant. There continues to be large numbers of aborted flowers. 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 ongoing drought and competition from invasive annual weeds, with 26.0% and 0.5% 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.

We revisited the PESCAL-1 Enefit North transplant site on May 27, 2021. Of the original 64 seedlings transplanted in October 2014, 20 (31.3%) survived to May 2021. Of the surviving plants, 6 (30.0%) flowered and averaged 3.7 flowering stems and 10.5 flowers per plant, which is approximately double the reproductive effort observed in 2020. The two seedlings documented in 2020 survived to 2021.

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 2022.

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 16 existing beardtongue macroplot monitoring sites and establish up to four new macroplot sites in May and June 2022. The addition of four 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 (PCT 2021). The revised methods comprise frequency monitoring of species composition, ground cover, disturbance, and invasive weeds using a nested quadrat approach. The revised disturbance monitoring methods will be tiered to a revised Livestock Grazing Management Plan.

8.3 Weed Management Plan

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

8.4 Restoration Plan

The Restoration Plan Subcommittee drafted an outline restoration plan in 2017. The plan is currently being updated with available information, but further restoration research is needed.

8.5 Other Future Activities

Ongoing conservation-related research and activities are being conducted by the Agreement partner agencies. Expected 2022 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 2022) 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 2022 as climate-linked flowering and fruiting permits.

9 LITERATURE CITED

Penstemon Conservation Team (PCT). 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.

———. 2015a. *Conservation Agreement and Strategy for Graham's Beardtongue (*Penstemon grahamii*) and White River Beardtongue (*P. scariosus *var.* albifluvis*): Mitigation Plan*. Prepared by the Penstemon Conservation Team. July 22, 2015.

———. 2015b. *Conservation Agreement and Strategy for Graham's Beardtongue (*Penstemon grahamii*) and White River Beardtongue (*P. scariosus *var.* albifluvis*): Weed Management Plan*. Prepared by the Penstemon Conservation Team. July 22, 2015.

———. 2015c. *Conservation Agreement and Strategy for Graham's Beardtongue (*Penstemon grahamii*) and White River Beardtongue (*P. scariosus *var.* albifluvis*): Livestock Grazing Management Plan*. Prepared by the Penstemon Conservation Team. July 23, 2015.

———. 2015d. *Conservation Agreement and Strategy for Graham's Beardtongue (*Penstemon grahamii*) and White River Beardtongue (*P. scariosus *var.* albifluvis*): Criteria for the Calculation of Baseline and New Surface Disturbance.* Prepared by the Penstemon Conservation Team. July 22, 2015.

———. 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.

———. 2021. *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. March 31, 2021.

PRISM Climate Group (PRISM). 2022. PRISM Data Explorer. Oregon State University, Corvallis, Oregon. https://prism.oregonstate.edu.

Appendix A

2021 Penstemon Population Monitoring Report

This page intentionally blank

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

2021 Population Monitoring Report

Prepared by

Phil Krening
Espinoza Consulting Services
Contractor, BLM Colorado State Office
Lakewood, Colorado

and

J. Hope Hornbeck
Manzanita Botanical Consulting
Contractor, Utah Department of Natural Resources
Salt Lake City, Utah

Prepared for

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 31, 2021

Contents

Tables

Figures

Introduction

The revised Penstemon Population Monitoring Plan was finalized in March 2021 (PCT 2021) with the goal of documenting range-wide population trends for both beardtongue species as required in the 2014 Penstemon Conservation Agreement and Strategy (PCT 2014). In addition to population trend monitoring, this report summarizes several supplemental methods initially piloted in 2020 and continued in 2021 to quantify disturbance (livestock, human activity, native herbivores), habitat composition, and invasive weeds. Seventeen monitoring sites have been established for Graham's (*Penstemon grahamii*) and White River (*Penstemon scariosus* var. *albifluvis*) to date (Figure 1).

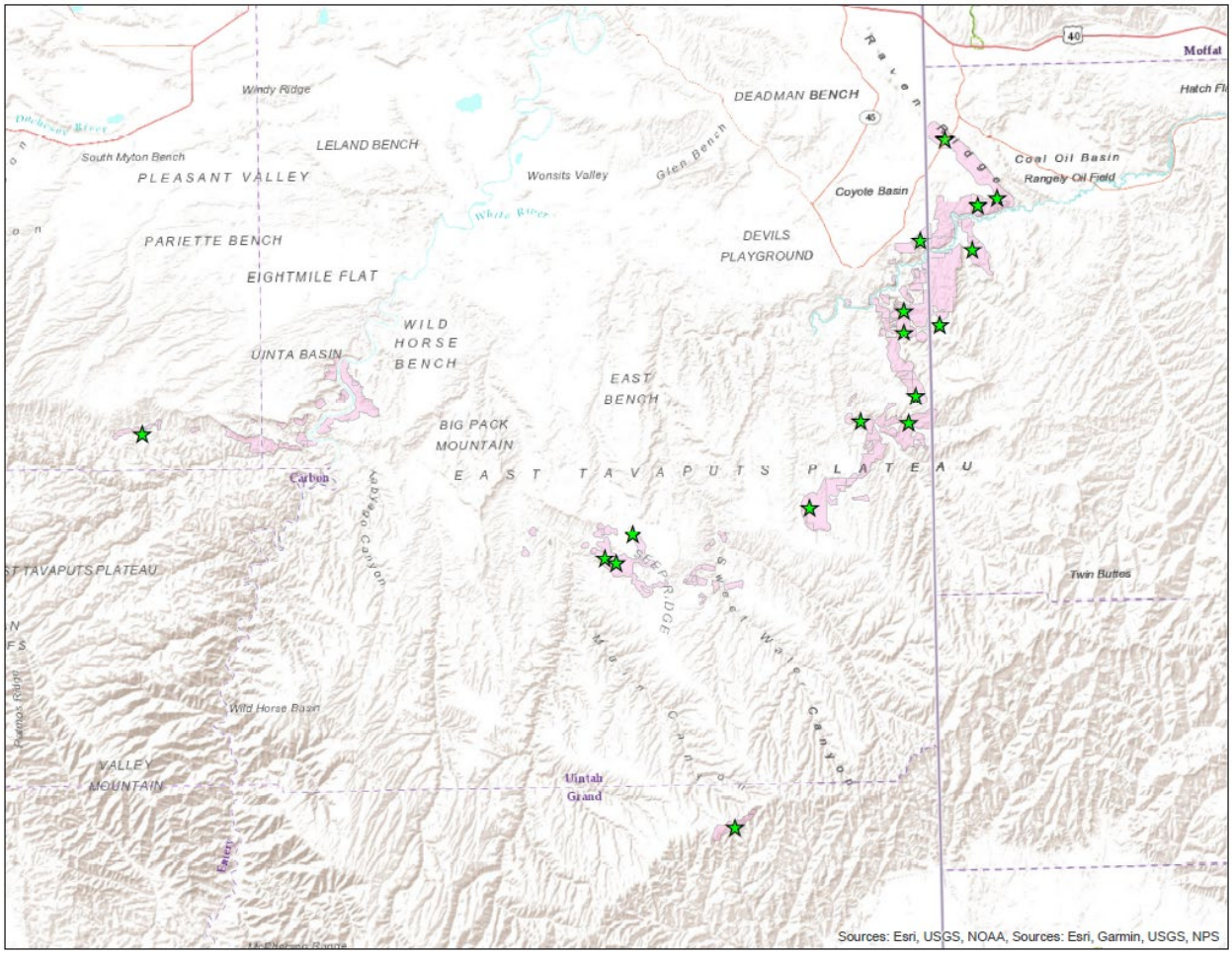


Figure 1. Graham's and White River beardtongue population monitoring locations. Green stars indicate established monitoring sites for Graham's and White River beardtongue within Penstemon conservation areas (pink polygons). Note: map includes retired Cottonwood Creek monitoring site.

Four macroplot monitoring sites were established from 2005 to 2018, and ten additional macroplots were established in 2020 as part of reimplementation of the Population Monitoring Plan. In May and June 2021, fourteen existing macroplots were revisited, one macroplot was retired (Cottonwood Creek), and two new macroplots were established (Weaver Canyon 2 and State Line) for a total of 16 macroplots. Four sites remain outstanding to be established in 2022 to the extent feasible: two

Graham's beardtongue sites (one each in Conservation Units 1 and 5) and two White River beardtongue sites (one each in Conservation Units 2 and 6; Table 1).

Table 1. 2021 Penstemon Range-wide Monitoring Implementation Progress

Conservation Unit	Species	Macroplots Established	2021 Existing	2021 New	2022 Needed	County
CU1 (Sand Wash)	PEGR	CU1-1 Wrinkles Road (2020-) *CU1-2 – no plot to date*	1	--	1	Duchesne *Duchesne*
CU2 (Seep Ridge)	PEAL	CU2-1 Sunday School 2 (2020-) *CU2-2 – no plot to date*	1	--	1	Uintah *Uintah*
	PEGR	CU2-1 East Sand Wash (2020-) CU2-2 Sunday School 1 (2020-)	2	--	--	Uintah Uintah
CU3 (Evacuation Creek)	PEAL	CU3-1 Don Holmes (2020-) CU3-2 Rabbit Mountain (2020-)	2	--	--	Uintah Uintah
	PEGR	CU3-1 Dragon (2020-) CU3-2 Wolf's Den (2020-)	2	--	1	Uintah Uintah
CU4 (White River)	PEAL	*CU4- Cottonwood Creek RETIRED* CU4-1 Weaver Canyon (2018-) CU4-2 State Line (2021-)	1	1	--	*Rio Blanco* Uintah Uintah
	PEGR	CU4-1 Hell's Hole (2020-) CU4-2 Weaver Canyon-2 (2021-)	1	1	--	Uintah Uintah
CU5 (Raven Ridge)	PEAL	CU5-1 Raven Ridge 1 (2017-) CU5-2 Raven Ridge 2 (2018-)	2	--	--	Rio Blanco Rio Blanco
	PEGR	CU5-1 Mormon Gap (2005-) *CU5-2 – no plot to date*	1	--	--	Rio Blanco *Rio Blanco*
CU6 (Book Cliffs)	PEAL	CU6-1 Book Cliffs 1 (2020-) *CU6-2 – no plot to date*	1	--	1	Grand *Grand*
		Total PEGR Plots	7	1	2	10
		Total PEAL Plots	7	1	2	10
	TOTAL		14	2	4	20 macroplots

This report summarizes the methods and 2021 population trend and habitat monitoring results for 16 macroplots distributed across the ranges of both species. We also include a brief discussion and management implications and recommendations based on the 2021 results.

Methods

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.

Population trend and supplemental habitat condition data were collected at a series of permanent macroplots distributed across the range of the two species (see Figure 1). Macroplot study site locations were stratified by species and conservation unit. Range wide trends were discerned by compiling the data from all the sites. Refer to the Penstemon Population Monitoring Plan for a detailed description of both population trend monitoring and supplemental habitat composition and disturbance methods (PCT 2021).

Revisitations of the ten macroplots established by the PCT in 2020 completed this year represent the second year of data collection - when power analysis is completed to determine the number of transects required to detect meaningful changes in plant density. 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 were 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:

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

If necessary, the number of sampling units within the macroplot will be adjusted to accommodate the necessary number of samples required to obtain statistically meaningful results.

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.

Results

Botanists from the Colorado BLM Threatened and Endangered Species Program, and BLM Vernal Field Office, University of Northern Colorado, Utah DNR, Utah State University Rare Plant Team, and U.S. Fish and Wildlife Service completed range wide Penstemon population monitoring from May 24 to 29, 2021 and on June 9, 2021. Population trend and disturbance and habitat composition results are summarized for each species and detailed for each monitoring site in the sections below.

Note on Interpreting Trends: In order to properly contextualize the results of the ten macroplots established in 2020, it's important to consider that 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.

While the twelve months preceding 2020 data collection featured below average precipitation across the range of both beardtongue species, trends documented at the four previously established monitoring sites in Conservation Units 4 and 5 (Mormon Gap, Raven Ridge 1 & 2, and Weaver Canyon 1) suggest that 2020 was not an outlier in terms of plant density and fell within the observed range of variability. However, the number of reproductive plants, rosettes of Graham's beardtongue, and flowering stalks of White River beardtongue were lower in 2020 than in the recent past. Between 2020 and 2021 hot and dry conditions were persistent. The year preceding sampling (May 2020 to April 2021) featured below average precipitation and above average temperatures across the Uinta Basin (PRISM Climate Group 2021). Total annual precipitation across all beardtongue monitoring sites averaged just 54.4% of thirty-year normal total annual precipitation (1980-2010). Temperatures averaged about one degree higher than normal for the year.

Graham's Beardtongue Population Trend

Population trend monitoring and supplemental habitat monitoring was completed at the seven established Graham's beardtongue study sites and at one new study site (Weaver Canyon 2) in Conservation Unit 4 from May 25 to May 30, 2021. In general, we observed slight decreases in plant density across the study system (Figure 2) though the decreases were not found to be statistically significant, with the exception of the Mormon Gap site (Table 2).

