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

2022 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 2023

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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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March 31, 2023

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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 Policy 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, 2022.

1.1 Mitigation Plan

There were no changes to the Mitigation Plan (PCT 2015a) in 2022.

1.2 Weed Management Plan

There were no changes to the Weed Management Plan (PCT 2015b) in 2022. 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 2022. The Team is currently revising this plan in coordination with signatory management planning.

1.4 Surface Disturbance Plan

There were no changes to the Surface Disturbance Plan (PCT 2015d) in 2022.

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. Population monitoring continued in 2021 and 2022. The third year (2022) 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 2022.

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 2022, 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 2022, the BLM Colorado White River Field Office authorized placement of 85 feet of pipeline within existing disturbance in occupied habitat in Conservation Unit 5. Construction occurred approximately 100 feet from the nearest plant. Utah Gas Corp agreed to the following mitigation measures: an on-site monitor during construction; keeping all equipment, personnel, and staging areas within existing disturbance; and a new survey prior to any disturbance in the future.

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 2022. SITLA currently administers $19,266.00 in the Penstemon Mitigation Fund on behalf of the Conservation Team.

2.4 PLPCO

Utah's Public Lands Policy Coordinating Office provided $6,351.11 in FY2022 for support of the monitoring and research activities associated with the Agreement.

2.5 Uintah County

Uintah County actively participated as a Team member in 2022.

2.6 Rio Blanco County

Rio Blanco County actively participated as a Team member in 2022.

2.7 State of Utah DWR

The State of Utah Department of Wildlife Resources ESMF provided $9,079.91 in FY2022 for support of the Penstemon Conservation Team and monitoring activities associated with the Agreement. In addition, the UDWR/USU botany crew revisited multiple White River beardtongue records in the Tavaputs Plateau which comprised approximately 60 hours and an additional $2,500.00 in direct funds.

2.8 Summary of Financial Contributions by Partnering Agencies

The Penstemon Conservation Team met via conference call three times in 2022. The direct funds and in-kind contributions associated with these meetings and other Agreement-related activities are summarized in Table 1.

Table 1. 2022 Conservation Agreement Financial Contributions by Partner Agencies

Partner	Direct Funds	In-Kind (hours)
BLM - CO	$5,100.00	259
BLM - UT	--	243
Utah DWR	$11,579.91	60
Manzanita Botanical Consulting	--	40
PLPCO	$6,351.11	60
Rio Blanco County, Colorado	--	4
SITLA	$930.00	25
Uintah County, Utah	--	56
USFWS - CO	--	35
USFWS - UT	--	35
TOTAL	**$23,961.02**	**817 hours**

A similar level of participation by the Agreement partner agencies is expected in 2023.

3 CONSERVATION AGREEMENT UPDATES

There were no changes to the Penstemon Conservation Agreement and Strategy in 2022.

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 2022 were submitted to the Penstemon Conservation Team for inclusion in this and future annual reports.

5 2022 FIELD SURVEY RESULTS

Surveys for Graham's beardtongue and White River beardtongue in 2022 were limited to efforts to identify additional monitoring sites for the Range-wide Population Monitoring Program.

5.1 BLM Vernal Field Office (Utah)

Surveys for White River beardtongue were conducted in 2022 in the Book Cliffs to identify additional monitoring sites. The Vernal Field Office botany crews surveyed a total of 276 acres for White River beardtongue monitoring sites.

5.2 BLM White River Field Office (Colorado)

The BLM WRFO did not conduct any surveys in 2022.

5.3 State of Utah

The Utah State University rare plant team conducted approximately 160 hours of surveys and point verification for White River beardtongue in the Tavaputs Plateau in 2022.

6 2022 SEED COLLECTIONS

No known seed collections took place in 2022 or are planned 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 2021, Utah DNR, BLM VFO, and BLM Colorado botanists monitored 14 established monitoring plots and established 2 additional macroplots: one each for Graham's and White River beardtongues in conservation unit 4. In 2022, Utah DNR, BLM VFO, and BLM Colorado botanists monitored 16 established monitoring plots and established 1 additional macroplot for White River beardtongue in conservation unit 2. The 2022 population monitoring results are detailed in Appendix A and summarized for each species in the following sections.

7.1.1 White River Beardtongue 2022 Monitoring Results

The Colorado BLM Threatened and Endangered Species Program, University of Northern Colorado, VFO, Utah State University Rare Plant Team, and volunteers from the U.S. Fish and Wildlife Service, Uintah County, and SITLA revisited seven existing White River beardtongue macroplot monitoring sites and established one new macroplot monitoring site in Conservation Unit 2 from May 22-25, 2022. The BLM VFO revisited one existing White River beardtongue monitoring site in Conservation Unit 6 on July 20, 2022. A total of nine macroplots have been established to date with one additional plot in Conservation Unit 6 to be added in June 2023. In general, range wide population trend remaining largely stable but with localized increases and decreases across the range of the species. There was a significant decrease in plant numbers in Conservation Unit 6 and modest decreases in Conservation Unit 5. There were stable or increased numbers in Conservation Units 2, 3, and 4. Disturbances within the monitoring plots in 2022 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 2022 Monitoring Results

The Colorado BLM Threatened and Endangered Species Program, University of Northern Colorado, VFO, Utah State University Rare Plant Team, and volunteers from the U.S. Fish and Wildlife Service, Uintah County, and SITLA revisited eight existing Graham's beardtongue macroplot monitoring sites from May 23-25, 2022. There was an overall increasing trend from 2021 to 2022, with modest increases that appear to be upward corrections following a harsh year in 2021 to were similar to 2020 densities. 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 2022, the BLM VFO assisted with range-wide population monitoring and transplant monitoring, and completed range-wide monitoring in conservation unit 6 (summarized in Section 7.1).

7.3 BLM Colorado

In May 2022, 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 macroplots 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 2022. The population monitoring year three (2022) 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 FY2019 through FY2022. 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 2022 with FY2022 Utah Endangered Species Recovery program funding.

The White River Enefit transplant location (PESCAL-1) was revisited on May 26, 2022 by Manzanita Botanical Consulting and the BLM VFO botanist and interns. Of the 64 seedlings transplanted in October 2014, 19 (29.7%) survived to May 2022. Of the surviving plants, 13 (68.4%) flowered and averaged 4.3 flowering stems and 31.3 flowers per plant, which is a three-fold greater effort than observed in 2021. Most of the flowers were in bud or open, and it was too early for developing fruits. In 2020, we documented two White River beardtongue seedlings in excellent condition near large reproductive transplants, both of these seedlings survived to 2022 and were flowering.

We did not revisit the PEGR-1 Red Leaf Seep Ridge experimental site in 2022 due to time and resource limitations. Plant survival at the experimental site appeared to have stabilized in 2021, with 21 (21.0%) of the original 100 seedlings transplanted in October 2015 surviving to May 2021. Monitoring of the Enefit North White River beardtongue and the Seep Ridge Graham's beardtongue experimental sites will continue in 2023.

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 17 existing Penstemon macroplot monitoring sites and establish one new macroplot site in conservation unit 6 in June 2023. Additional suitable Graham's beardtongue macroplot monitoring locations in conservation units 1 and 5 have not been identified and are not expected. The plan target of two macroplots per conservation unit will be achieved for White River beardtongue. The total macroplot monitoring sites for Graham's beardtongue will be limited to one macroplot in conservation units 1 and 5, and two macroplots in conservation units 2, 3, and 4.

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 2023 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 2023) 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 2023 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). 2023. PRISM Data Explorer. Oregon State University, Corvallis, Oregon. https://prism.oregonstate.edu.

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Appendix A

2022 Penstemon Population Monitoring Report

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

2022 Population Monitoring Report

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March 31, 2023

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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). This report details the 2020-2022 population trend and disturbance monitoring results for the eight Graham's (*Penstemon grahamii*) and nine White River (*Penstemon scariosus* var. *albifluvis*) monitoring locations that have been established to date (Figure 1).

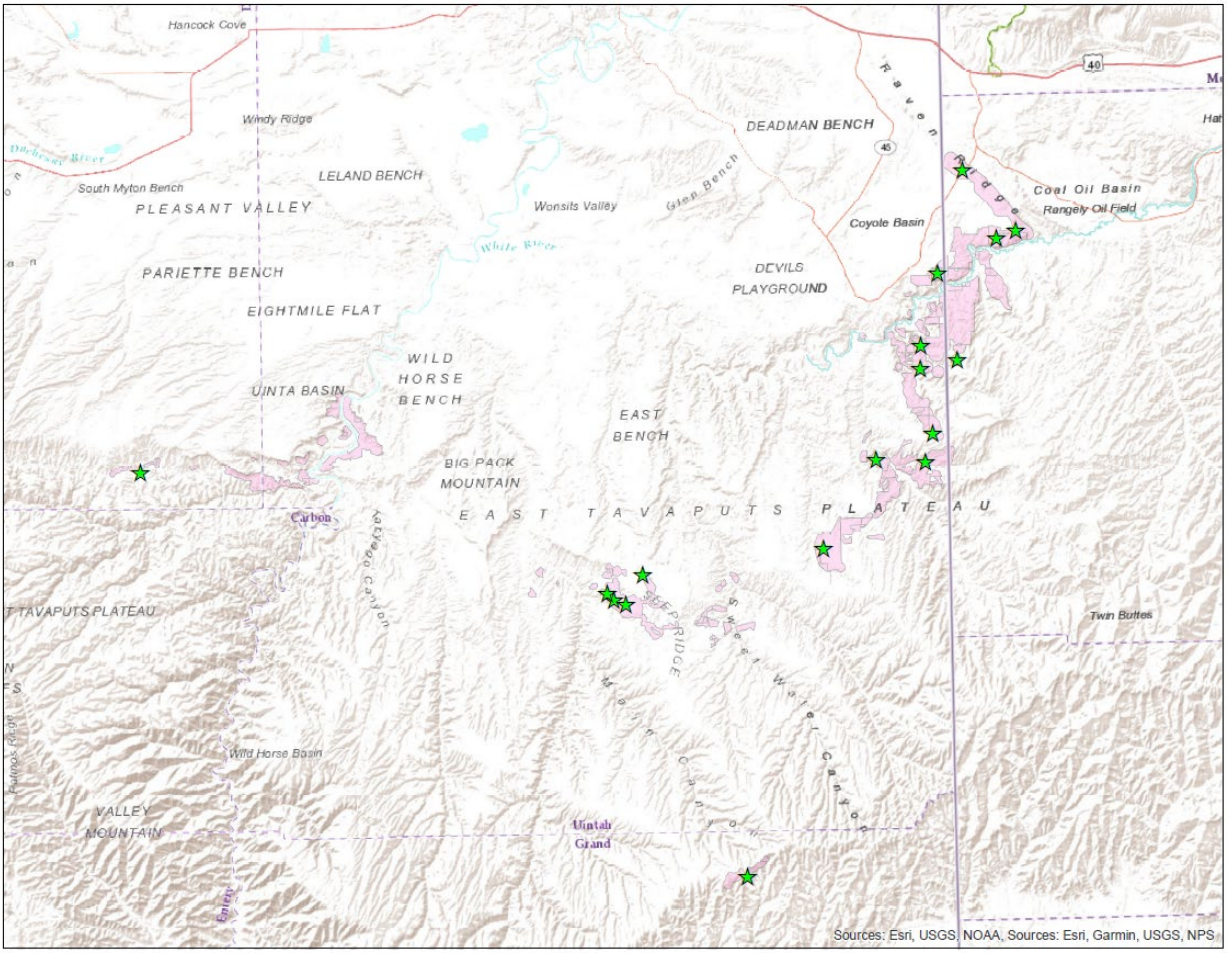


Figure 1. Graham's and White River beardtongue population monitoring locations. Green stars indicate established monitoring sites for Graham's and White River beardtongue within Penstemon conservation areas (pink polygons).