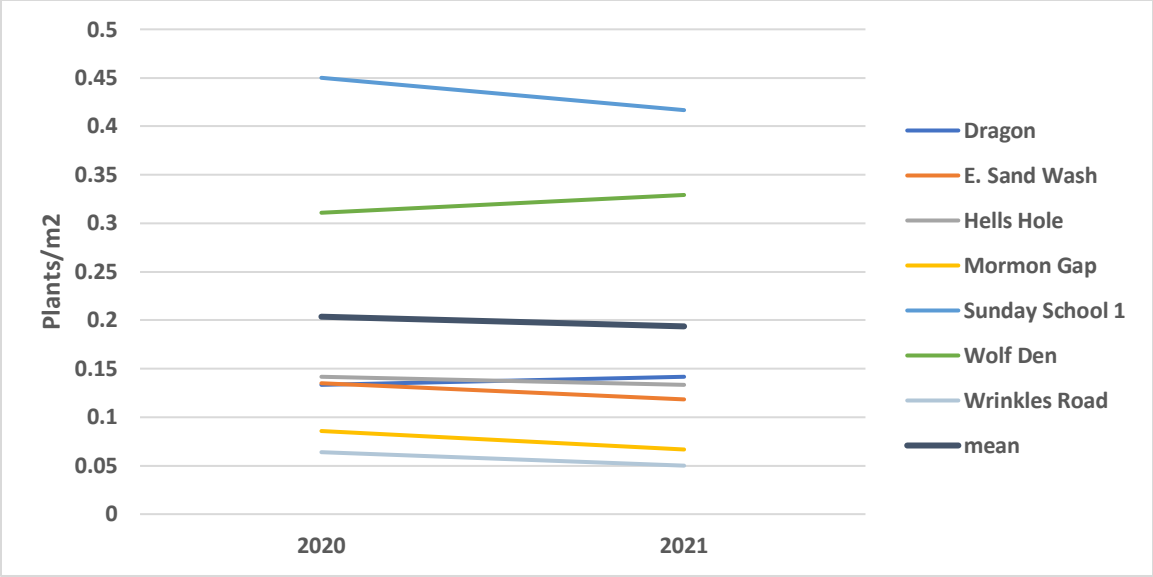


Figure 2. Range wide average and site-specific Graham's beardtongue population trends between 2020 and 2021. Note: Trend was estimated as the change in mean plant density (avg. plants/m^2) between two observations. The mean was defined using a ratio estimator whereby the total number of plants among all sites is divided by the average combined area of the sites (Stehman and Salzer 2001).

Table 2. 2021 Summary Statistics for the *Penstemon grahamii* Monitoring Sites

	Unit 1	Unit 2		Unit 3		Unit 4		Unit 5
	Wrinkles Road	East Sand Wash	Sunday School 1	Dragon	Wolf's Den	Hell's Hole	Weaver Canyon 2	Mormon Gap
Date Established with Sample Size	2021	2021	2021	2021	2021	2021	N/A	2009
Macroplot Area (m^2)	1200	1500	1200	800	1200	240	1100	700
Transects (m)	12 (30m)	12 (30m)	12 (30m)	12 (20m)	12 (40m)	6 (20m)	10 (55m)	15 (35m)
2021 Estimated Total Plants	60	178	500	113	395	32	54	47
Percent Reproductive	6%	30%	20%	0%	37%	56%	26%	0%
Significant Change Since Establishment	No/Stable	No/Stable	No/Stable	No/Stable	No/Stable	No/Stable	No/Stable	**Significant Decrease**
*p-value**	0.19	0.15	0.18	> 0.50	0.36	0.22	N/A	**< 0.05**
2021 Mean Density (plants/m^2)	**0.05**	**0.12**	**0.42**	**0.14**	**0.33**	**0.13**	**0.05**	**0.06**

*** *p* values are the result of a two-tailed paired t test performed between 2021 and the year the site was established. A result of < 0.05 is considered statistically significant. N/A indicates sites that lack sufficient data to complete calculations.**

Average range wide Graham's beardtongue population density did not significantly change from 2020 to 2021 (Figure 2 mean), although there were differences in density trends between conservation units and macroplots. The only observed significant change in population density was at Mormon Gap, which continued to exhibit significant decrease ($p < 0.05$) in the number of plants per square meter. Without performing in-depth analysis, we can assume that below average precipitation and higher than average temperatures combined to create conditions amounting to water deficit - or higher than normal

evaporative demand - and therefore increased stress to vascular plants, including Graham's beardtongue.

Graham's Beardtongue Disturbance and Habitat Composition

In May 2021, we collected disturbance and habitat composition data at seven 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*), and Barneby's cryptantha (*Cryptantha barnebyi*).

Total frequency is given as a proportion for four disturbance classes (human, livestock, native ungulate, other), four ground cover types (shale, bare ground, biological soil crust (BSC), litter), four vegetation classes (shrubs, forbs, grasses, invasive species), and for the target species. The frequency of Graham's beardtongue is also included in the forbs class. The average frequency for each of the cover types in 2020 and 2021 is shown in Figure 3.

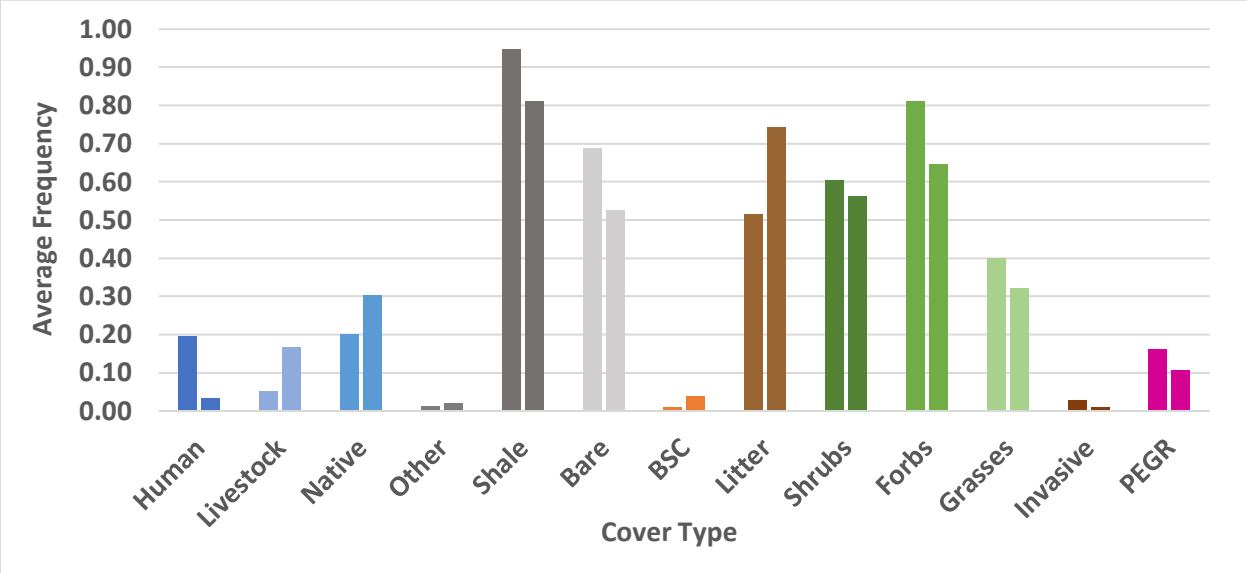


Figure 3. 2020 and 2021 average frequency for disturbance, ground cover, native and invasive vegetation, and target species cover types in the Graham's beardtongue macroplots.

Nested frequency quadrat sample size will be reassessed for all monitoring sites in 2022. Year 2 results are summarized for each monitoring macroplot following the population trend results, where available.

Conservation Unit 1 (Sand Wash)

The PCT established one Graham's beardtongue macroplot near Wrinkles Road in Conservation Unit 1 in May 2020. A second suitable site has yet to be identified.

WRINKLES ROAD

WRINKLES ROAD POPULATION TREND

Graham's beardtongue density decreased slightly at Wrinkles Road between 2020 (M=1.92, SD=2.78) and 2021 (M=1.5, SD=2.78; **Figure 4a**). The decrease was not found to be statistically significant (t(11)=1.39, *p*=0.19). Power analysis was completed at the site indicating the addition of 9 transects is required to meet our sampling objective of being 80% confident of detecting at least a 20% change in mean plant density. No additional sample units were added in 2021. Power analysis will be completed again following 2022 data collection. Wrinkles Road has maintained the lowest observed plant density ($\bar{x}$=0.06 plants/m^2) of the eight established Graham's beardtongue sample sites over the last two sampling intervals.

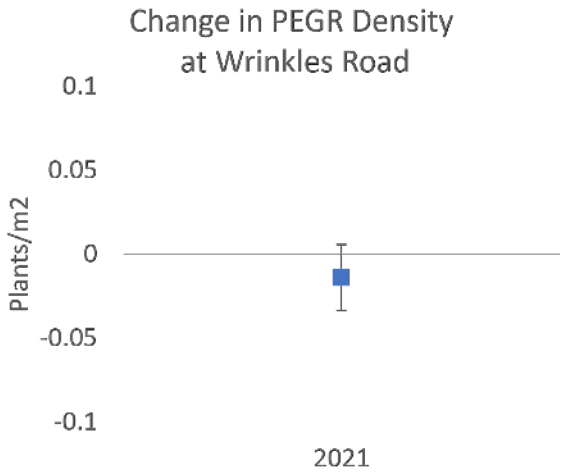
There was an insignificant downward trend in the total number of Graham's beardtongue individuals and total rosettes at Wrinkles Road in 2021 compared to 2020 (**Figure 5a**). However, there was a slight increase in the number of reproductive plants. There was an insignificant reduction in the estimated total number of Graham's beardtongue individuals Wrinkles Road in 2021 compared to 2020 (**Figure 6a**).

Overall, there was very little change in population densities, abundances, or trend from 2020 to 2021, despite continuing drought.

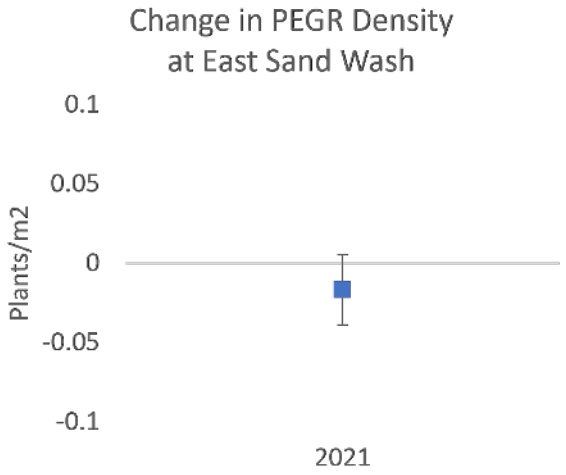
WRINKLES ROAD DISTURBANCE AND HABITAT COMPOSITION

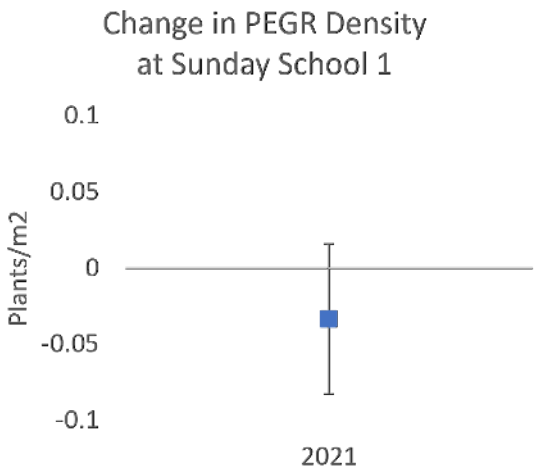
The Wrinkles Road monitoring site comprises a relatively small Graham's beardtongue population on a west-south-west facing slope with soft shale soils. The Wrinkles Road monitoring macroplot is dominated by surface shale, stemless four-nerve daisy (*Tetraneuris* [*Hymenoxys*] *acaulis*), and salina wild rye (*Leymus salinus*). Surface disturbance by livestock and native ungulates occurred at approximately 25% frequency in 2021. No invasive species have been detected in the plot to date. Frequency of disturbance, ground cover, and vegetation by cover class is illustrated in **Figure 7a**. Nested frequency quadrat sample size will be reassessed in 2022.

a) Conservation Unit 1 – Sand Wash

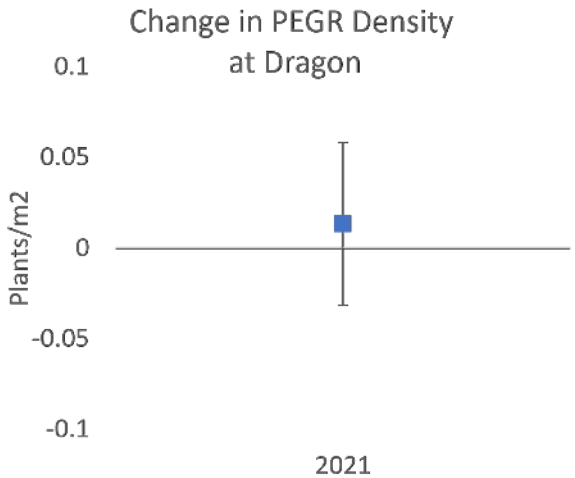


b) Conservation Unit 2 – Seep Ridge





c) Conservation Unit 3 – Evacuation Creek



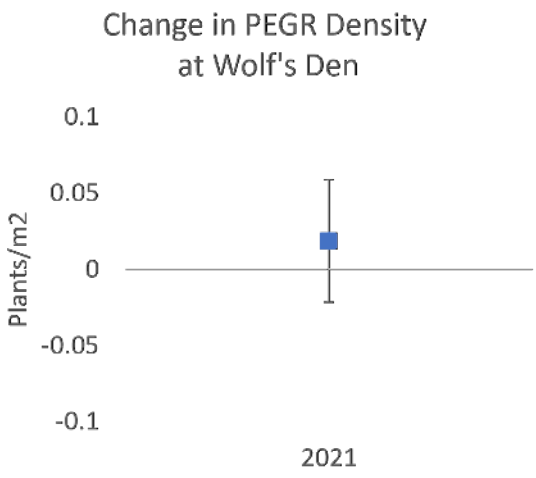
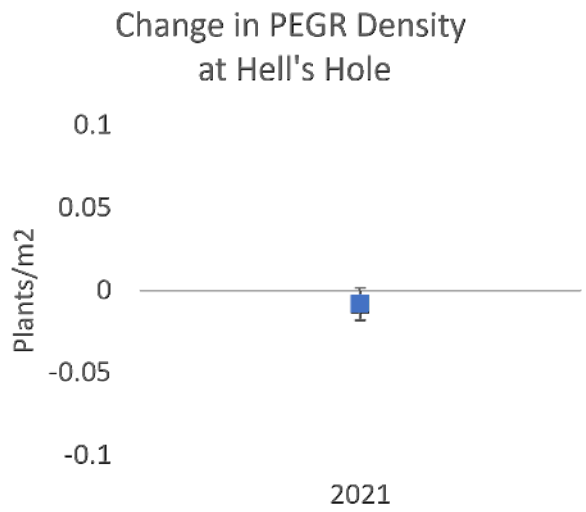


Figure 4a-c. Changes in Graham's beardtongue densities from establishment to 2021 for conservation unit 1 (a), unit 2 (b), and unit 3 (c) monitoring sites (error bars represent 90% confidence intervals).

d) Conservation Unit 4 – White River



e) Conservation Unit 5 – Raven Ridge

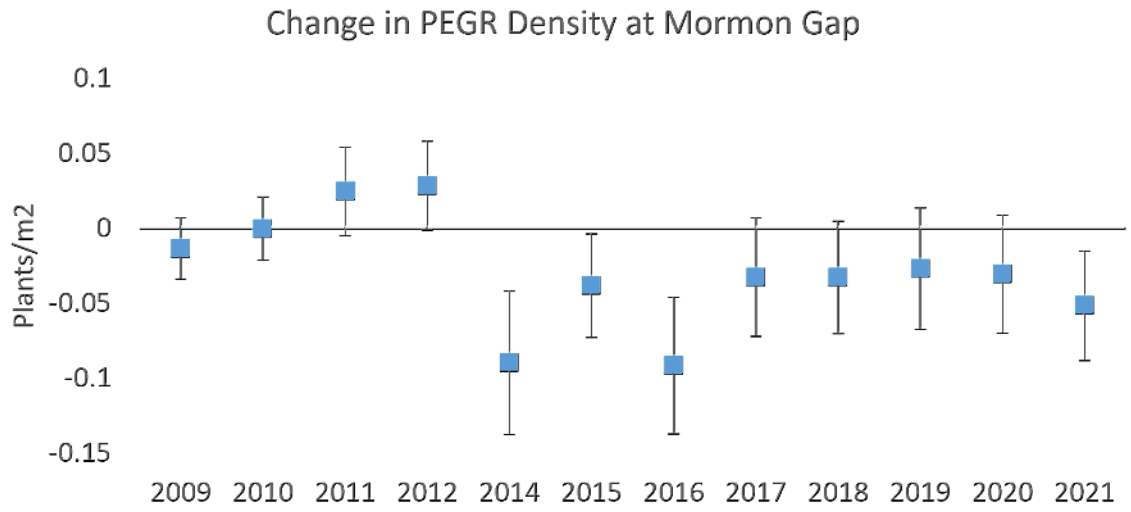
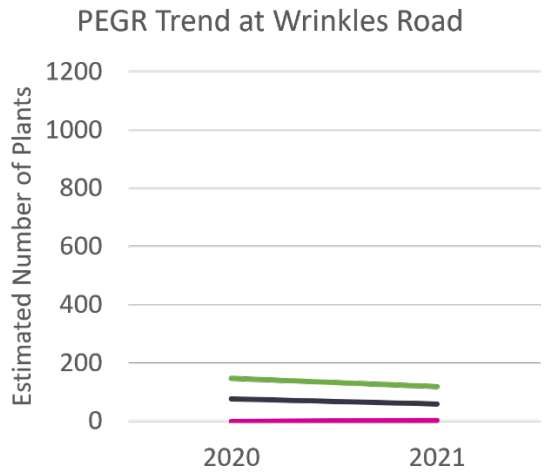
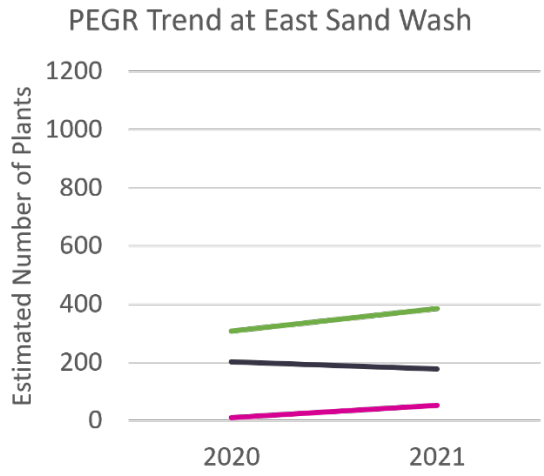


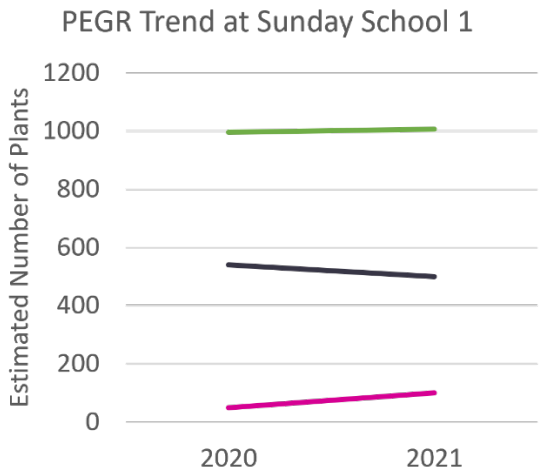
Figure 4d-e. Changes in Graham's beardtongue densities from establishment to 2021 for conservation unit 4 (d) and unit 5 (e) monitoring sites (error bars represent 90% confidence intervals).

a) Conservation Unit 1 – Sand Wash

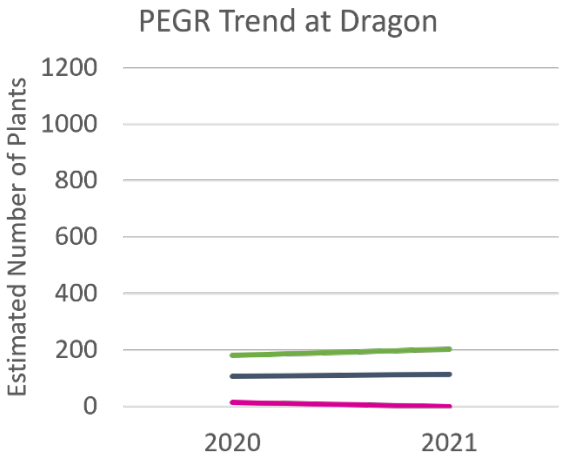


b) Conservation Unit 2 – Seep Ridge





c) Conservation Unit 3 – Evacuation Creek



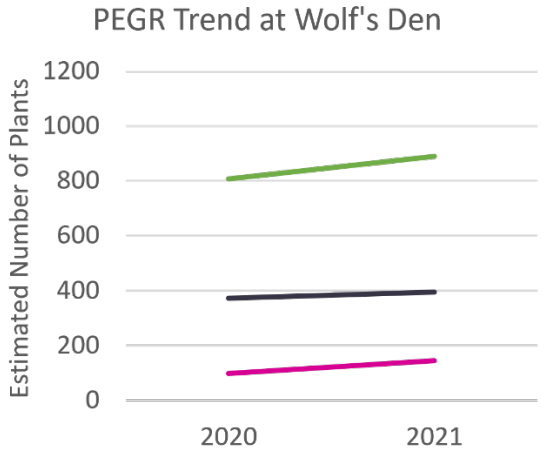
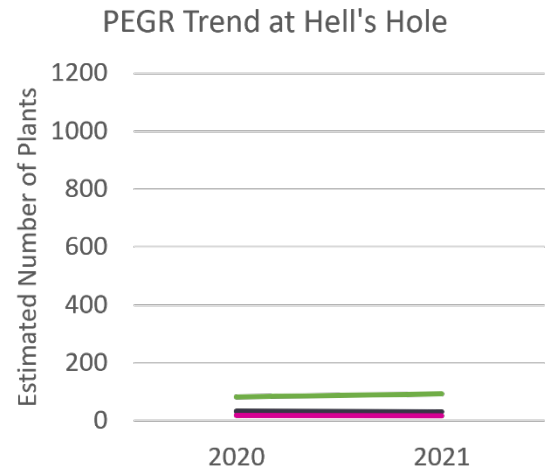


Figure 5a-c. Graham's beardtongue estimated abundance trend from establishment to 2021 for conservation unit 1 (a), unit 2 (b), and unit 3 (c) monitoring sites (legend in Figure 4e).

d) Conservation Unit 4 – White River



e) Conservation Unit 5 – Raven Ridge

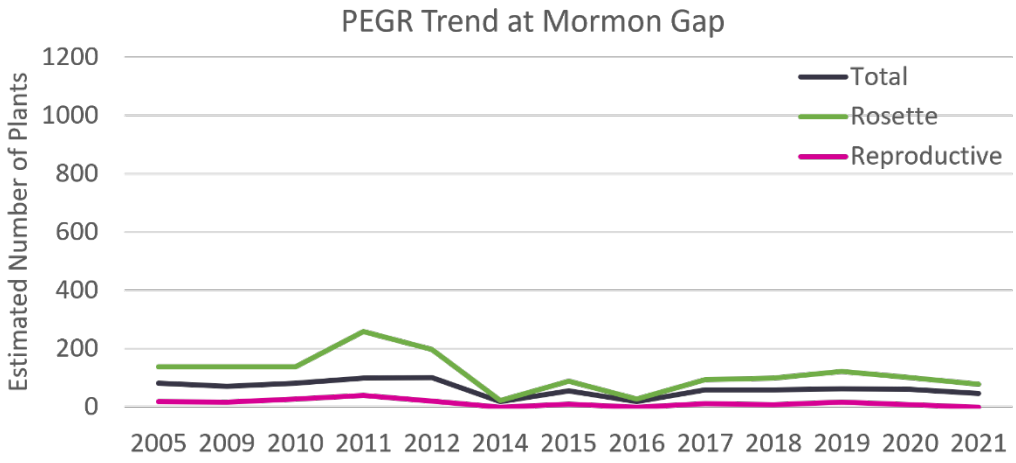
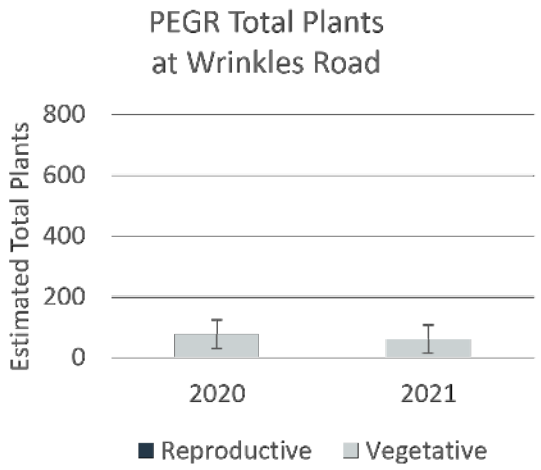
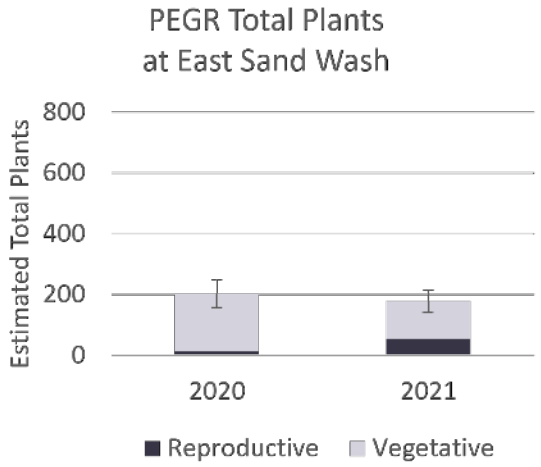


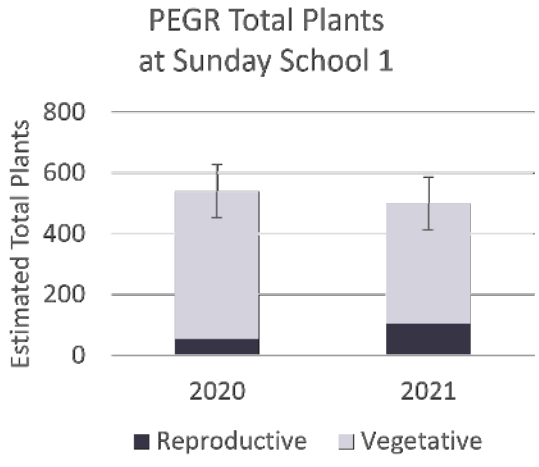
Figure 5d-e. Graham's beardtongue estimated abundance trend from establishment to 2021 for conservation unit 4 (d) and unit 5 (e) monitoring sites (legend in Figure 4e).

a) Conservation Unit 1 – Sand Wash

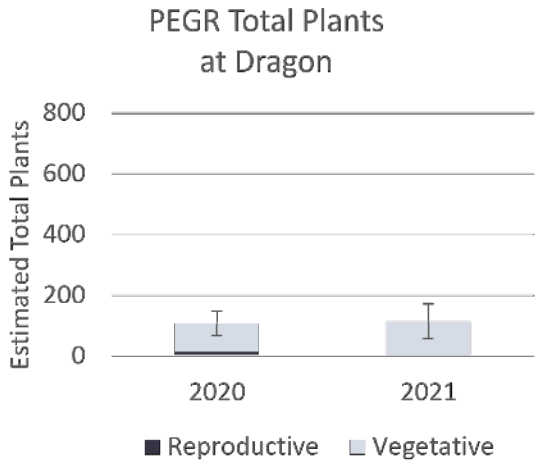


b) Conservation Unit 2 – Seep Ridge





c) Conservation Unit 3 – Evacuation Creek



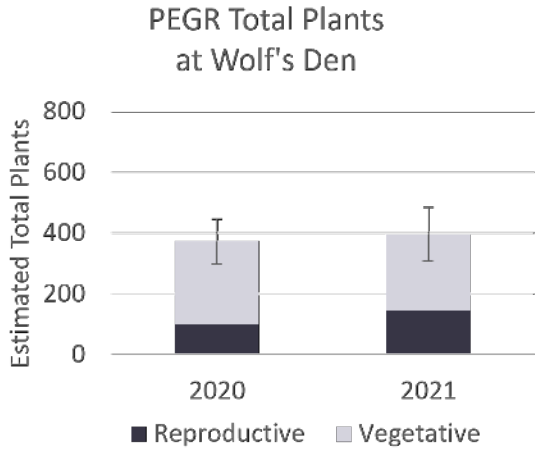
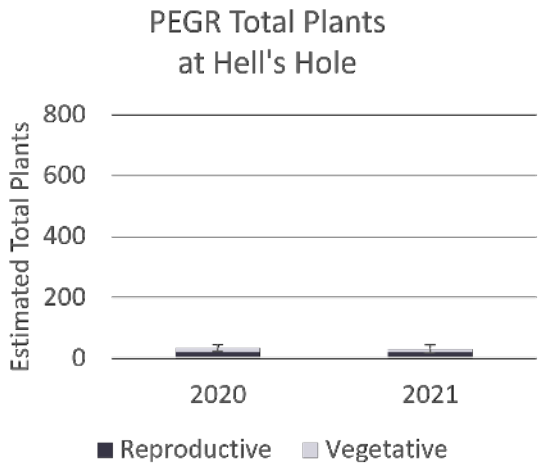