Four macroplot monitoring sites were established from 2005 to 2018, and twelve additional macroplots were established in 2020 and 2021 as part of reimplementation of the Population Monitoring Plan. In May 2022, sixteen existing macroplots were revisited and one new macroplot was established for White River beardtongue in Conservation Unit 2 (Buck Canyon) for a total of seventeen macroplots. One more macroplot remains to be established in Conservation Unit 6 (Book Cliffs). We do not expect to identify suitable monitoring populations for Graham's beardtongue in Conservation Units 1 or 5. Therefore, the

final target number of macroplots is eighteen: eight for Graham's beardtongue in Conservation Units 1 to 5 and ten for White River beardtongue in Conservation Units 2 to 6 (Table 1).

Table 1. 2020-2022 Penstemon Range-wide Monitoring Implementation Progress

Conservation Unit	Species	Macroplots Established	2020 Plots	2021 Plots	2022 Plots	County
CU1 (Sand Wash)	PEGR	CU1-1 Wrinkles Road (2020-) *CU1-2 – no plot expected*	1	1	1	Duchesne *Duchesne*
CU2 (Seep Ridge)	PEAL	CU2-1 Sunday School 2 (2020-) CU2-2 Sunday School 3 (2022-)	1	1	2	Uintah Uintah
	PEGR	CU2-1 East Sand Wash (2020-) CU2-2 Sunday School 1 (2020-)	2	2	2	Uintah Uintah
CU3 (Evacuation Creek)	PEAL	CU3-1 Don Holmes (2020-) CU3-2 Rabbit Mountain (2020-)	2	2	2	Uintah Uintah
	PEGR	CU3-1 Dragon (2020-) CU3-2 Wolf's Den (2020-)	2	2	2	Uintah Uintah
CU4 (White River)	PEAL	CU4-1 Weaver Canyon (2018-) CU4-2 State Line (2021-)	1	2	2	Uintah Uintah
	PEGR	CU4-1 Hell's Hole (2020-) CU4-2 Weaver Canyon-2 (2021-)	1	2	2	Uintah Uintah
CU5 (Raven Ridge)	PEAL	CU5-1 Raven Ridge 1 (2017-) CU5-2 Raven Ridge 2 (2018-)	2	2	2	Rio Blanco Rio Blanco
	PEGR	CU5-1 Mormon Gap (2005-) *CU5-2 – no plot expected*	1	1	1	Rio Blanco *Rio Blanco*
CU6 (Book Cliffs)	PEAL	CU6-1 Book Cliffs 1 (2020-) *CU6-2 – expected 2023*	1	1	1	Grand *Grand*
		Total PEGR Plots	**7**	**8**	**8**	
		Total PEAL Plots	**7**	**8**	**9**	
		Total Range Wide Monitoring Plots	**14**	**16**	**17**	

This report summarizes the 2020 to 2022 population trend and habitat monitoring results for 17 macroplots distributed across the ranges of both species. We also include a brief discussion and management implications and recommendations based on the 2020-2022 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.

Climate Summary

As stated in the Penstemon Population Monitoring Plan (PCT 2021), interactions between climate (precipitation and temperature) and population trend will be evaluated using spatially explicit climate data. We obtained PRISM (Parameter-elevation Regressions on Independent Slopes Model; PRISM Climate Group 2021) annual total precipitation (inches) and annual average temperature (degrees Fahrenheit) data for each macroplot monitoring site, and 30-year average normal for these parameters (1981-2010) at a spatial resolution of four kilometers. We used a multivariate departure from 30-year normals using both precipitation and temperature variables to examine interactions between plant density and climate. A ten to twenty-year dataset will be needed to demonstrate any statistical relationships between plant abundance and climate variables.

Population Trend and Habitat Composition

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 13 macroplots established by the PCT in 2020 and 2021 completed this year represent the third year of data collection. Power analyses were conducted during the second year of data collection at each site to determine the number of transects required to detect meaningful changes in plant density. Additional power analyses were completed using the third year of data as needed. 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:

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

Nested frequency quadrat sample size was reassessed in 2023 using Equations 4 and 5 (Elzinga et al. 1998). The nested quadrat sample from 2020-2022 was approximately 50 quadrats per macroplot (ten transects with five randomly positioned quadrats each). The number of nested quadrats necessary to detect a 20% change with 80% confidence is approximately 15, whereby our current sample size is more than adequate to detect a less than 10% increase or decrease in the frequency of any cover type. Changes in frequency of livestock hoofprints, native ungulate hoofprints, and invasive weeds were evaluated using chi-square (X2) tests (2x2 contingency tables) for 2020-2021 and 2021-2022 paired data. Changes in average frequency of target cover types across all macroplots were also evaluated using t-tests and single-factor analysis of variance (ANOVA). 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.

Management Objectives

The Penstemon Population Monitoring Program addresses three management objectives outlined in the Penstemon Conservation Agreement:

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 subsequent 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, University of Northern Colorado, and the Utah State University Rare Plant Team, and volunteers from the U.S. Fish and Wildlife Service, Uintah County, and SITLA completed range wide Penstemon population monitoring in Conservation Units 1-5 from May 23 to 27, 2022. BLM Vernal Field Office biologists completed monitoring in Conservation Unit 6 on July 20, 2022. 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 macroplots established in 2020 and 2021, it's important to consider that the first year of data establishes the benchmark for the subsequently documented trend. Therefore, the climatic 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.

Climate Summary

Both 2020 and 2021 (when the majority of the macroplots were established) featured drought conditions with below average precipitation and above average temperatures across the Uinta Basin. The year preceding 2021 sampling was particularly harsh, total annual precipitation amounted to approximately 55% of normal (PRISM Climate Group 2021). Population 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 and 2021 were not outliers 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 both 2020 and 2021 than in the recent past.

Drought conditions improved during the twelve-months preceding 2022 sampling (June 2021-May 2022; Table 2). Total annual precipitation was slightly above average while temperatures remained hot relative to the recent historic baseline – averaging 1.7˚F above normal for the year (PRISM Climate Group 2022).

Table 2. June 2021-May 2022 Climate Summary for Penstemon Population Monitoring Locations

Conservation Unit	Monitoring Location	Total Precipitation (inches)	Precipitation Percent of 30-Year Normal (1981-2010)	Precipitation Percent of 30-Year Normal (1981-2010)	Average Temperature (F°)	Temperature Departure from 30-Year Normal (1981-2010)	Average Temperature Departure from 30-Year Normal (1981-2010)
CU1	**Wrinkles Road**	10.0	97.4%	97.4%	49.8	2.1	+2.0°F
CU2	**Sunday School 2**	11.7	105.5%	107.1%	49.8	1.8	+1.3°F
	Sunday School 1	11.7	105.5%		49.1	1.1	

Table 2. June 2021-May 2022 Climate Summary for Penstemon Population Monitoring Locations

Conservation Unit	Monitoring Location	Total Precipitation (inches)	Precipitation Percent of 30-Year Normal (1981-2010)	Precipitation Percent of 30-Year Normal (1981-2010)	Average Temperature (F°)	Temperature Departure from 30-Year Normal (1981-2010)	Average Temperature Departure from 30-Year Normal (1981-2010)
	East Sand Wash 1	12.1	104.5%		49.2	1.4	
	Buck Canyon	11.8	112.9%		49.5	0.9	
CU3	**Dragon**	11.7	106.6%	103.1%	50.1	1.9	+1.9°F
	Rabbit Mtn	11.3	97.2%		50.0	2.1	
	Wolf's Den	11.5	105.2%		50.1	1.6	
	Don Holmes Rd	11.2	103.5%		50.7	2.1	
CU4	**Hell's Hole**	11.0	103.3%	104.4%	50.3	1.4	+1.6°F
	Weaver Canyon 1	11.3	98.0%		49.6	1.7	
	Weaver Canyon 2	10.6	108.7%		49.8	1.0	
	State Line	10.0	107.5%		50.5	2.2	
CU5	**Mormon Gap**	10.7	111.7%	108.0%	50.0	1.9	+1.9°F
	Raven Ridge 1	11.3	105.7%		50.4	1.7	
	Raven Ridge 2	10.4	106.6%		50.5	2.0	
CU6	**Book Cliffs 1**	17.8	98.6%	98.6%	46.2	1.7	+1.7°F

The PRISM climate data summarized in Table 2 is consistent with conditions observed during that time frame, with extreme drought in 2021 and hot and wet conditions in 2022. A minimum of five years, and possibly up to twenty years of population density and climate tracking will be required to make a rigorous estimation of climate-linked population behavior.

Graham's Beardtongue Population Trend

Population trend monitoring and supplemental habitat monitoring was completed at the eight established Graham's beardtongue study sites May 23 to May 27, 2022. We observed slight increases in Graham's beardtongue density between 2021 and 2022 at the Sunday School 1, Wolf's Den, Dragon, East Sand Wash, and Mormon Gap study sites leading to a slight increase in Graham's beardtongue trend range wide. Overall, the observed increases were modest and appear to be upward corrections

following a harsh year in 2021 to fall more closely in line with 2020 densities. The Wolf's Den and Dragon macroplots exhibited a second consecutive year of increasing plant density. The Hell's Hole, Wrinkles Road, and Weaver Canyon 2 study sites all decreased slightly in 2022 relative to the previous sampling interval. Only the decrease at Weaver Canyon 2 was found to be statistically significant (Table 3, Figure 4a).

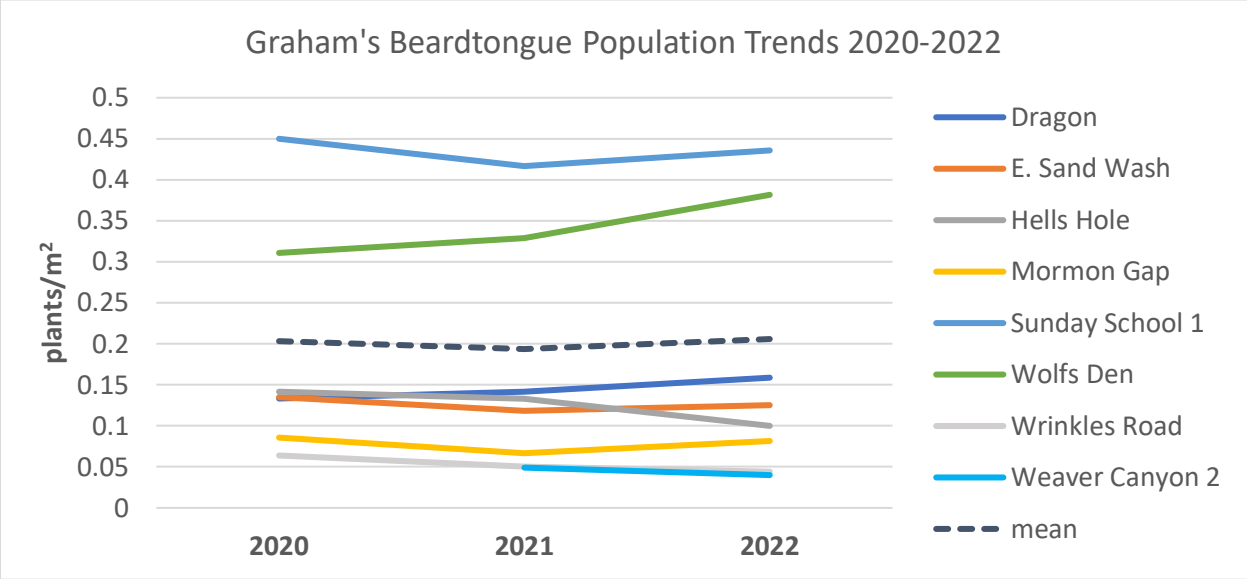


Figure 2. Range wide average and site-specific Graham's beardtongue population trends from 2020 to 2022. Note: Trend was defined as the change in mean plant density (avg. plants/m^2) between two observations. The mean was defined using a ratio estimator whereby the total number of plants among all sites is divided by the average combined area of the sites (Stehman and Salzer 2001).