Figure 6a-c. Graham's beardtongue estimated total plants per year for conservation unit 1 (a), unit 2 (b), and unit 3 (c) monitoring sites.

d) Conservation Unit 4 – White River



e) Conservation Unit 5 – Raven Ridge

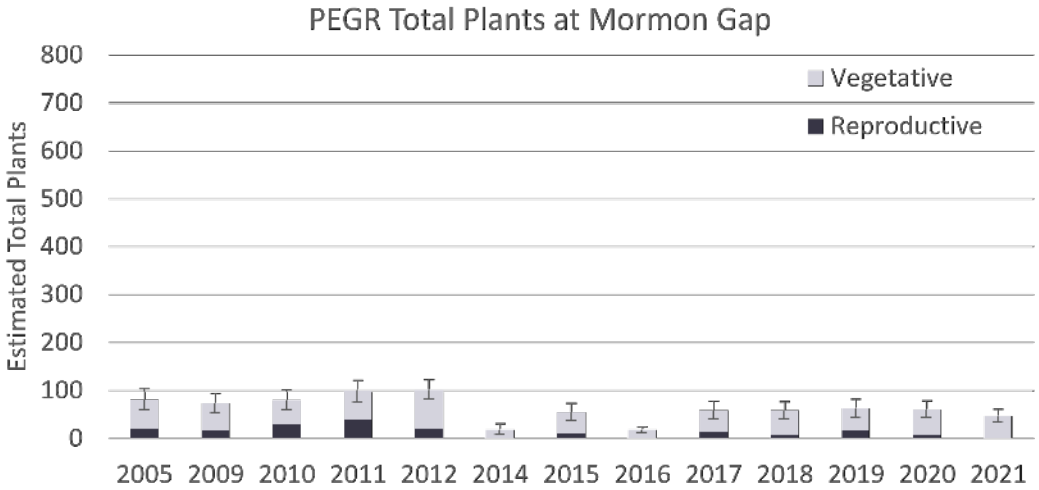


Figure 6d-e. Graham's beardtongue estimated total plants per year for conservation unit 4 (d) and unit 5 (e) monitoring sites.

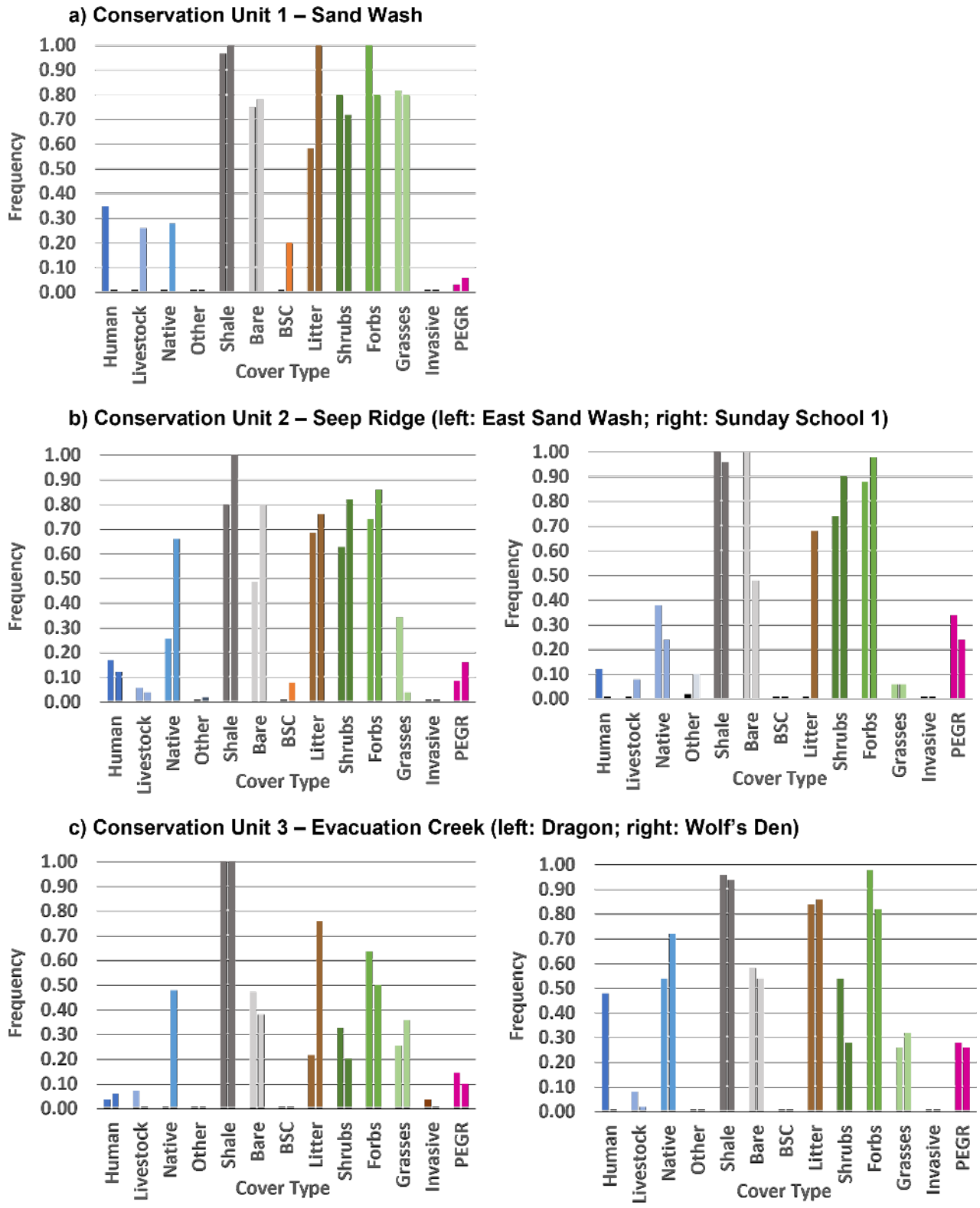


Figure 7a-c. Frequency of disturbance, ground cover, vegetation, and Graham's beardtongue at the conservation unit 1 (a), unit 2 (b), and unit 3 (c) monitoring sites (black indicates zero detection)**.**

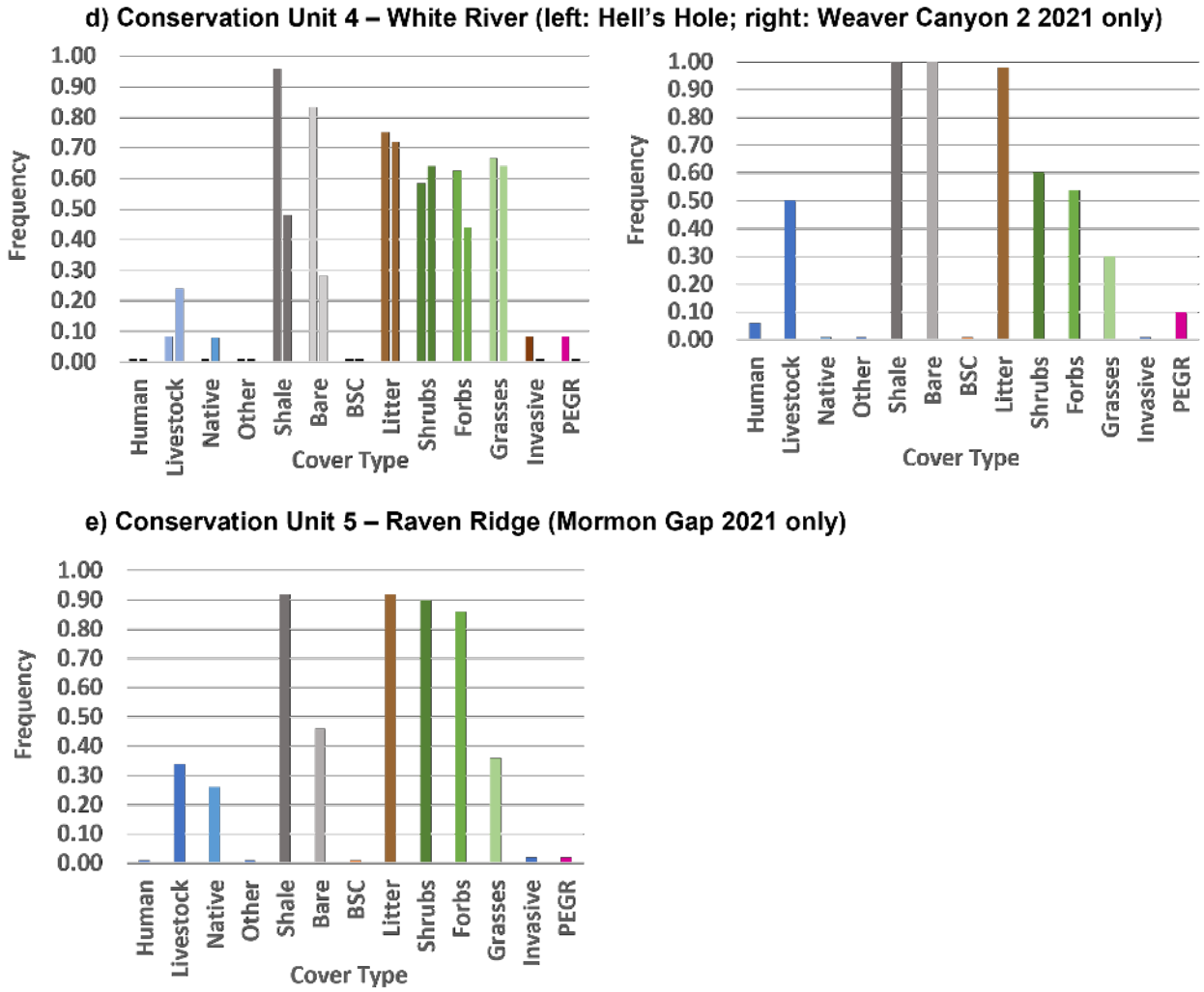


Figure 7d-e. Frequency of disturbance, ground cover, vegetation, and Graham's beardtongue at the conservation unit 4 (d) and unit 5 (e) monitoring sites.

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.

EAST SAND WASH

EAST SAND WASH POPULATION TREND

Graham's beardtongue density decreased slightly at East Sand Wash between 2020 (M=6.75, SD=3.28) and 2021 (M=5.98, SD=3.2; see **Figure 4b**). The decrease was found to not be statistically significant t(11)=1.6, p=0.15. Power analysis was completed at the site indicating that the existing series of 12 transects are sufficient to be 90% certain of detecting at least a 15% change in mean plant density.

There was an insignificant downward trend in the total number of Graham's beardtongue individuals at East Sand Wash in 2021 compared to 2020 (**Figure 5b**). However, there was a slight increase in the number of total rosettes and reproductive plants. There was an insignificant reduction in the estimated total number of Graham's beardtongue individuals East Sand Wash in 2021 compared to 2020 (**Figure 6b**).

EAST SAND WASH DISTURBANCE AND HABITAT COMPOSITION

Frequency of disturbance, ground cover, and vegetation by cover class in 2020 and 2021 is illustrated in **Figure 7b**. There was evidence of vehicle tire tracks and livestock activity within the plot. Native ungulate sign was also present. Nested frequency quadrat sample size will be reassessed in 2022.

SUNDAY SCHOOL CANYON 1

SUNDAY SCHOOL CANYON 1 POPULATION TREND

Graham's beardtongue density decreased slightly at Sunday School Canyon 1 between 2020 (M=13.5, SD=5.11) and 2021 (M=12.5, SD=5.07; see **Figure 4b**). The decrease was found to not be statistically significant t(11)=1.44, p=0.18. Power analysis was completed at the site indicating that our existing series of 12 transects at the site are sufficient to be 90% certain of detecting at least a 12% change in mean plant density. Sunday School Canyon 1 has maintained the highest observed plant density ($\bar{x}$=0.433 plants/m^2) of the eight established Graham's beardtongue study sites over the last two sampling intervals.

There was an insignificant downward trend in the total number of Graham's beardtongue individuals in 2021 compared to 2020 (**Figure 5b**), also with an increase in the number of total rosettes and reproductive plants; and an insignificant decline in the estimated total individuals in 2021 (**Figure 6b**).

SUNDAY SCHOOL CANYON 1 DISTURBANCE AND HABITAT COMPOSITION

Frequency of disturbance, ground cover, and vegetation by cover class in 2020 and 2021 is illustrated in **Figure 7b**. There was evidence of relatively high native ungulate activity, and vehicle tire tracks and livestock activity within the plot. Nested frequency quadrat sample size will be reassessed in 2022.

Conservation Unit 3 (Evacuation Creek)

We established two macroplot monitoring sites at Dragon and Wolf's Den in conservation unit 3 in May 2020. We are trying to identify a population to replace the Dragon macroplot monitoring site, but a suitable location has not been located to date.

DRAGON

DRAGON POPULATION TREND

Graham's beardtongue density increased slightly at Dragon between 2020 (M=2.67, SD=2.39) and 2021 (M=2.83, SD=3.35; **see Figure 4c**). The increase was found not to be statistically significant t(11)=0.26, p >0.5. Power analysis was performed at the site indicating that 13 additional transects are required to meet our sampling objective of being 80% certain of detecting at least a 20% change in mean plant density. No additional sample units were added in 2021.

There was an insignificant increase in the total number of Graham's beardtongue individuals in 2021 compared to 2020 (**Figure 5c**), with a slight increase in the number of total rosettes. There was also an insignificant decline in the estimated total reproductive plants in 2021 (**Figure 6c**).

DRAGON DISTURBANCE AND HABITAT COMPOSITION

Frequency of disturbance, ground cover, and vegetation by cover class in 2020 and 2021 is illustrated in **Figure 7c**. There was relatively high native ungulate sign throughout the macroplot. Nested frequency quadrat sample size will be reassessed in 2022.

WOLF'S DEN

WOLF'S DEN POPULATION TREND

Graham's beardtongue density increased slightly at Wolf's Den between 2020 (M=12.42, SD=6.16) and 2021 (M=13.17, SD=7.42; see **Figure 4c**). The increase was found to not be statistically significant t(11)=0.99, p=0.37. Power analysis was completed at the site indicating that our initial series of 12 transects are sufficient to be 90% certain of detecting at least an 11% change in mean plant density.

There was an insignificant increase in the total number of Graham's beardtongue individuals in 2021 compared to 2020 (**Figure 5c**), with larger numbers of reproductive plants and total rosettes. There was also an insignificant increase in the estimated total reproductive plants in 2021 (**Figure 6c**).

WOLF'S DEN DISTURBANCE AND HABITAT COMPOSITION

Frequency of disturbance, ground cover, and vegetation by cover class in 2020 and 2021 is illustrated in **Figure 7c**. There was relatively high native ungulate sign throughout the macroplot with a single detection of livestock activity. Nested frequency quadrat sample size will be reassessed in 2022.

Conservation Unit 4 (White River)

We established one macroplot monitoring site in Hell's Hole Canyon in conservation unit 4 in May 2020, and a second macroplot in Weaver Canyon in May 2021. No additional monitoring locations are planned.

HELL'S HOLE

HELL'S HOLE POPULATION TREND

Graham's beardtongue density decreased slightly at Hell's Hole between 2020 (M=2.83, SD=1.83) and 2021 (M=2.67, SD=2.07; see **Figure 4d**). The decrease was not found to be statistically significant $t(5)=1.41$, $p=0.22$. Power analysis was completed at the site indicating that our initial set of six transects are sufficient to maintain 90% certainty of detecting at least a 15% change in mean plant density.

There was no change in the total number of Graham's beardtongue individuals in 2021 compared to 2020 (**Figure 5d**), with approximately the same number of reproductive plants and total rosettes. There was also no change in the estimated total reproductive plants in 2021 (**Figure 6d**).

HELL'S HOLE DISTURBANCE AND HABITAT COMPOSITION

Frequency of disturbance, ground cover, and vegetation by cover class in 2020 and 2021 is illustrated in **Figure 7d**. There was limited evidence of livestock or high native ungulate activity in the plot. Nested frequency quadrat sample size will be reassessed in 2022.

Conservation Unit 5 (Raven Ridge)

No additional macroplot monitoring sites were established for Graham's beardtongue in conservation unit 5 in 2021. A second macroplot monitoring location in conservation unit 5 has not been identified to date.

MORMON GAP

MORMON GAP POPULATION TREND 2005-2021

Data collection has occurred at Mormon Gap during twelve of the sixteen years since monitoring was established at the site in 2005 (no data collected in 2006, 2007, 2008, and 2013). The population has experienced a statistically significant decrease ($t(14)=4.36$, p <0.01) in Graham's beardtongue density between 2005 (M=4.07, SD=3.94) and 2021 (M=2.33, SD=2.55; see **Figure 4e**). 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 6e**).

The population suffered from a livestock trailing event which occurred between the 2012 and 2014 sampling intervals and has been slow to recover (**Figure 5e and Figure 6e**). Despite being smaller than when monitoring was established, the population has been largely stable to increasing over the last seven monitoring intervals (2014 - 2021). Since 2017 the population has exhibited very little change in size, the standard deviation in the total number of plants from 2017 – 2020 is $\sigma = 1.41$.

MORMON GAP DISTURBANCE AND HABITAT COMPOSITION 2021

No disturbance or habitat composition data were collected at the Mormon Gap site in 2020. In May 2021, nested frequency data were collected for 25 quadrats. Frequency of disturbance, ground cover, and vegetation by cover class in 2021 is illustrated in **Figure 7e**. There was limited evidence of livestock or high native ungulate activity in the plot. Two years of disturbance and habitat data will be required to evaluate sample size adequacy and to evaluate differences between years.

White River Beardtongue Population Trend

Population trend monitoring and supplemental habitat monitoring was completed at seven of the eight previously established White River beardtongue study sites between May 25 and May 30, 2021. Four sites (Weaver Canyon, Sunday School 2, Rabbit Mountain and Don Holmes Road) experienced decreases, two sites (Raven Ridge 1 & 2) experienced increases, and one site (Bookcliffs) remained unchanged. The four sites which experienced decreases were found to be statistically significant (Figure 8, Table 3).

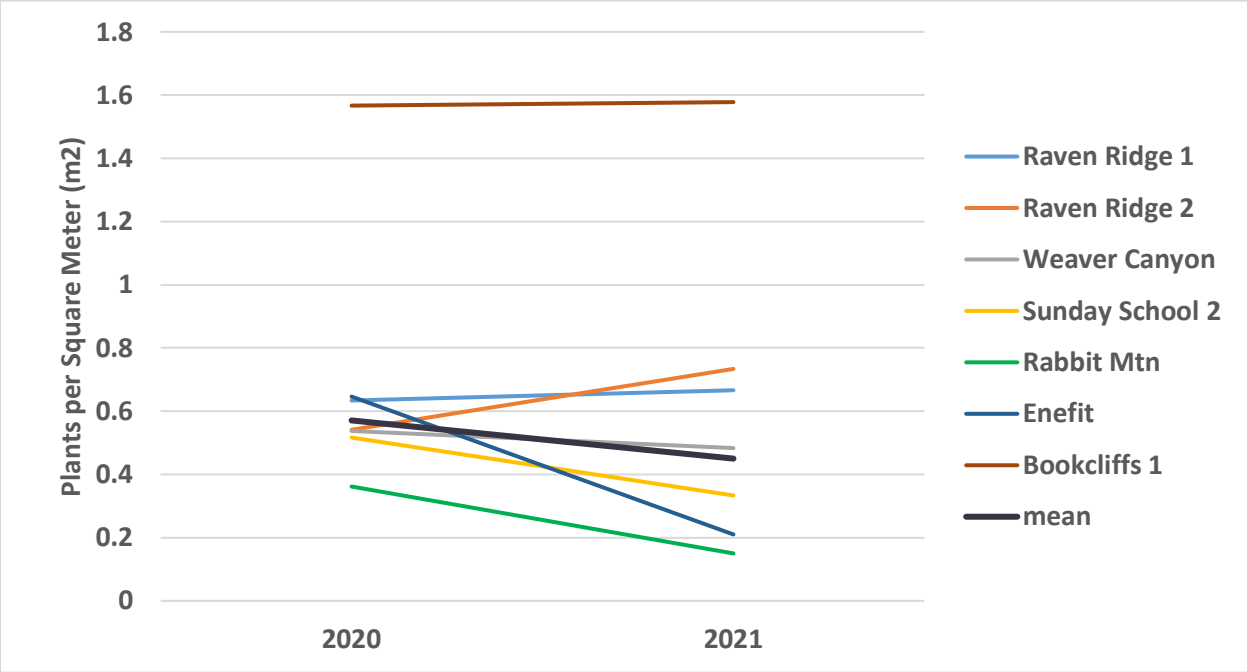


Figure 8. Range wide average and site-specific White River beardtongue population trends between 2020 and 2021. Note: Trend was estimated as the change in mean plant density (avg. plants/m^2) between two observations. The mean was defined using a ratio estimator whereby the total number of plants among all sites is divided by the average combined area of the sites (Stehman and Salzer 2001).

The year preceding sampling (May 2020-April 2021) featured below average precipitation and above average temperatures across the Uinta Basin (PRISM climate group 2021). Across all our Penstemon monitoring sites total annual precipitation averaged just 54.4% compared to the recent historic reference period (1980-2010). Temperatures averaged about a degree higher than normal for the year. Without performing in-depth analysis, we can assume that below average precipitation and higher than average temperatures combined to create conditions amounting to water deficit - or higher than normal evaporative demand - and therefore increased stress to vascular plants, including White River beardtongue. The Book Cliffs White River beardtongue monitoring site, which typically receives nearly twice the annual amount of precipitation and averages approximately 4 degrees cooler than the Basin, experienced proportionally hot and dry conditions.

Table 3. 2021 Summary Statistics for the *Penstemon scariosus* var. *albifluvis* Monitoring Sites

	Unit 2	Unit 3		Unit 4		Unit 5		Unit 6
	Sunday School 2	Don Holmes	Rabbit Mountain	Weaver Canyon	State Line	Raven Ridge 1	Raven Ridge 2	Book Cliffs 1
Date Established with Sample Size	2021	N/A	N/A	2019	N/A	2017	2019	2020
Macroplot Area (m^2)	840	800	1800	720	900	800	800	360
Transects (m)	17 (20m)	19 (20m)	12 (50m)	12 (20m)	12 (25m)	12 (20m)	12 (20m)	12 (15m)
2021 Estimated Total Plants	280	168	270	348	258	533	587	568
Percent Reproductive	8%	30%	28%	55%	47%	13%	50%	43%
Significant Change Since Establishment	N/A	N/A	**sig. decrease**	**sig. decrease**	N/A	**sig. increase**	no/stable	no/stable
*p-value**	N/A	N/A	**0.04**	**0.03**	N/A	**<0.01**	0.07	>0.05
2021 Mean Density (plants/m^2)	**0.31**	**0.21**	**0.36**	**0.48**	**0.29**	**0.67**	**0.73**	**1.58**

* *p* values are the result of a two-tailed paired t test performed between 2021 and the year the site was established. A result of < 0.05 is considered statistically significant. N/A indicates sites that lack sufficient data to complete calculations.

One new study site (State Line) was established in 2021 in Conservation Unit 4. The Cottonwood Creek site was not visited in 2021.

White River Beardtongue Disturbance and Habitat Composition

In May and June 2021, we collected pilot disturbance and habitat composition data at the seven established macroplot monitoring sites and at a new macroplot site in conservation unit 4 (State Line). This was the first year of disturbance and habitat data collection using the nested quadrat methods at the Weaver Canyon, Raven Ridge 1, and Raven Ridge 2 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*), and Barneby's cryptantha (*Cryptantha barnebyi*).

Total frequency is given as a proportion for four disturbance classes (human, livestock, native ungulate, other), four ground cover types (shale, bare ground, biological soil crust (BSC), litter), four vegetation classes (shrubs, forbs, grasses, invasive species), and for the target species. The frequency of White River beardtongue is also included in the forbs class. The average frequency for each of the cover types in 2020 and 2021 is shown in Figure 9.

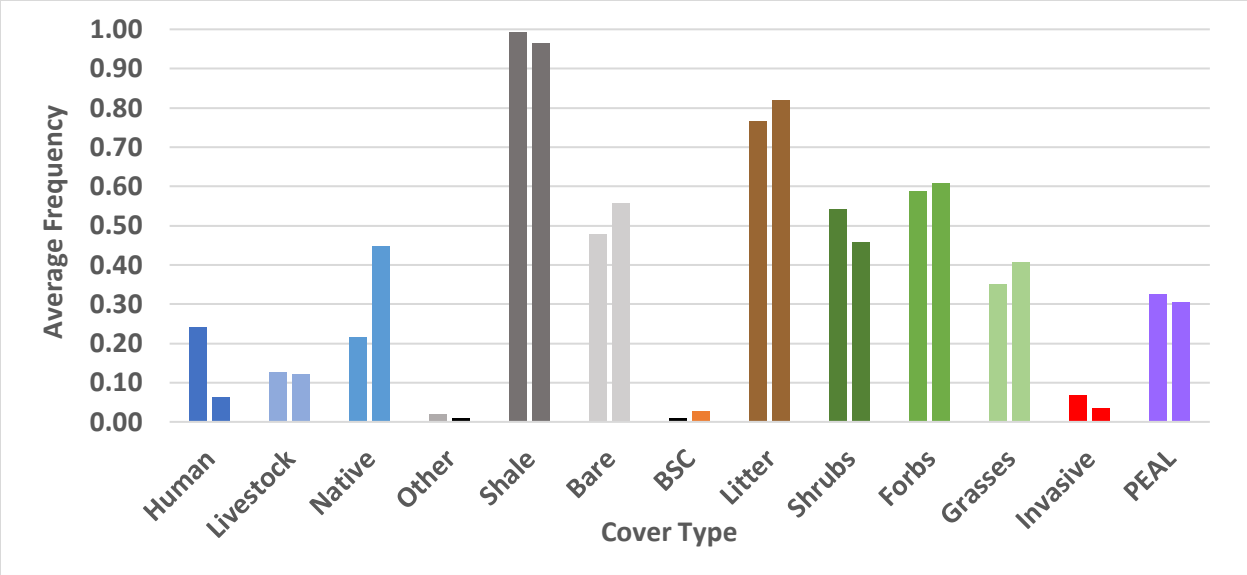


Figure 9. 2020 and 2021 average frequency for disturbance, ground cover, native and invasive vegetation, and target species cover types in the White River beardtongue macroplots.

Year 2 results are summarized for each monitoring macroplot following the population trend results, where available. Average total disturbance frequency across all White River beardtongue population monitoring macroplots in 2020 (n=5) and 2021 (n=8) was 0.60 and 0.64, respectively. These values include all forms of surface disturbance and sign, including human footprints. Our early estimates of the minimum number of nested quadrats needed to detect a 20% change in disturbance frequency indicated that additional quadrats may be needed (n=66 quadrats); however, this may be an overestimate due to disturbance caused during plot establishment, and additional sample size assessments will be performed following the third year of range wide monitoring.

Conservation Unit 2 (Seep Ridge)

We established one macroplot monitoring site at Sunday School Canyon in conservation unit 2 in May 2020. Surveys to locate an additional White River beardtongue macroplot monitoring location took place in 2021, but a suitable site was not identified. Reconnaissance will continue in 2022.