Table 3. 2022 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	2021	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)
2022 Estimated Total Plants	53	188	523	127	458	24	44	57
Percent Reproductive	0%	13%	15%	0%	39%	67%	14%	36%
Significant Change Since Establishment	Decrease	No/Stable	No/Stable	Increase	Significant Increase	Decrease	Significant Decrease	Significant Decrease
*p-value**	0.19	0.46	>0.5	0.29	0.01	0.09	0.03	0.01
2022 Mean Density (plants/m^2)	0.04	0.13	0.44	0.16	0.38	0.10	0.04	0.08

** p* values are the result of a two-tailed paired t test performed between 2022 and the year the site was established. A result of < 0.05 is considered statistically significant.

In general, Graham's beardtongue tends to exhibit less variability in plant density than White River beardtongue.

Graham's Beardtongue Disturbance and Habitat Composition

In May 2022, we collected disturbance and habitat composition data at eight 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 regional endemic 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), three ground cover types (shale, bare ground, 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 from 2020 to 2022 is shown in Figure 3.

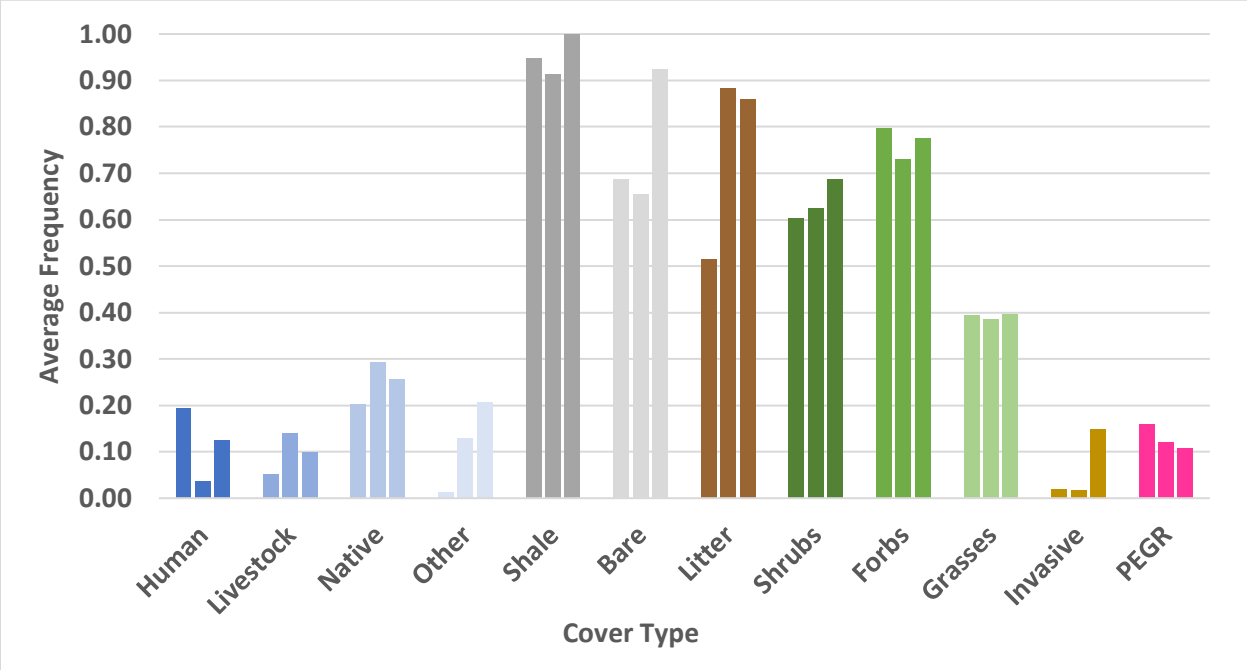


Figure 3. 2020-2022 average frequency for disturbance, ground cover, native and invasive vegetation, and target species cover types in the Graham's beardtongue macroplots.

There were no significant changes in average frequency for any cover type across the Graham's beardtongue macroplot monitoring sites from 2020-2022; however, significant changes were detected at the macroplot level (addressed by macroplot monitoring site below).

Year 3 results are summarized for each monitoring macroplot following the population trend results.

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 not been identified and we do not expect to establish another macroplot monitoring location in Conservation Unit 1.

WRINKLES ROAD

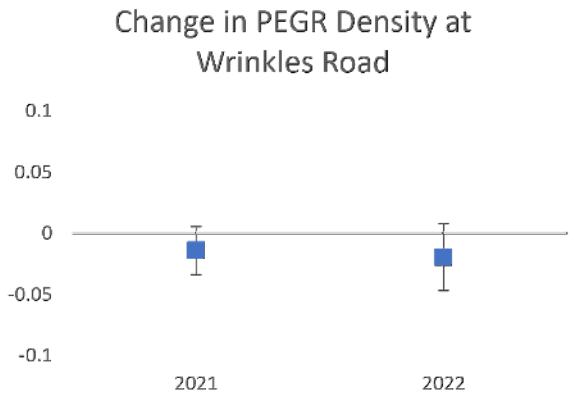
WRINKLES ROAD POPULATION TREND

Graham's beardtongue density decreased slightly at Wrinkles Road for a second consecutive year (**Figure 4a**; 2021: [M=1.5, SD=2.78], 2022: [M=1.3, SD=1.9]). While not statistically significant ($t(11)=1.40$, $p=0.19$), the decrease is likely biologically meaningful given the limited number of plants at the site, and in Conservation Unit 1 overall. None of the plants sampled in 2022 were flowering (**Figure 5a**). The Wrinkles Road macroplot has among the lowest plant density (0.04 plants/m^2) of the eight Graham's beardtongue macroplots and contained an estimated 53 plants in 2022 (**Figure 6a**).

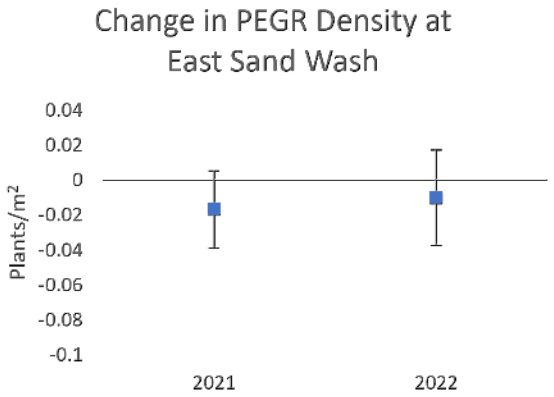
WRINKLES ROAD DISTURBANCE AND HABITAT COMPOSITION

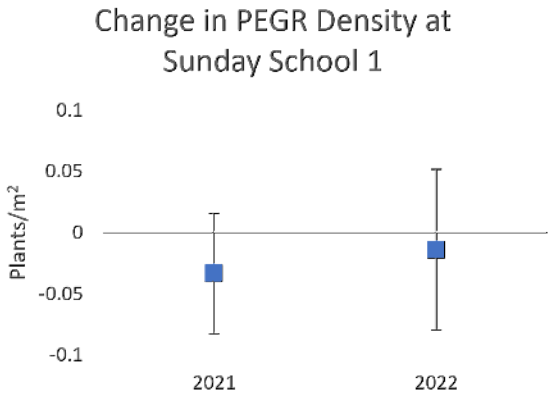
The Wrinkles Road monitoring site comprises a relatively small Graham's beardtongue population on a west-south-west facing slope with soft shale soils. The Wrinkles Road monitoring macroplot is dominated by surface shale, stemless four-nerve daisy (*Tetraneuris* [*Hymenoxys*] *acaulis*), and salina wild rye (*Leymus salinus*). There was a significant increase in livestock and native ungulate disturbance from 2020 to 2021 (χ^2 $p < 0.0001$ and $p < 0.001$, respectively), and a significant decrease in livestock disturbance from 2021 to 2022 (χ^2 $p < 0.001$). 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**.

a) Conservation Unit 1 – Sand Wash

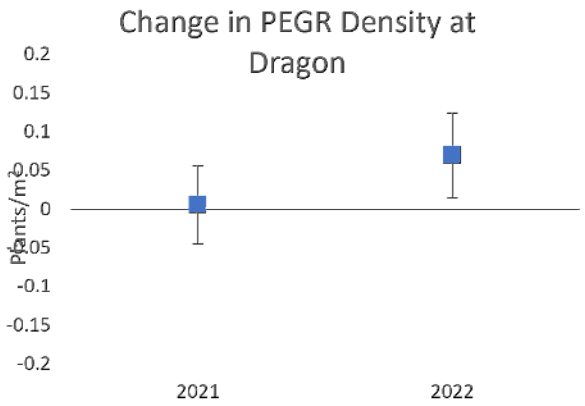


b) Conservation Unit 2 – Seep Ridge





c) Conservation Unit 3 – Evacuation Creek



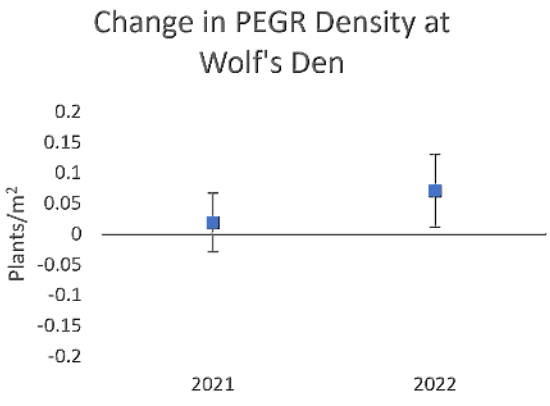
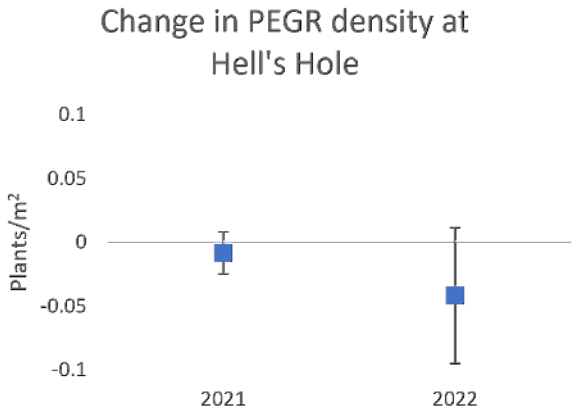


Figure 4a-c. Changes in Graham's beardtongue densities from establishment to 2022 for conservation unit 1 (a), unit 2 (b), and unit 3 (c) monitoring sites (error bars represent 90% confidence intervals).