SUNDAY SCHOOL CANYON 2

SUNDAY SCHOOL CANYON 2 POPULATION TREND

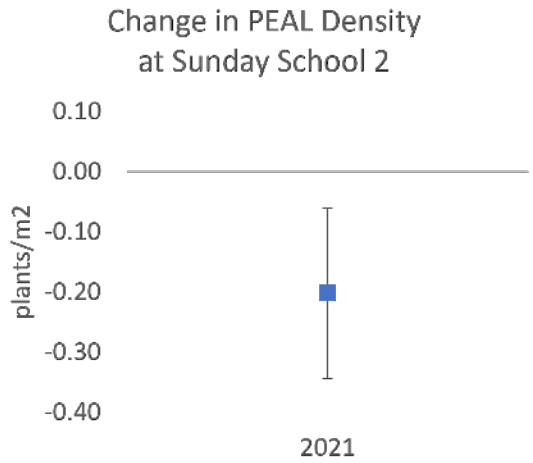
White River beardtongue density decreased at Sunday School Canyon 2 between 2020 (M=10.33, SD=7.94) and 2021 (M=6.29, SD=3.67; **Figure 10a**). The decrease was statistically significant $t(14)=3.24$, $p<0.01$. Power analysis indicated two additional transects were required to be 80% certain of detecting at least a 20% change in plant density. Those two additional transects were installed and sampled at the time of site visitation in 2021.

There was a significant decrease in the total number of White River beardtongue individuals in 2021 compared to 2020 (**Figure 11a**), with fewer reproductive plants and flowering stems (**Figure 12a**). The observed decrease was not attributable to any land management related action and is likely the product of hot and dry conditions.

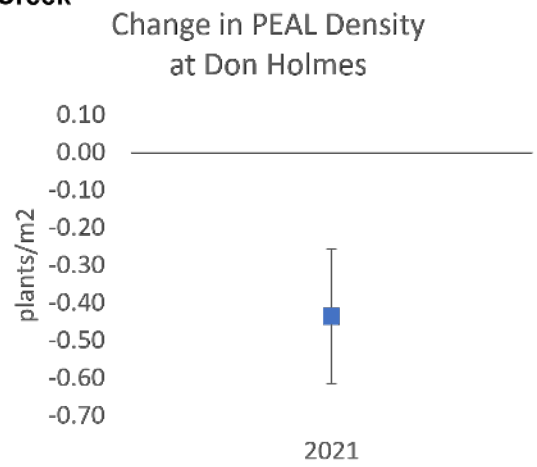
SUNDAY SCHOOL CANYON 2 DISTURBANCE AND HABITAT COMPOSITION

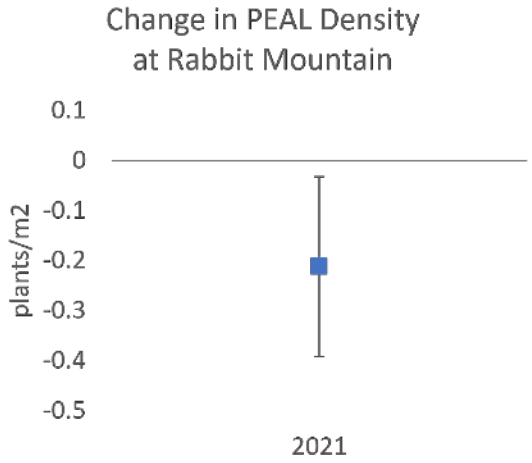
Frequency of disturbance, ground cover, and vegetation by cover class in 2020 and 2021 is illustrated in **Figure 13a**. The site is dominated by shale with scattered native forbs and shrubs. There was evidence of relatively high native ungulate activity the plot. Graham's beardtongue was present in the macroplot in 2020 but was not detected in 2021. No invasive species have been detected in the plot to date. Nested frequency quadrat sample size will be reassessed in 2022.

a) Conservation Unit 2 – Seep Ridge



b) Conservation Unit 3 – Evacuation Creek





c) Conservation Unit 4 – White River

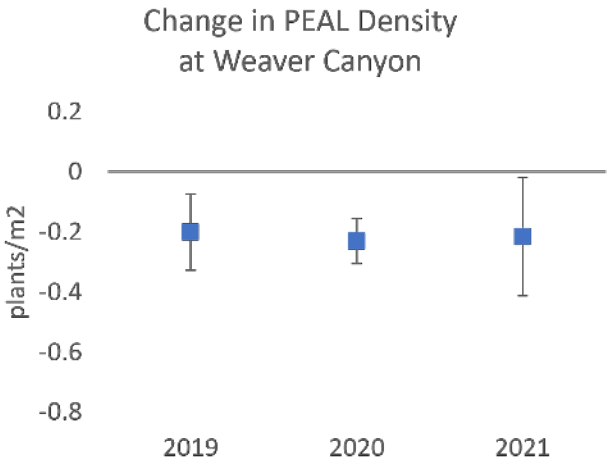
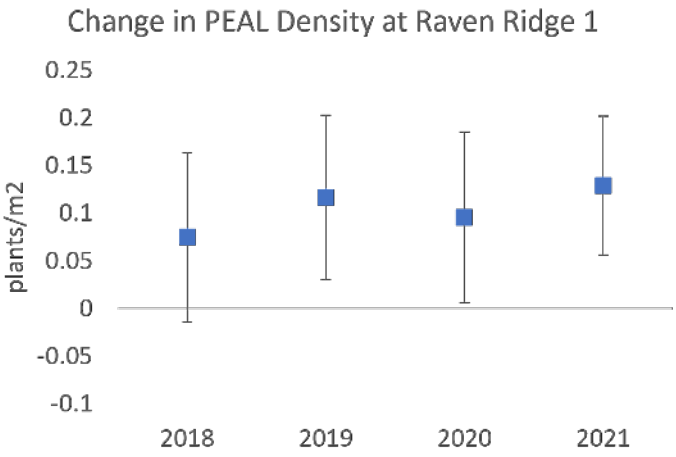
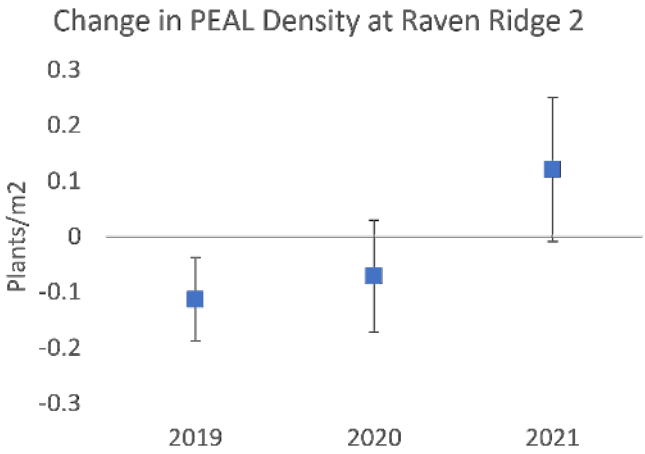


Figure 10a-c. Changes in White River beardtongue densities from establishment to 2021 for conservation unit 2 (a), unit 3 (b), and unit 4 (c) monitoring sites (error bars represent 90% confidence intervals).

d) Conservation Unit 5 – Raven Ridge





e) Conservation Unit 6 – Book Cliffs

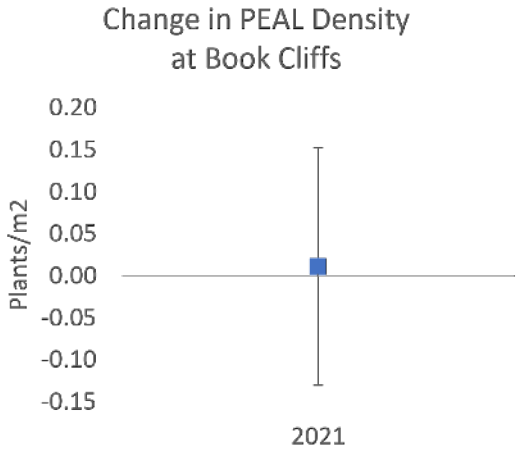
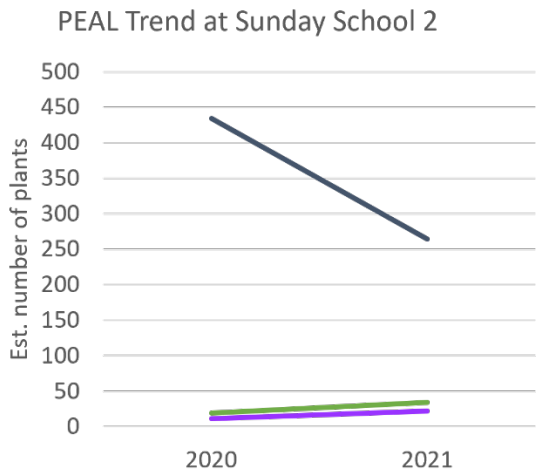
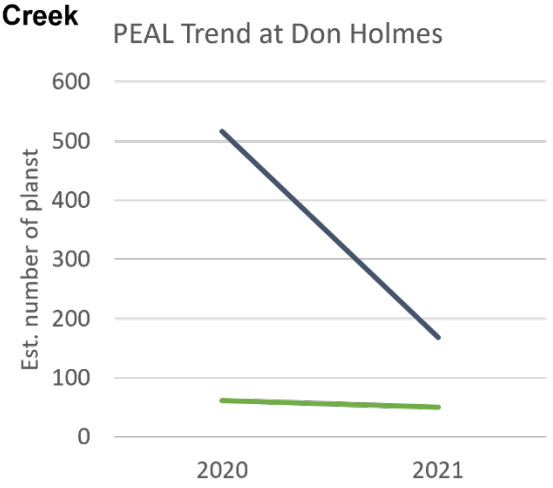


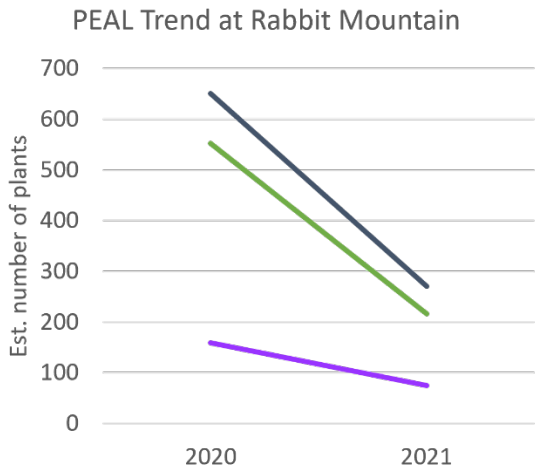
Figure 10d-e. Changes in White River beardtongue densities from establishment to 2021 for conservation unit 5 (d) and unit 6 (e) monitoring sites (error bars represent 90% confidence intervals).

a) Conservation Unit 2 – Seep Ridge



b) Conservation Unit 3 – Evacuation Creek





c) Conservation Unit 4 – White River

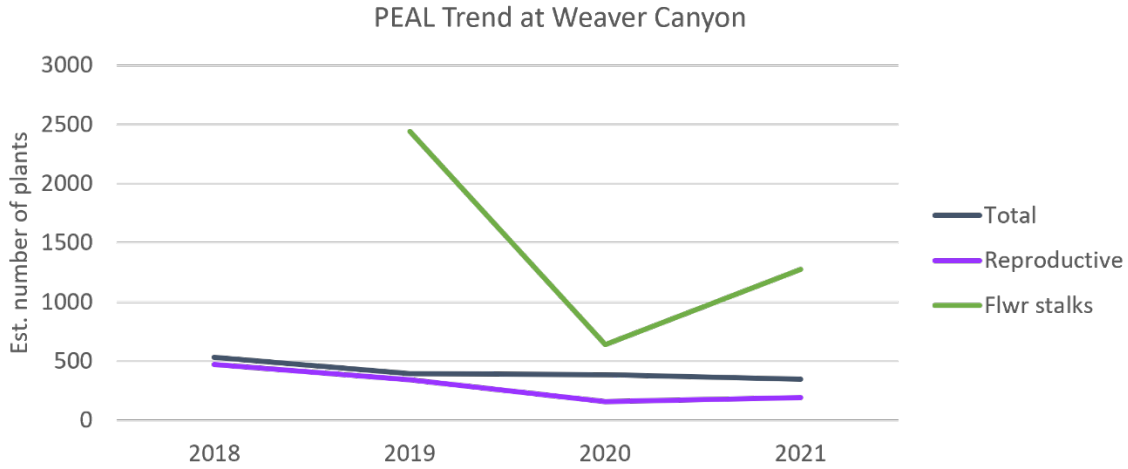
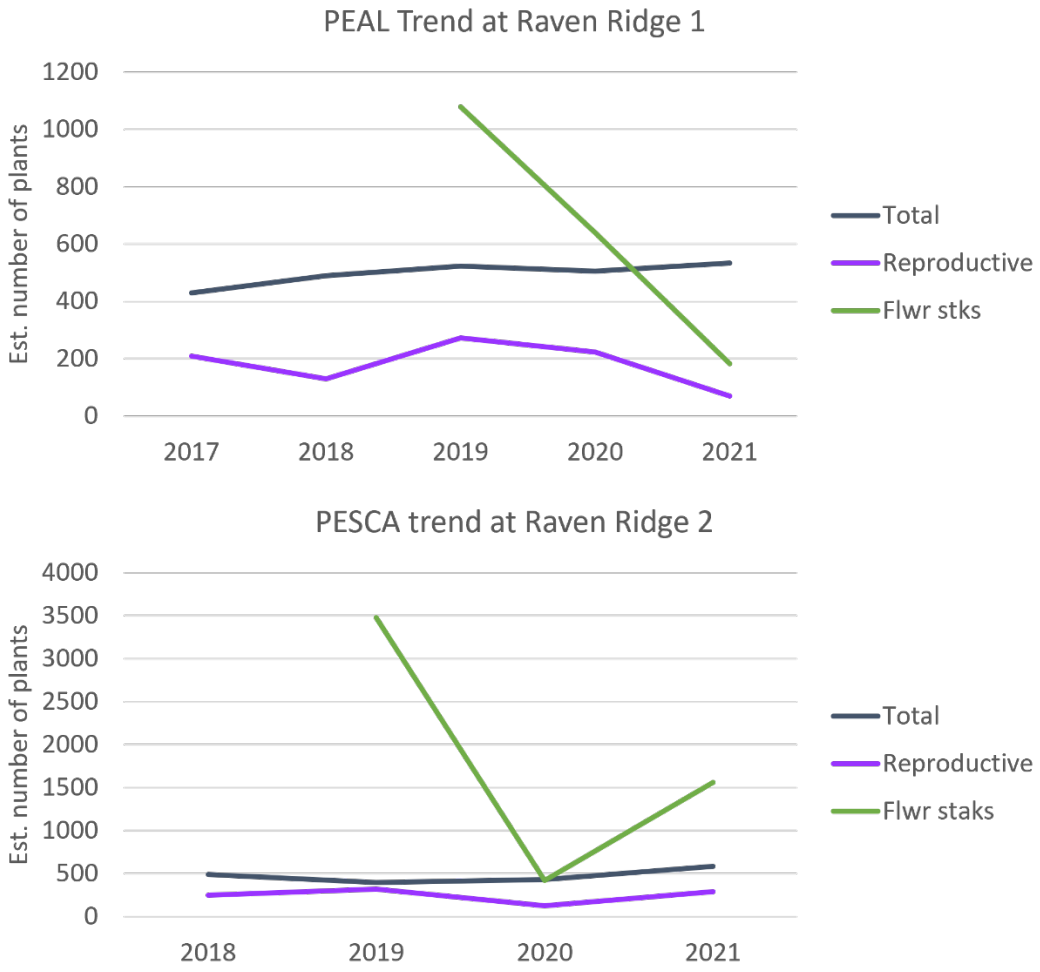