d) Conservation Unit 4 – White River



e) Conservation Unit 5 – Raven Ridge

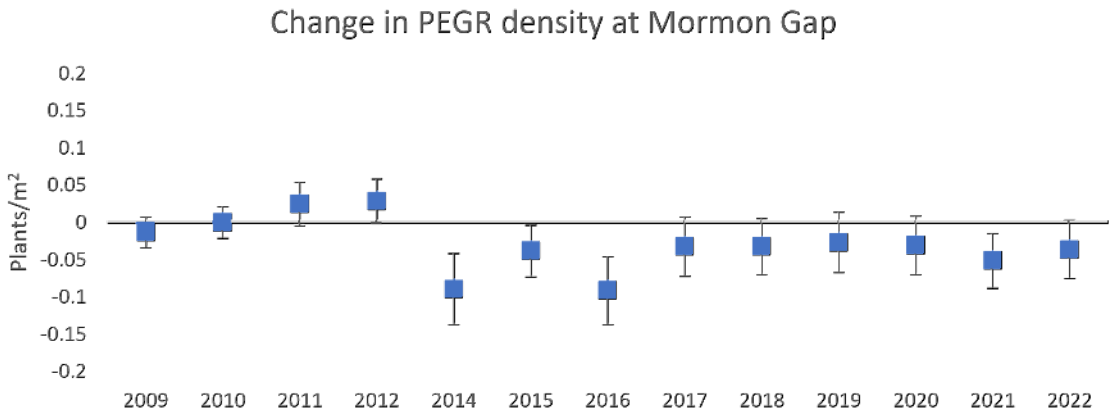
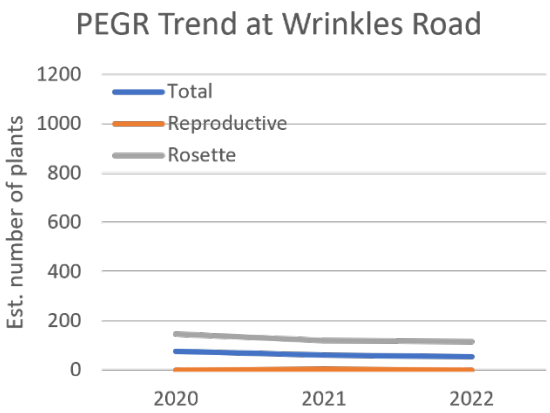
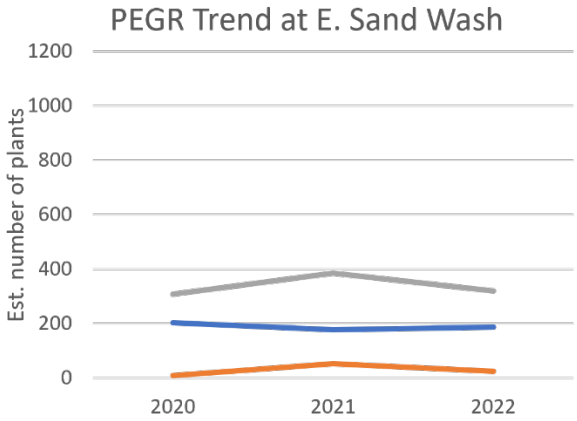


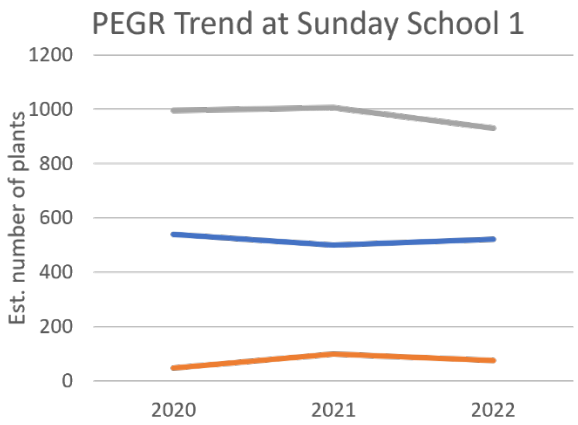
Figure 4d-e. Changes in Graham's beardtongue densities from establishment to 2022 for conservation unit 4 (d) and unit 5 (e) monitoring sites (error bars represent 90% confidence intervals).

a) Conservation Unit 1 – Sand Wash

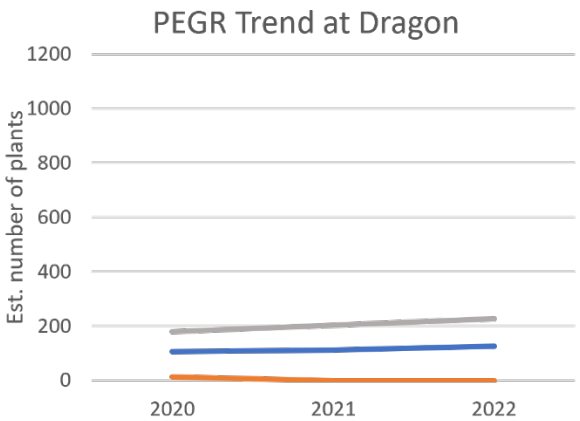


b) Conservation Unit 2 – Seep Ridge





c) Conservation Unit 3 – Evacuation Creek



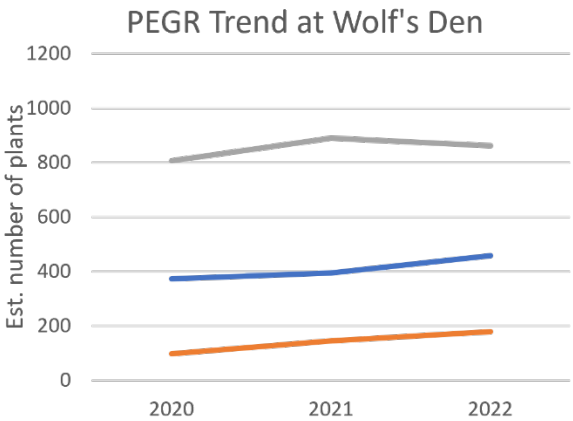
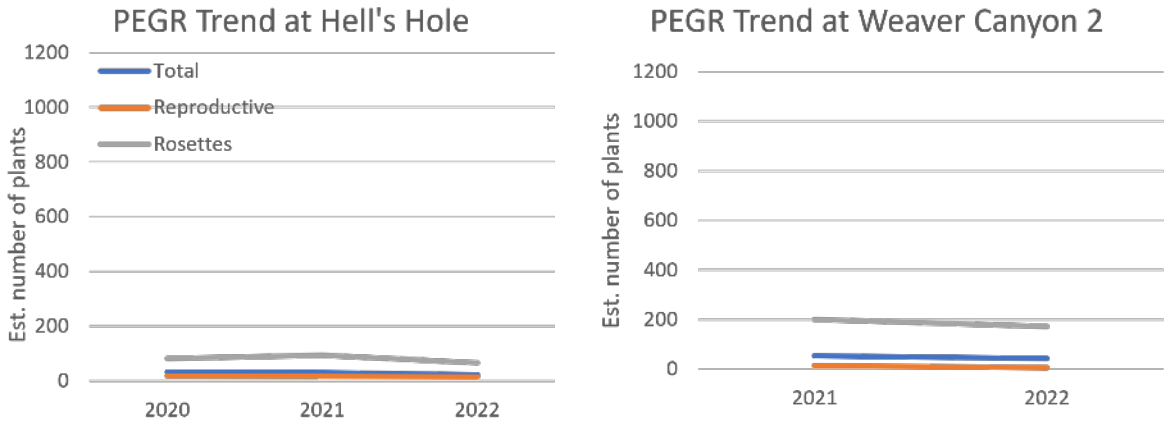


Figure 5a-c. Graham's beardtongue estimated abundance trend from establishment to 2022 for conservation unit 1 (a), unit 2 (b), and unit 3 (c) monitoring sites.

d) Conservation Unit 4 – White River



e) Conservation Unit 5 – Raven Ridge

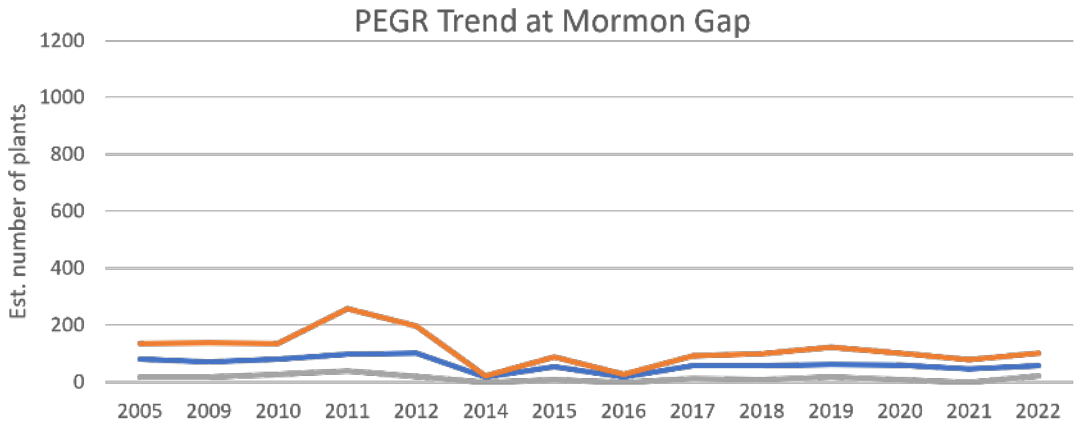
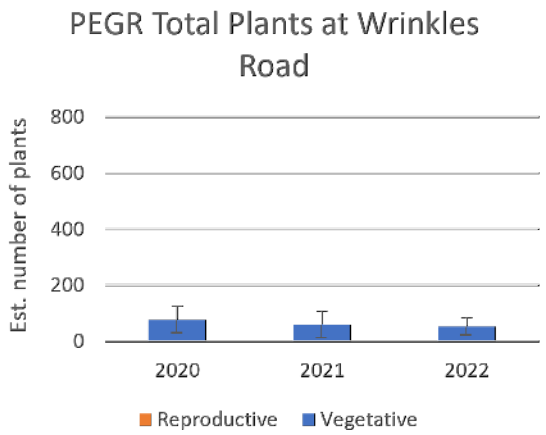
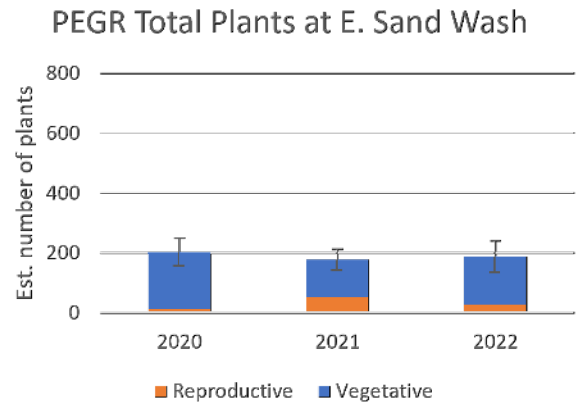


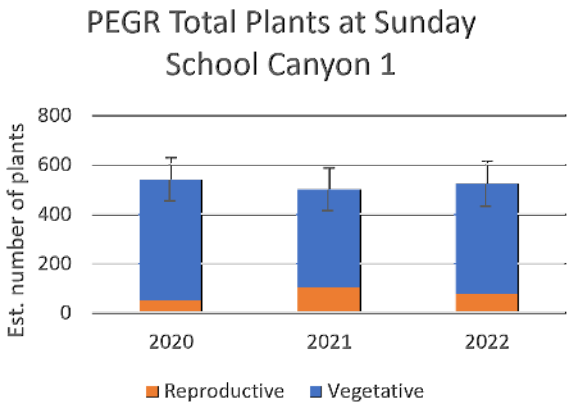
Figure 5d-e. Graham's beardtongue estimated abundance trend from establishment to 2022 for conservation unit 4 (d) and unit 5 (e) monitoring sites.

a) Conservation Unit 1 – Sand Wash

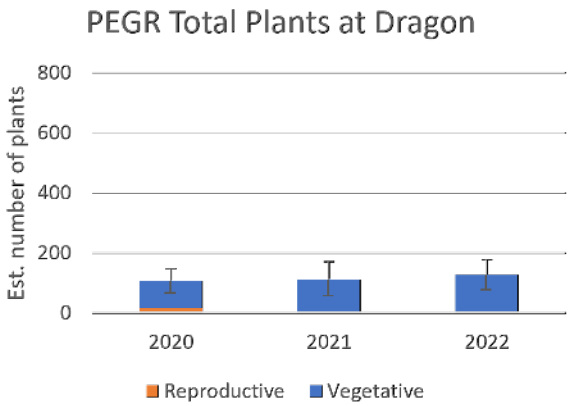


b) Conservation Unit 2 – Seep Ridge





c) Conservation Unit 3 – Evacuation Creek



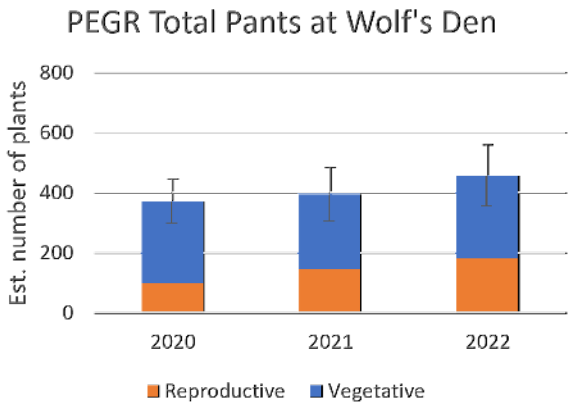
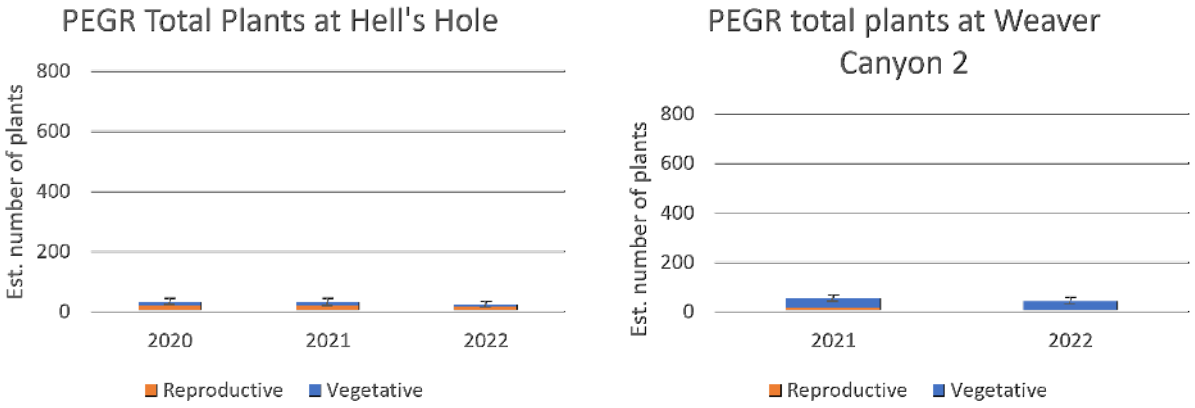


Figure 6a-c. Graham's beardtongue estimated total plants per year from establishment to 2022 for conservation unit 1 (a), unit 2 (b), and unit 3 (c) monitoring sites.

a) Conservation Unit 4 – White River



e) Conservation Unit 5 – Raven Ridge

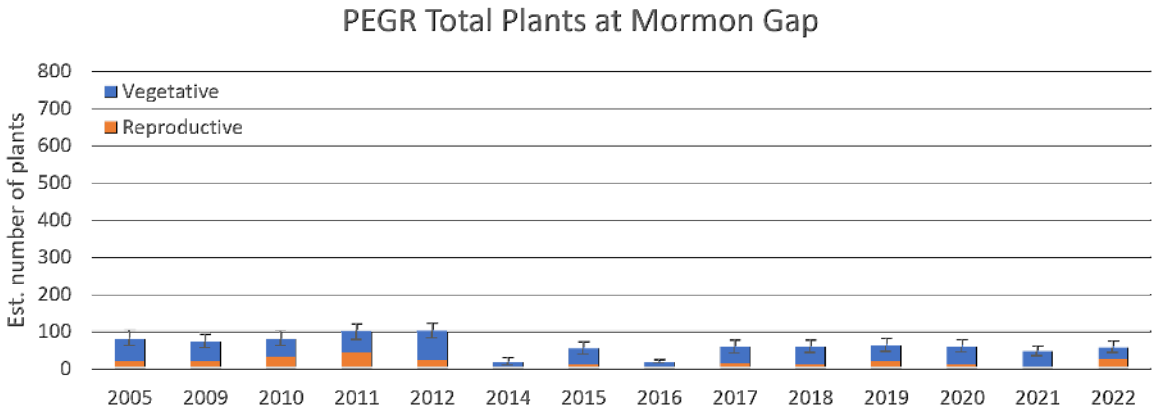
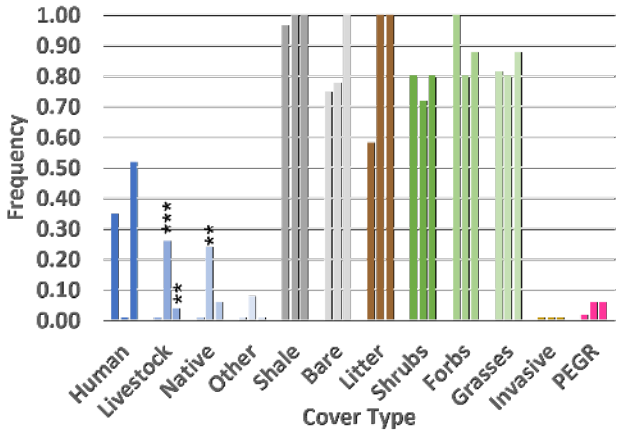
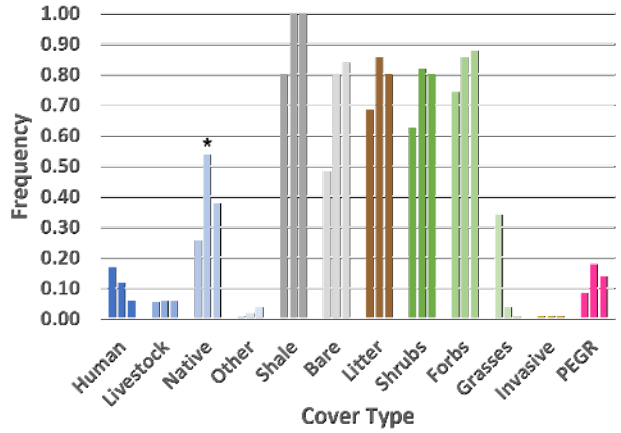


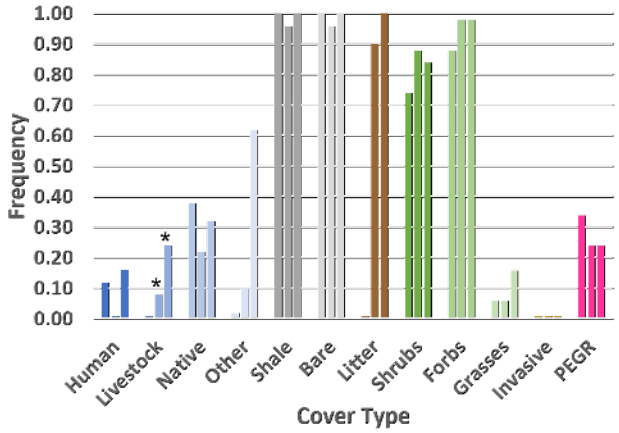
Figure 6d-e. Graham's beardtongue estimated total plants per year from establishment to 2022 for conservation unit 4 (d) and unit 5 (e) monitoring sites.

a) Conservation Unit 1 – Sand Wash

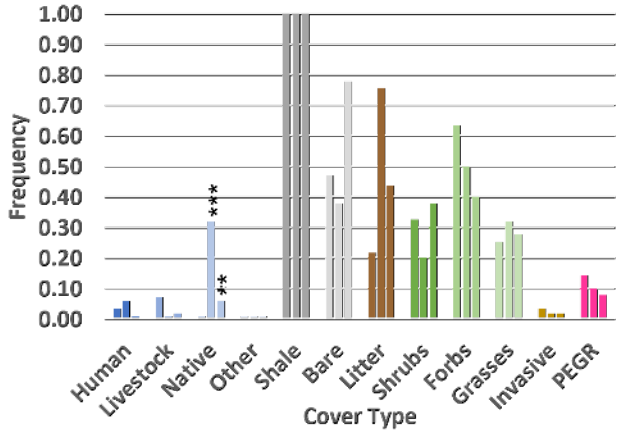


b) Conservation Unit 2 – Seep Ridge (left: East Sand Wash; right: Sunday School 1)





c) Conservation Unit 3 – Evacuation Creek (left: Dragon; right: Wolf's Den)



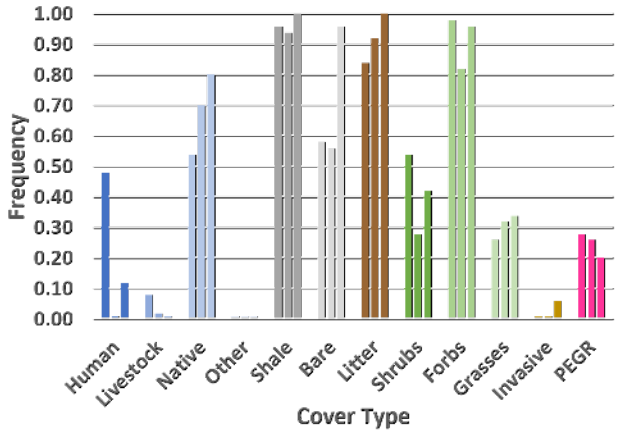
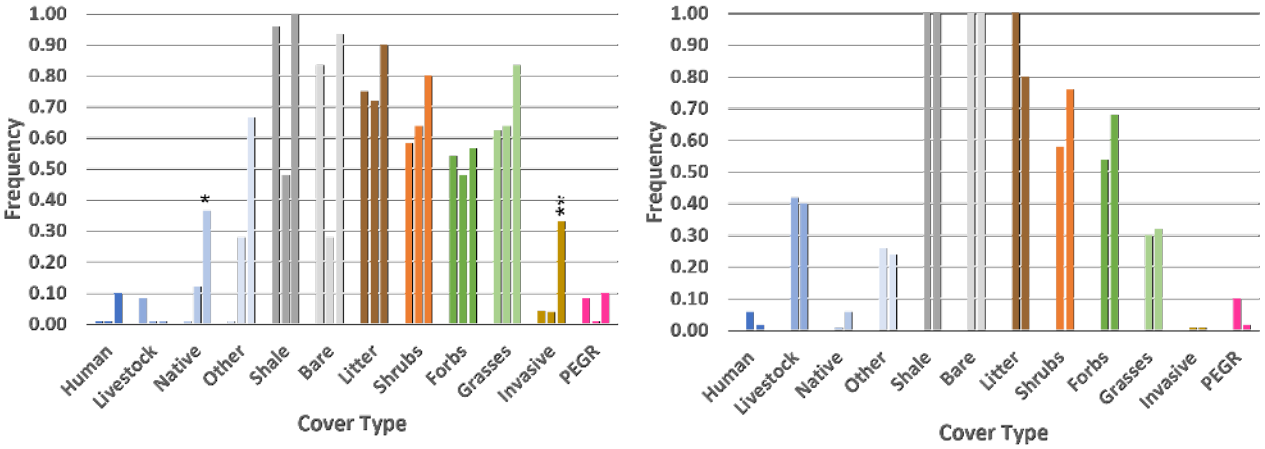