Figure 11a-c. White River beardtongue estimated abundance trend from establishment to 2021 for conservation unit 5 (d) and unit 6 (e) monitoring sites.

d) Conservation Unit 5 – Raven Ridge



e) Conservation Unit 6 – Book Cliffs

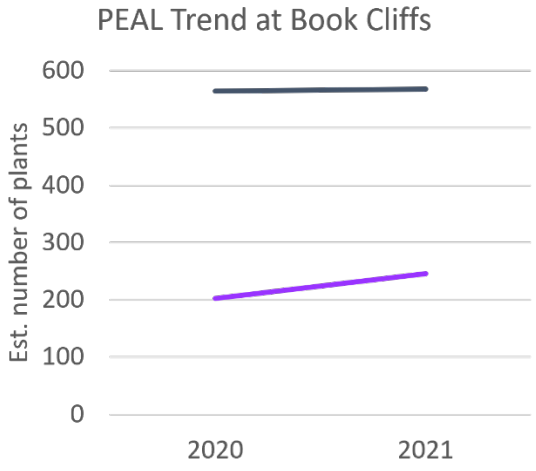
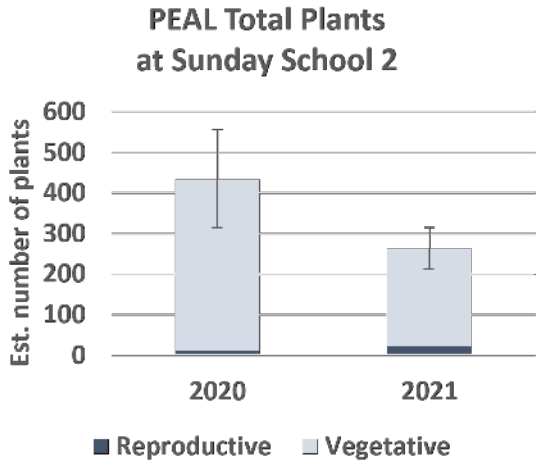
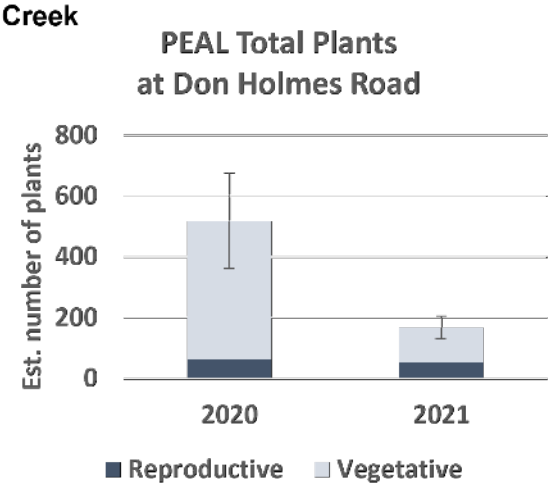


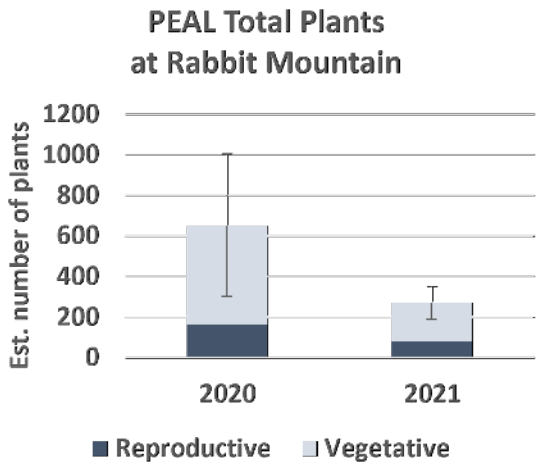
Figure 11d-e. White River beardtongue estimated abundance trend from establishment to 2021 for conservation unit 2 (a), unit 3 (b), and unit 4 (c) monitoring sites.

a) Conservation Unit 2 – Seep Ridge



b) Conservation Unit 3 – Evacuation Creek





c) Conservation Unit 4 – White River

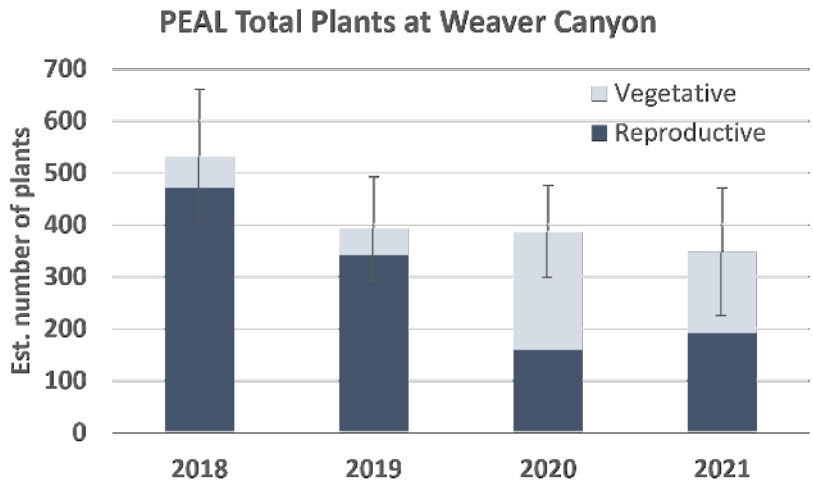
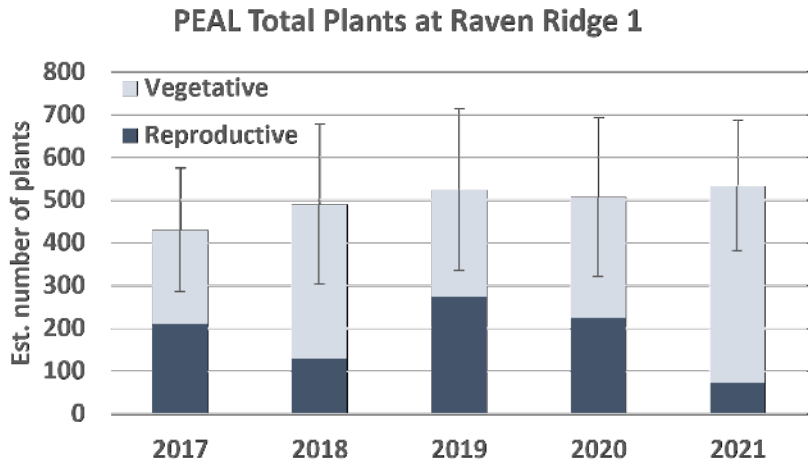
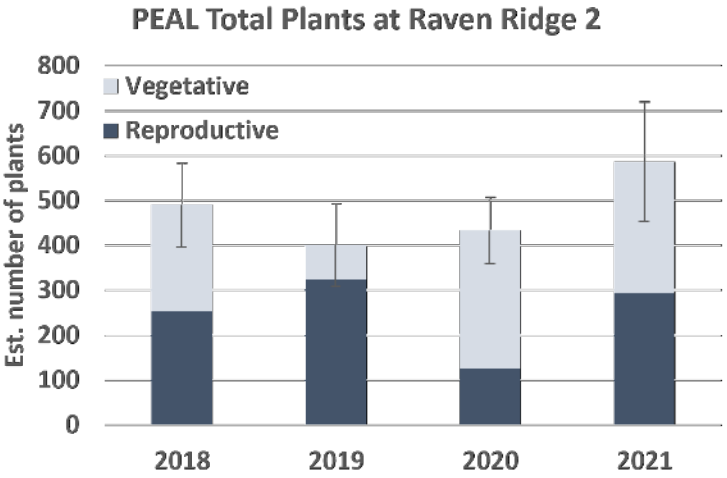


Figure 12a-c. White River beardtongue estimated total plants per year for conservation unit 2 (a), unit 3 (b), and unit 4 (c) monitoring sites.

d) Conservation Unit 5 – Raven Ridge





e) Conservation Unit 6 – Book Cliffs

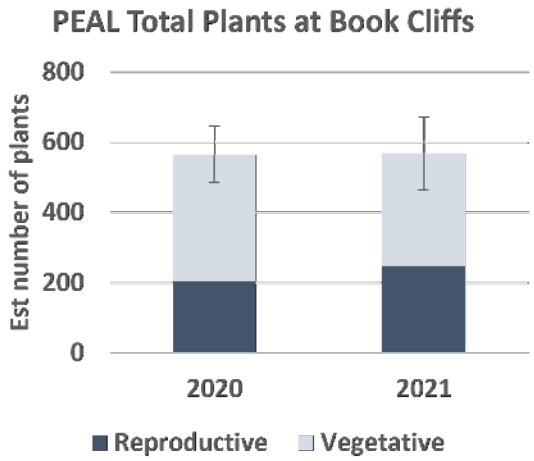
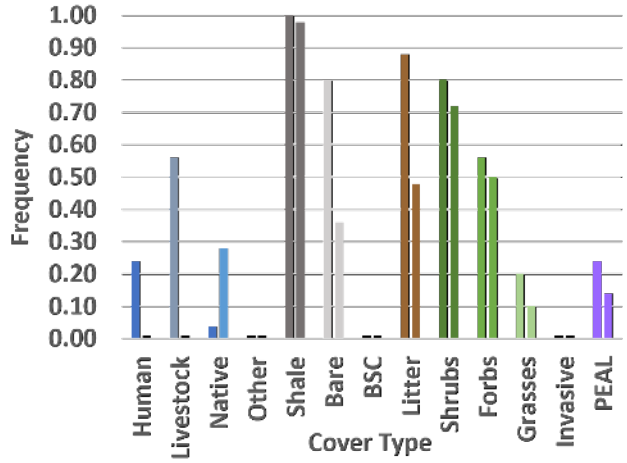
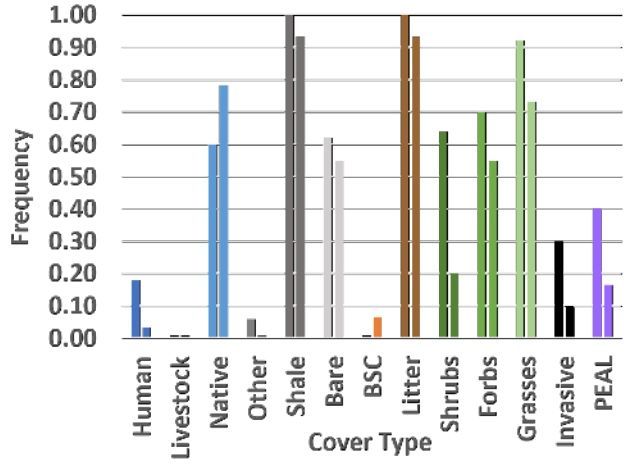


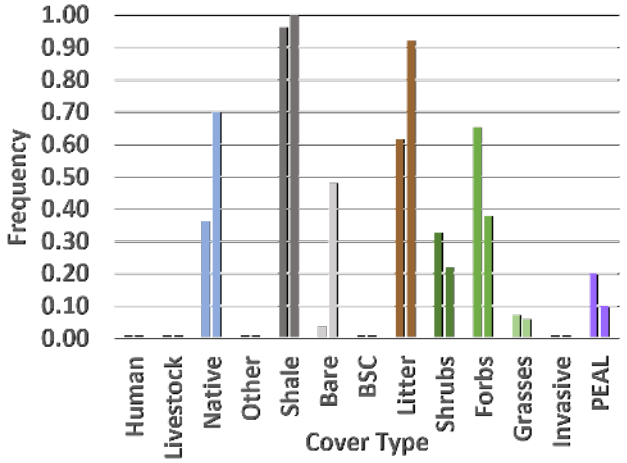
Figure 12d-e. White River beardtongue estimated total plants per year for conservation unit 5 (d) and unit 6 (e) monitoring sites.

a) Conservation Unit 2 – Seep Ridge (Sunday School 2)

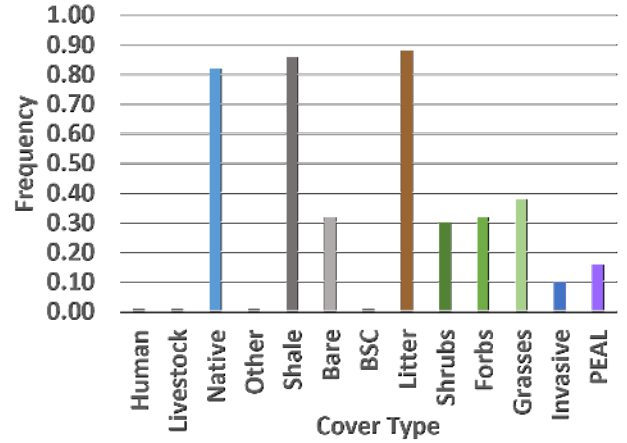


b) Conservation Unit 3 – Evacuation Creek (left: Don Holmes Road; right: Rabbit Mtn)





c) Conservation Unit 4 – White River (left: Weaver Canyon; right: State Line; both 2021 only)