Figure 7a-c. 2020-2022 frequency of disturbance, ground cover, vegetation, and Graham's beardtongue at the conservation unit 1 (a), unit 2 (b), and unit 3 (c) monitoring sites (black indicates zero detection). Significant changes in livestock disturbance, native ungulate disturbance, and invasive weed frequencies are marked with an asterisk(s) (*$p < 0.05$, **$p < 0.001$, ***$p < 0.0001$).

d) Conservation Unit 4 – White River (left: Hell's Hole; right: Weaver Canyon 2 [2021-2022])



e) Conservation Unit 5 – Raven Ridge (Mormon Gap)

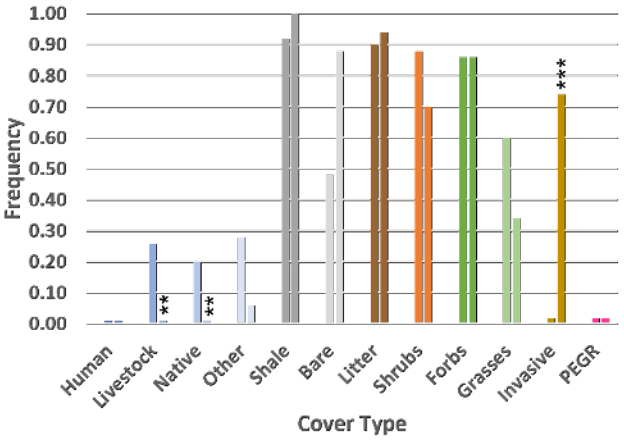


Figure 7d-e. 2020-2022 frequency of disturbance, ground cover, vegetation, and Graham's beardtongue at the conservation unit 4 (d) and unit 5 (e) monitoring sites. Significant changes in livestock disturbance, native ungulate disturbance, and invasive weed frequencies are marked with an asterisk(s) (*$p < 0.05$, **$p < 0.001$, ***$p < 0.0001$).

Conservation Unit 2 (Seep Ridge)

Two Graham's beardtongue macroplot monitoring sites were established 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 increased slightly at East Sand Wash from the previous year [**Figure 4b**; 2021: (M=5.9, SD=3.2), 2022: (M=6.3, SD=4.4)]. The upward change brings population density in line with sampling year 2020, the year that monitoring was established at the site. Despite the increase in total number of plants at the site, both the number of individual rosettes and reproductive individuals decreased somewhat in 2022 (**Figure 5b**). Plant density at the East Sand Wash macroplot (0.13 plants/m^2) falls near the median of the eight Graham's beardtongue monitoring sites and contained an estimated 188 plants in 2022 (**Figure 6b**).

EAST SAND WASH DISTURBANCE AND HABITAT COMPOSITION

The East Sand Wash macroplot is within a sparsely vegetated flat shale barren adjacent to a two-track through native rock. There was a significant increase in native ungulate disturbance from 2020 to 2021 ($\mathcal{X}^2$ $p < 0.05$) with no other significant changes in cover frequencies to date. We did not document any vehicle tire tracks in the plot in 2022. No invasive species have been documented in the macroplot to date. Frequency of disturbance, ground cover, and vegetation by cover class from 2020 to 2022 is illustrated in **Figure 7b**.

SUNDAY SCHOOL CANYON 1

SUNDAY SCHOOL CANYON 1 POPULATION TREND

Graham's beardtongue density at Sunday School Canyon 1 increased slightly from the previous year (**Figure 4b**; [2021: (M=12.5, SD=5.07), 2022: (M=13.1, SD=5.4]). Similar to our observation at the other Graham's beardtongue macroplots in Conservation Unit 2, this upward correction brought plant density back in line with 2020 levels. The number of reproductive plants and rosettes at the site decreased slightly (**Figure 5b**). The Sunday School Canyon 1 macroplot has the highest plant density (0.44 plants/m^2) of the eight Graham's beardtongue study sites and contained an estimated 523 plants in 2022 (**Figure 6b**).

SUNDAY SCHOOL CANYON 1 DISTURBANCE AND HABITAT COMPOSITION

The Sunday School Canyon macroplot bisects a sloping wash that is occasionally used as a road. The habitat is a convex to concave shale barren. There was a significant increase in livestock disturbance from 2020 to 2021 ($\mathcal{X}^2$ $p < 0.05$) and from 2021-2022 ($\mathcal{X}^2$ $p < 0.05$). There was a non-significant increase in native ungulate disturbance from 2021-2022. Tire tracks were not observed in the plot in 2022, though there was evidence of erosion and rilling. Frequency of disturbance, ground cover, and vegetation by cover class from 2020 to 2022 is illustrated in **Figure 7b**.

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.

DRAGON

DRAGON POPULATION TREND

Graham's beardtongue density increased slightly for the second consecutive year at Dragon (**Figure 4c**; 2021: [M=2.67, SD=3.35], 2022: [M=3.2, SD=2.9]). The change has not been statistically significant relative to 2020, the year monitoring was established at the site ($t(11) = 1.16$, $p = 0.29$). None of the plants sampled at the site in 2022 were reproductive (**Figure 5c**). Plant density at Dragon (0.16 plants/m^2) is slightly below the average of the eight Graham's beardtongue macroplots and contained an estimated 127 plants in 2022 (**Figure 6c**).

DRAGON DISTURBANCE AND HABITAT COMPOSITION

The Dragon macroplot is on a relatively steep northeast facing slope with shale ledges. There was a significant increase (χ^2 $p < 0.0001$) in native ungulate disturbance from 2020-2021 followed by a significant decrease (χ^2 $p < 0.001$) from 2021-2022. Frequency of livestock disturbance and invasive weeds has been very low all years of observation. Frequency of disturbance, ground cover, and vegetation by cover class from 2020 to 2022 is illustrated in **Figure 7c**.

WOLF'S DEN

WOLF'S DEN POPULATION TREND

Graham's beardtongue density increased for the second consecutive year at Wolf's Den (2021: [M=12.17, SD=7.42], 2022: [M=15.3, SD=8.5]). The increase is statistically significant relative to when the study site was established in 2020 ($t(11)=3.04$, $p=0.01$). Wolf's Den has the second highest plant density on average of the eight Graham's beardtongue study sites and contained an estimated 458 plants in 2022 (Figure xx).

WOLF'S DEN DISTURBANCE AND HABITAT COMPOSITION

The Wolf's Den macroplot is a relatively densely vegetated shale barren on a shallow slope. Frequency of native ungulate disturbance has been high all years of observation (range 0.54-0.80), but there have not been any significant changes from 2020-2022. Nested frequency quadrat sample size will be reassessed in 2023. Frequency of disturbance, ground cover, and vegetation by cover class from 2020 to 2022 is illustrated in **Figure 7c**.

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 for the second consecutive year at Hell's Hole (**Figure 4d**; 2021: [M=2.67, SD=2.07], 2022: [M=2.0, SD=1.7]). The decrease is nearing statistical significance relative to when monitoring was established at the site in 2020 ($t(5)=2.17$, $p=0.08$). The Hell's Hole macroplot has below average plant density and contained an estimated 24 plants in 2022 (**Figures 5d and 6d**).

HELL'S HOLE DISTURBANCE AND HABITAT COMPOSITION

The Hell's Hole macroplot monitoring site occurs on a sparsely vegetated sloping shale barren with multiple tiers of shale ledges. There was a significant increase in native ungulate disturbance ($\mathcal{X}^2$ $p < 0.05$) and in invasive plant frequency ($\mathcal{X}^2$ $p < 0.05$) from 2021-2022`. Frequency of livestock disturbance and invasive weeds has been very low all years of observation. Frequency of livestock disturbance has been absent or very low all years of observation. Frequency of disturbance, ground cover, and vegetation by cover class from 2020 to 2022 is illustrated in **Figure 7d**.

WEAVER CANYON 2

WEAVER CANYON 2 POPULATION TREND

Sampling year 2022 was the second year of data collection at the Weaver Canyon 2 macroplot. Power analysis indicated that our initial series of 10 transects at the site are sufficient to be 90% confident of detecting at least a 17% change in mean plant density. No additional transects were added in 2022. Graham's beardtongue density decreased at the site from the previous year (**Figure 4d**; 2021: [M=2.7, SD=1.5], 2022: [M=2.2, SD=1.5]). The decline was found to be statistically significant ($t(9)=2.58$, $p=0.03$). The number of rosettes and reproductive individuals decreased year over year at the site as well. Weaver Canyon 2 has the lowest plant density (0.04 plants/m^2) of the eight Graham's beardtongue macroplots and contained an estimated 44 plants in 2022 (**Figures 5d and 6d**).

WEAVER CANYON 2 DISTURBANCE AND HABITAT COMPOSITION

The Weaver Canyon 2 macroplot monitoring site occurs on a sparsely vegetated south-facing and relatively steeply sloped shale barren. Livestock disturbance at the site has been relatively high both years of observation, but there have not been any significant changes in disturbance or invasive plant frequency. Frequency of disturbance, ground cover, and vegetation by cover class from 2020 to 2022 is illustrated in **Figure 7d**.

Conservation Unit 5 (Raven Ridge)

No additional macroplot monitoring sites were established for Graham's beardtongue in Conservation Unit 5 in 2021. No additional monitoring locations are planned.

MORMON GAP

MORMON GAP POPULATION TREND 2005-2021

Data collection has occurred at Mormon Gap during fourteen of the eighteen years since monitoring was established at the site in 2005 (no data collected in 2006, 2007, 2008, and 2013). Graham's beardtongue density has experienced a statistically significant decrease since monitoring was established (**Figure 4e**; 2005: [M=4.07, SD=3.94], 2022: [M=2.87, SD=3.04]). Over the eighteen-year period of observation the site has ranged from an estimated 19 to 101 plants – correlating to an average plant density of 0.09 plants/m^2, among the lowest of the eight Graham's beardtongue monitoring sites (**Figures 5e and 6e**).

The site suffered from a livestock trailing event between the 2012 and 2014 sampling intervals and has been slow to recover. Despite containing approximately one-third fewer individuals than when monitoring was established the population has been largely stable to increasing over the past eight monitoring intervals (2014-2022).

MORMON GAP DISTURBANCE AND HABITAT COMPOSITION

No disturbance or habitat composition data were collected at the Mormon Gap site in 2020. In May 2021 and 2022, nested frequency data were collected for 50 quadrats. There was a significant decrease in livestock and native ungulate disturbance (χ^2 $p < 0.001$), and a significant increase in invasive plant frequency (χ^2 $p < 0.0001$) from 2021-2022. Frequency of disturbance, ground cover, and vegetation by cover class in 2021 and 2022 is illustrated in **Figure 7e**.

White River Beardtongue Population Trend

Population trend monitoring and supplemental habitat monitoring was completed at nine established White River beardtongue study sites from May 23 to 26, 2022 and on July 20, 2022. One new macroplot (Buck Canyon) was established in Conservation Unit 2. Over the duration assessed White River beardtongue macroplot trends have been more variable than those of Graham's beardtongue. In general, sampling year 2022 was better for White River beardtongue than the previous year with range wide population trend remaining largely stable. Though there were differences across the range of the species. In particular, the Book Cliffs study site (Conservation Unit 6) exhibited a significant decrease from the previous year – this is likely related to the timing of monitoring being completed later in the summer season past peak phenology. The State Line and Weaver Canyon 1 macroplots both decreased modestly. The Rabbit Mountain, Sunday School 2, and Raven Ridge macroplots all increased from the previous year. The Don Holmes (Enefit) site remained stable (Figure 8, Table 4).

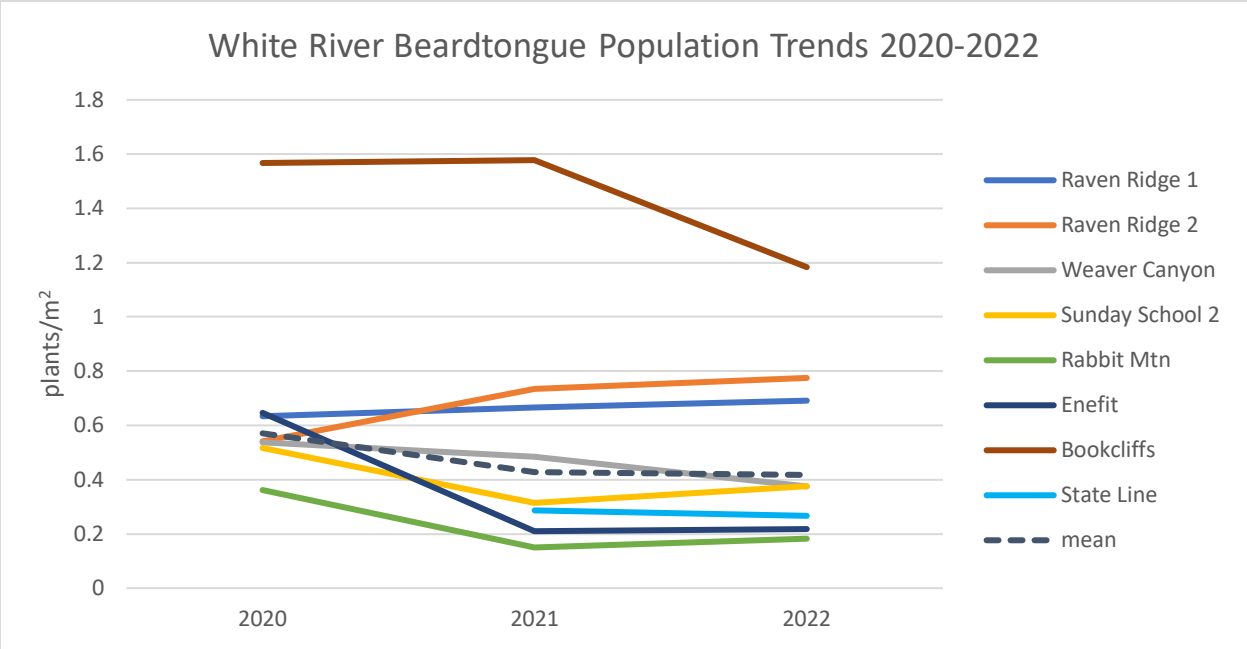


Figure 8. Range wide average and site-specific White River beardtongue population trends from 2020 to 2022. Note: Trend was defined as the change in mean plant density (avg. plants/m2) between two observations. The mean was defined using a ratio estimator whereby the total number of plants among all sites is divided by the average combined area of the sites (Stehman and Salzer 2001).

Table 4. 2022 Summary Statistics for the Penstemon scariosus var. albifluvis Monitoring Sites

	Unit 2		Unit 3		Unit 4		Unit 5		Unit 6
	Sunday School 2	Buck Canyon	Don Holmes	Rabbit Mountain	Weaver Canyon	State Line	Raven Ridge 1	Raven Ridge 2	Book Cliffs 1
Date Established with Sample Size	2020	N/A	2021	2020	2019	2021	2017	2019	2020
Macroplot Area (m^2)	840	600	800	1800	720	900	800	800	360
Transects (m)	17 (20m)	10 (20m)	19 (20m)	12 (50m)	12 (20m)	12 (25m)	12 (20m)	12 (20m)	12 (15m)

Table 4. 2022 Summary Statistics for the Penstemon scariosus var. albifluvis Monitoring Sites

	Unit 2		Unit 3		Unit 4		Unit 5		Unit 6
	Sunday School 2	Buck Canyon	Don Holmes	Rabbit Mountain	Weaver Canyon	State Line	Raven Ridge 1	Raven Ridge 2	Book Cliffs 1
2022 Estimated Total Plants	316	93	175	330	270	240	553	620	426
Percent Reproductive	13%	55%	40%	41%	79%	54%	44%	73%	40%
Significant Change Since Establishment	Decrease	N/A	No/Stable	Decrease	Sig. Decrease	Decrease	Sig. Increase	Sig. Increase	Sig. Decrease
*p-value**	0.18	N/A	> 0.5	0.08	< 0.01	0.28	< 0.01	0.01	< 0.01
2022 Mean Density (plants/m²)	0.38	0.16	0.22	0.18	0.38	0.27	0.69	0.78	1.18

** p* values are the result of a two-tailed paired t test performed between 2022 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.

White River Beardtongue Disturbance and Habitat Composition

In May and July 2022, we collected pilot disturbance and habitat composition data at eight established macroplot monitoring sites and at a new macroplot site in Conservation Unit 2 (Buck Canyon). In general, White River beardtongue 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 regional endemic 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), three ground cover types (shale, bare ground, 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 from 2020 to 2022 is shown in Figure 9.

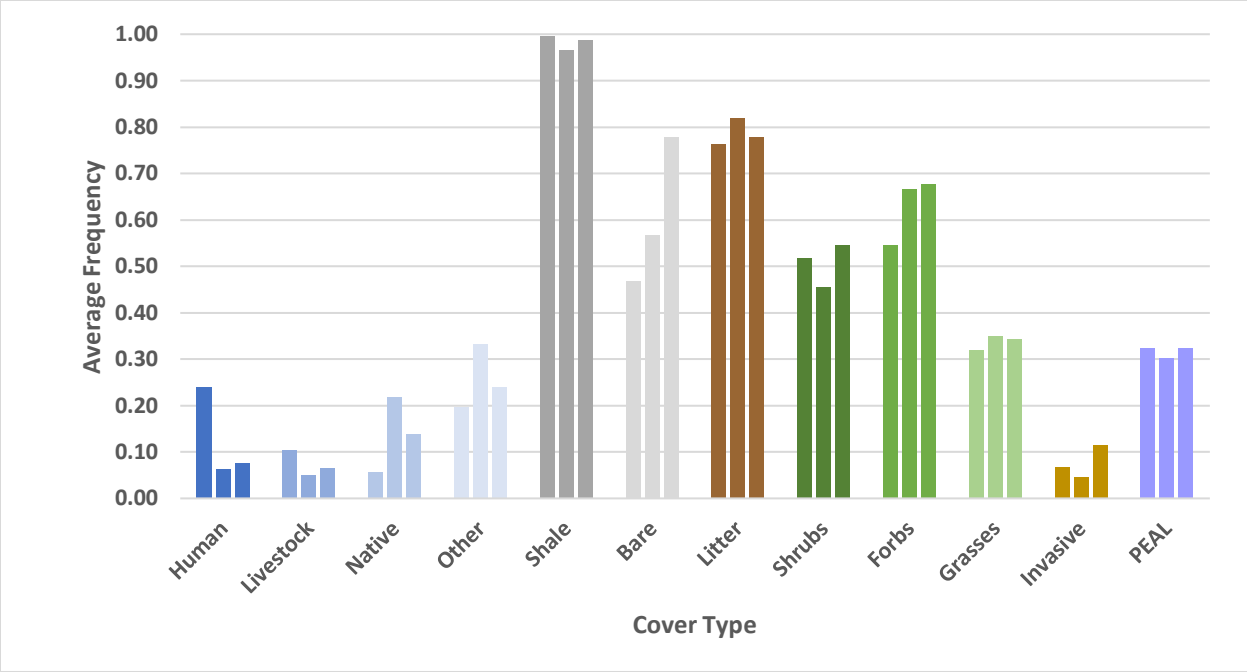


Figure 9. 2020-2022 average frequency for disturbance, ground cover, native and invasive vegetation, and target species cover types in the White River beardtongue macroplots.

There were no significant changes in average frequency for any cover type across the White River beardtongue macroplot monitoring sites from 2020-2022; however, significant changes were detected at the macroplot level (addressed by macroplot monitoring site below).

Conservation Unit 2 (Seep Ridge)

We established one macroplot monitoring site at Sunday School Canyon in Conservation Unit 2 in 2020, and a second macroplot (Buck Canyon) in May 2022.

SUNDAY SCHOOL CANYON 2

SUNDAY SCHOOL CANYON 2 POPULATION TREND

White River beardtongue density increased at Sunday School Canyon 2 from the previous year but remains below 2020 levels (**Figure 10a**; 2021: [M=6.29, SD=3.67], 2022: [M=7.5, SD=4.6]). Reproduction as a proportion of the total population increased but remains the lowest of the nine White River beardtongue monitoring sites (**Figure 11a**). Plant density at Sunday School 2 is slightly below the average of the nine sites and contained an estimated 316 plants in 2022 (**Figure 12a**).

SUNDAY SCHOOL CANYON 2 DISTURBANCE AND HABITAT COMPOSITION

The Sunday School Canyon 2 site is dominated by shale with scattered native forbs and shrubs. There was a significant decrease in livestock disturbance ($\mathcal{X}^2$ $p < 0.0001$) and a significant increase in native ungulate disturbance ($\mathcal{X}^2$ $p < 0.05$) from 2020-2021. There was significant increase in invasive plant frequency ($\mathcal{X}^2$ $p < 0.05$) and a significant decrease in native ungulate disturbance ($\mathcal{X}^2$ $p < 0.05$) from 2021-2022. Frequency of disturbance, ground cover, and vegetation by cover class from 2020 to 2022 is illustrated in **Figure 13a**.

BUCK CANYON

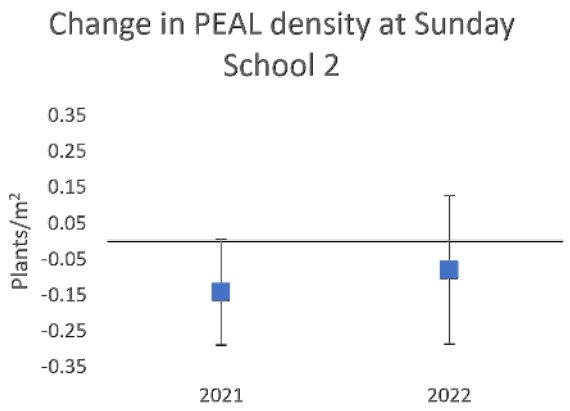
BUCK CANYON POPULATION TREND

The Buck Canyon macroplot was established in 2022 as the second and final White River beardtongue monitoring site in Conservation Unit 2. The site has the lowest plant density of the nine White River beardtongue macroplots (0.16 plants/m^2) and contained an estimated 91 plants in 2022. Power analysis will be completed following 2023 data collection (2022 plant abundance is illustrated in **Figure 12a**).