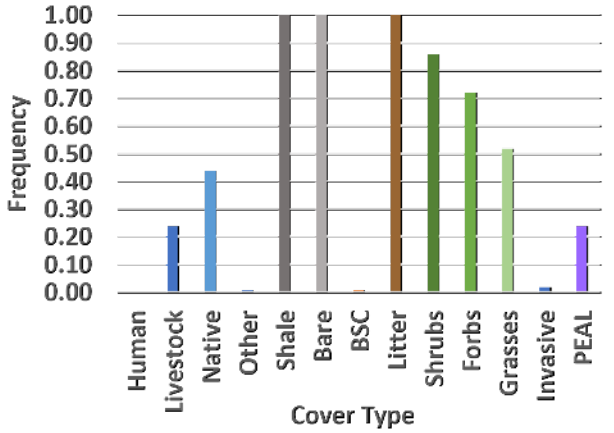
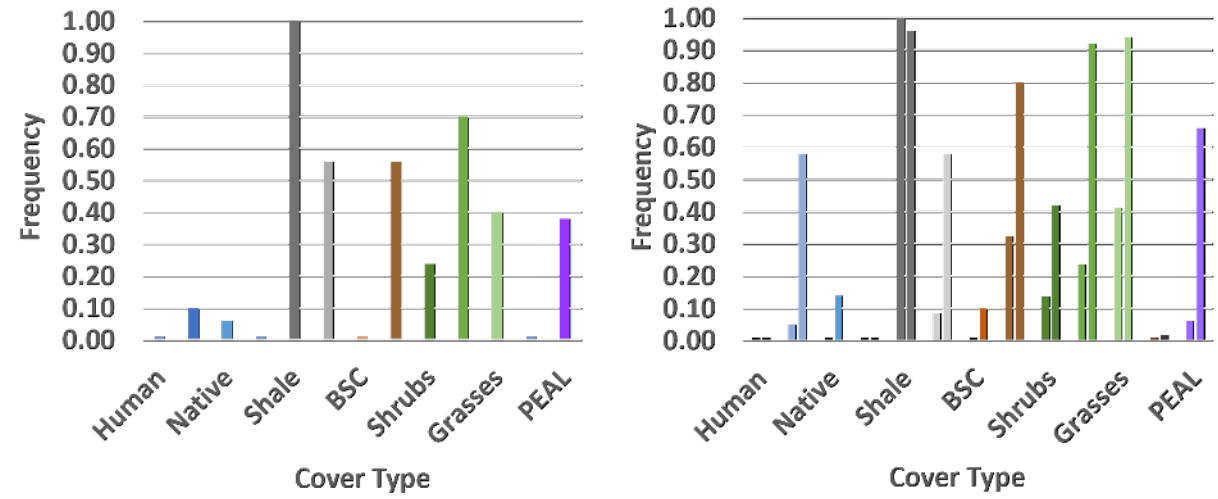


Figure 13a-c. Frequency of disturbance, ground cover, vegetation, and White River beardtongue at the conservation unit 2 (a), unit 3 (b), and unit 4 (c) monitoring sites (black indicates zero detection).

d) Conservation Unit 5 – Raven Ridge (left: Raven Ridge 1 2021; right: Raven Ridge 2)



e) Conservation Unit 6 – Book Cliffs

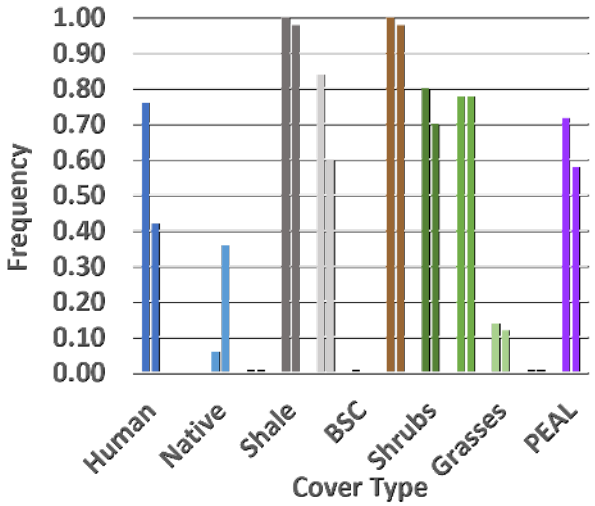


Figure 13d-e. Frequency of disturbance, ground cover, vegetation, and White River beardtongue at the conservation unit 5 (d) and unit 6 (e) monitoring sites.

Conservation Unit 3 (Evacuation Creek)

We established two macroplot monitoring sites at Don Holmes Road and Rabbit Mountain in May 2020 and monitored the sites in May 2021. No additional monitoring locations are planned.

DON HOLMES ROAD

DON HOLMES ROAD POPULATION TREND

White River beardtongue density decreased at Don Holmes Road between 2020 (M=12.92, SD=9.72) and 2021 (M=4.21, SD=3.24; **Figure 10b**). The decrease was statistically significant $t(12)=4.9$, $p<0.01$, reducing plant density at the site by two-thirds (67%). Power analysis indicated that the addition of six transects was required to be 80% certain of detecting a 20% change in mean plant density. Those six additional transects were installed and sampled at the time of site visitation in 2021.

There was a significant decline in the total number of White River beardtongue individuals in 2021 compared to 2020 (**Figure 11b**). There were associated declines in both the estimated total plants and number of reproductive plants in 2021 (**Figure 12b**). The observed decrease was not attributable to any land management related action and is likely the result of hot and dry conditions.

DON HOLMES ROAD DISTURBANCE AND HABITAT COMPOSITION

Frequency of disturbance, ground cover, and vegetation by cover class in 2020 and 2021 is illustrated in **Figure 13b**. The site is dominated by shale with scattered native forbs and shrubs. There was evidence of relatively high native ungulate activity the plot. No invasive species have been detected in the plot to date. Nested frequency quadrat sample size will be reassessed in 2022.

RABBIT MOUNTAIN

RABBIT MOUNTAIN POPULATION TREND

White River beardtongue density decreased at Rabbit Mountain between 2020 (M=18.08, SD=23.12) and 2021 (M=7.5, SD=5.2; **Figure 10b**). The decrease was statistically significant $t(11)=2.37$, $p=0.04$. Power analysis indicated that the addition of sixteen transects are required in order to be 80% certain of detecting a 20% change in mean plant density. No additional transects were added in 2021. There was a significant decline in the total number of White River beardtongue individuals in 2021 compared to 2020 (**Figure 11b**). There were associated declines in both the estimated total plants and number of reproductive plants in 2021 (**Figure 12b**). The loss of a large group of seedlings present in several transects in 2020 (evident by the wide standard deviation) which didn't persist to 2021 is a primary reason our power analysis indicated the need for additional transects. Power analysis will be completed again following 2022 data collection. Rabbit Mountain has maintained the lowest observed plant density ($\bar{x}$=0.26 plants/m^2) of the eight established White River beardtongue study sites over the last two sampling intervals. The observed decrease was not attributable to any land management related action and is likely the result of hot and dry conditions.

RABBIT MOUNTAIN DISTURBANCE AND HABITAT COMPOSITION

Frequency of disturbance, ground cover, and vegetation by cover class in 2020 and 2021 is illustrated in **Figure 13b**. There was evidence of increased native ungulate activity the plot. No invasive species were detected in 2021. Nested frequency quadrat sample size will be reassessed in 2022.

Conservation Unit 4 (White River)

We revisited the Weaver Canyon macroplot monitoring site for the fourth year and established a new macroplot at the State Line area on SITLA land in May 2021.

WEAVER CANYON

WEAVER CANYON POPULATION TREND 2018-2020

White River beardtongue density has decreased at Weaver Canyon since the site was established in 2018 (M=17.75, SD=8.52) and 2021 (M=9.67, SD=8.13; **Figure 10c**). The decrease is statistically significant t(11)=3.35, p=0.03.

There was little or no change in the total number of White River beardtongue individuals in 2021 compared to 2020 (**Figure 11c**), but there was an increase in the number of reproductive plants and total rosin total flowering stems (**Figure 12c**).

Weaver Canyon Disturbance and Habitat Composition

No disturbance or habitat composition data were collected at the Weaver Canyon site in 2020. Frequency by cover type for 2021 is illustrated in **Figure 13c.** There was very high frequency of native ungulate hoof prints and sign. Cheatgrass was present at very low frequency. Nested frequency quadrat sample size will be assessed in 2022.

Conservation Unit 5 (Raven Ridge)

Two macroplot monitoring sites were established for White River beardtongue in conservation unit 5 in 2017 and 2018. No additional macroplot monitoring locations are planned.

RAVEN RIDGE 1

RAVEN RIDGE 1 POPULATION TREND 2017-2020

White River beardtongue density has increased at Raven Ridge 1 since the site was in 2017 (M=10.75, SD=6.81) and 2021 (M=13.33, SD=7.22; **Figure 10d**). The increase was statistically significant t(11)=2.13, p <0.01. Despite the increase in plant density, a combination of insect herbivory and browsing by wildlife has contributed to a stark decline in the number of flowering stalks over the last three sampling intervals. While the total number of White River beardtongue individuals increased in 2021, there was a decline in the number of reproductive plants and flowering stems (**Figure 11d**, **Figure 12d**).

RAVEN RIDGE 1 DISTURBANCE AND HABITAT COMPOSITION

Frequency of disturbance, ground cover, and vegetation by cover class for 2021 is illustrated in **Figure 13d**. Nested frequency data were not collected in 2020, instead a pilot method was used at the site that is not comparable here. There was little evidence of ungulate activity the plot. No invasive species were detected in 2021. Nested frequency quadrat sample size will be assessed in 2022.

RAVEN RIDGE 2

RAVEN RIDGE 2 POPULATION TREND 2018-2020

White River beardtongue density has increased at Raven Ridge 2 since the site was established in 2018 (M=12.25, SD=5.36) and 2021 (M=14.65, SD=7.64; **Figure 10d**). The increase is nearing statistical significance t(11)=2.0, p=0.07. The total number of White River beardtongue reproductive plants and flowering stems also increased in 2021 compared to 2020 (**Figure 11d**, **Figure 12d**).

RAVEN RIDGE 2 DISTURBANCE AND HABITAT COMPOSITION

Frequency of disturbance, ground cover, and vegetation by cover class in 2020 and 2021 is illustrated in **Figure 13d**. There was increased livestock (sheep) activity and a slight increase in invasive species frequency in the plot in 2021 compared to 2020. Nested frequency quadrat sample size will be reassessed in 2022.

Conservation Unit 6 (Book Cliffs)

We established one macroplot monitoring site, Book Cliffs 1, in conservation unit 4 in June 2020. Surveys to locate a second Book Cliffs macroplot monitoring location took place in 2021, but a suitable site was not identified. Reconnaissance will continue in 2022.

BOOK CLIFFS

BOOK CLIFFS 1 POPULATION TREND

White River beardtongue density at Bookcliffs remained virtually unchanged ($t(11)=0.18$, $p>0.5$) between 2020 (M=23.5, SD=9.17) and 2021 (M=23.67, SD=11.73; **Figure 10e**). Power analysis indicated that our initial suite of twelve transects are sufficient to be 90% confident in detecting at least a 10% change in mean plant density. There was a slight increase in the number of White River beardtongue reproductive plants and flowering stems in 2021 compared to 2020 (**Figure 11e**, **Figure 12e**).

Adding important representation to our study system, at an elevation of 2,334m (7,657ft.) the Book Cliffs study site is the highest site in our study system by nearly 400m (1,300ft). Based on its elevation the site differs from others in terms of dominant plant community and climatic baseline. On average, the site receives nearly twice the amount of precipitation annually and averages 4 degrees cooler than sites in the Uinta Basin. Perhaps not surprisingly, the site differs in its plant density as well. In 2021 White River beardtongue density at Book Cliffs (1.58 plants/m^2) was 3.5 times higher than the average (0.45 plants/m^2).

BOOK CLIFFS 1 DISTURBANCE AND HABITAT COMPOSITION

Frequency of disturbance, ground cover, and vegetation by cover class in 2020 and 2021 is illustrated in **Figure 13e**. No livestock sign or invasive species have been detected in the plot to date. There was a slight decrease in the number of White River beardtongue plants detected in the nested quadrats, though the plot showed an increase in plant numbers. Nested frequency quadrat sample size will be reassessed in 2022.

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 2021, we established 2 new macroplot monitoring sites, and collected population trend and habitat condition data at the new sites and 14 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 to 2021 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. We also noted an increase in native ungulate activity in the plots in 2021.

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 four more macroplot monitoring locations: two for Graham's beardtongue in conservation units 1 and 5; and two for White River beardtongue in conservation units 2 and 6. Reconnaissance for these monitoring sites will continue in 2022.

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

Literature Cited

Elzinga, C. L., D. W. Salzer, and J. W. Willoughby. 1998. Measuring & Monitoring Plant Populations. BLM Technical Reference 1730–1:496 pp.

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.

_____. 2015b. Conservation Agreement and Strategy for Graham's Beardtongue (*Penstemon grahamii*) and White River Beardtongue (*P. scariosus* var. *albifluvis*): Weed Management Plan. Prepared by the Penstemon Conservation Team. July 22, 2015.

_____. 2015c. Conservation Agreement and Strategy for Graham's Beardtongue (*Penstemon grahamii*) and White River Beardtongue (*P. scariosus* var. *albifluvis*): Livestock Grazing Management Plan. Prepared by the Penstemon Conservation Team. July 23, 2015.

_____. 2021. 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. March 2021. 15 pages.

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

Stehman, S. V., & Salzer, D. W. (2000). Estimating density from surveys employing unequal-area belt transects. *Wetlands*, *20*(3), 512-519.