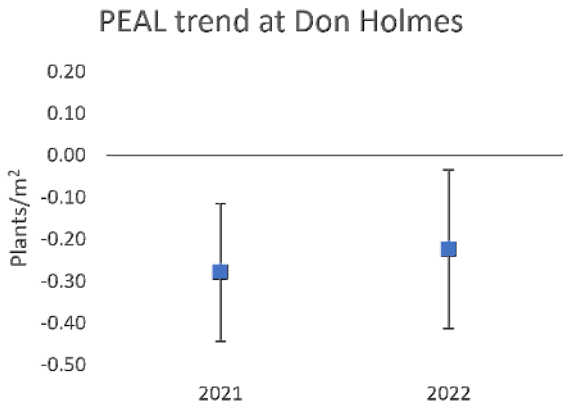
BUCK CANYON DISTURBANCE AND HABITAT COMPOSITION

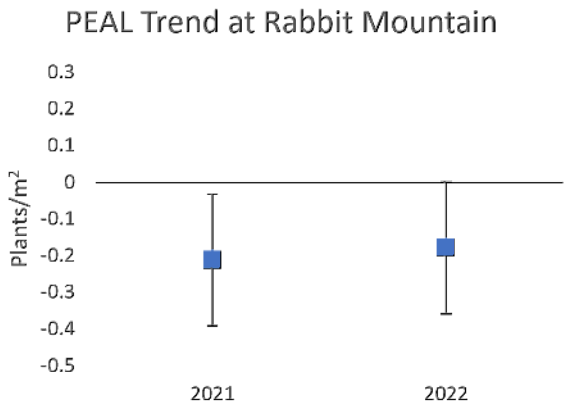
The Buck Canyon site is a flat sparsely vegetated ridge top with soft shale soils. Disturbance by livestock or native ungulates was very low in 2022 with no observations of invasive plant species. Frequency of disturbance, ground cover, and vegetation by cover class from 2020 to 2022 is illustrated in **Figure 13a**.

a) Conservation Unit 2 – Seep Ridge (no change data for Buck Canyon)

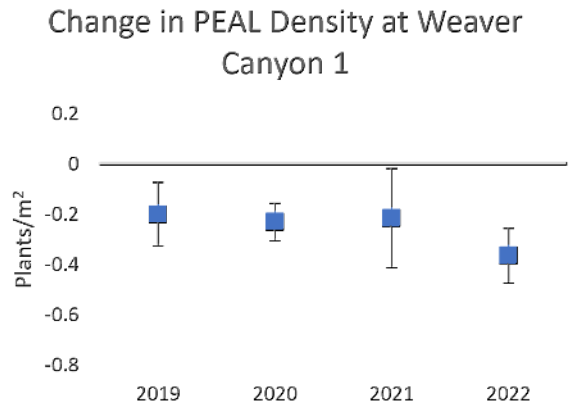


b) Conservation Unit 3 – Evacuation Creek





c) Conservation Unit 4 – White River



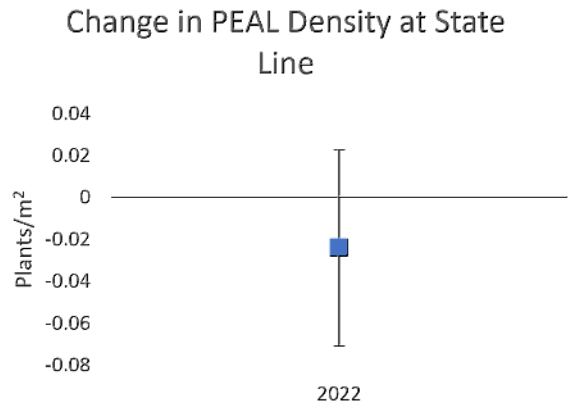
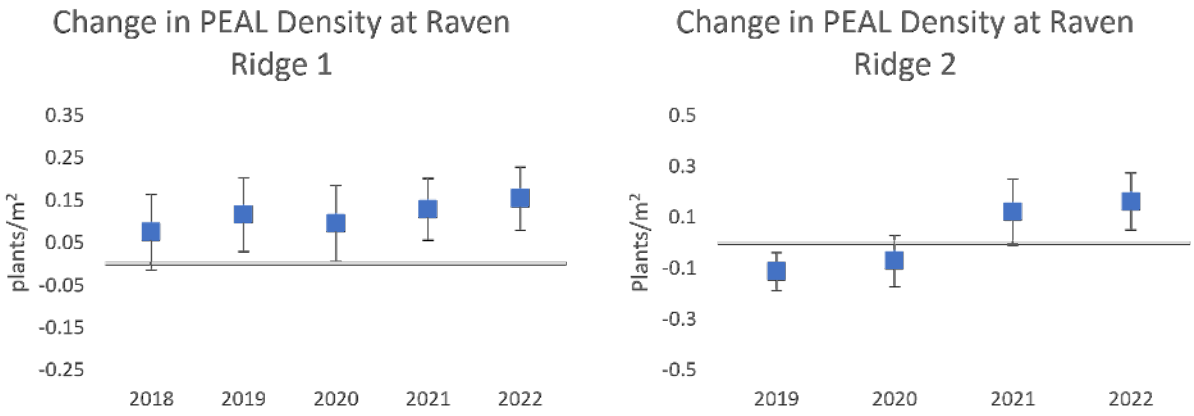


Figure 10a-c. Changes in White River beardtongue densities from establishment to 2022 for conservation unit 2 (a), unit 3 (b), and unit 4 (c) monitoring sites (error bars represent 90% confidence intervals).

d) Conservation Unit 5 – Raven Ridge



e) Conservation Unit 6 – Book Cliffs

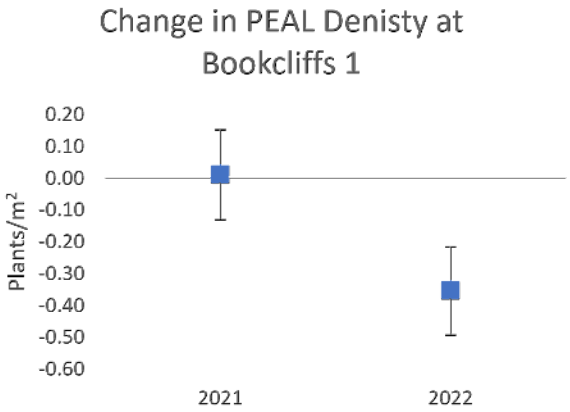
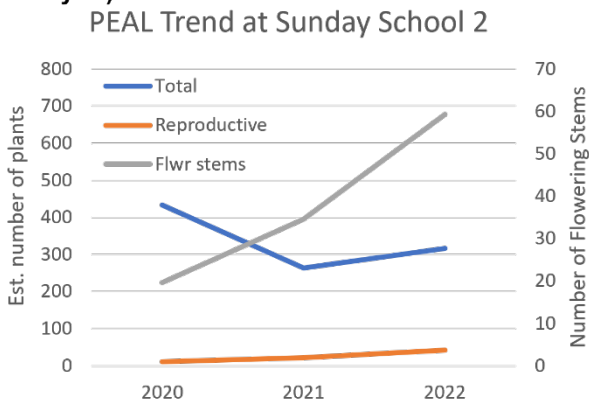
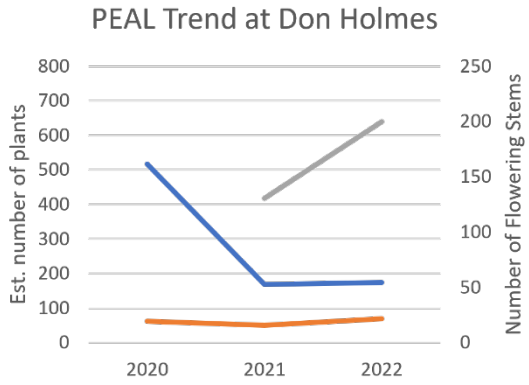


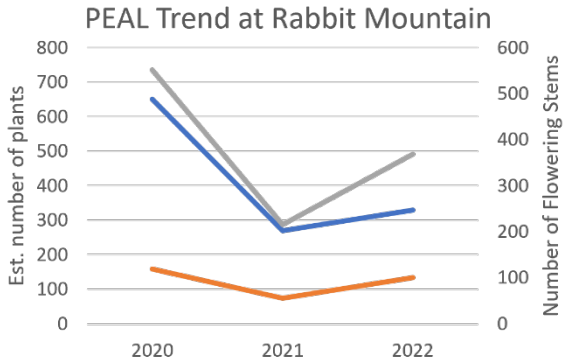
Figure 10d-e. Changes in White River beardtongue densities from establishment to 2022 for conservation unit 5 (d) and unit 6 (e) monitoring sites (error bars represent 90% confidence intervals).

a) Conservation Unit 2 – Seep Ridge (no trend data for Buck Canyon)

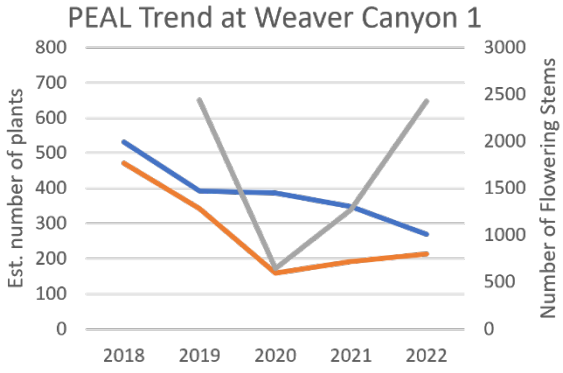


b) Conservation Unit 3 – Evacuation Creek





c) Conservation Unit 4 – White River



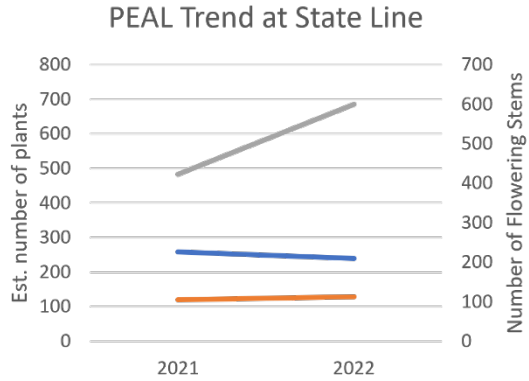
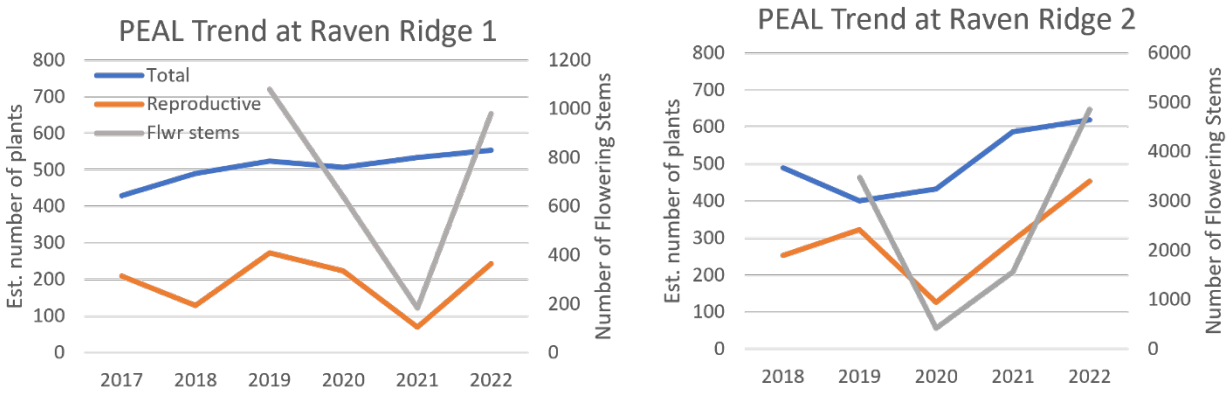


Figure 11a-c. White River beardtongue estimated abundance trend from establishment to 2022 for conservation unit 5 (d) and unit 6 (e) monitoring sites**.**

d) Conservation Unit 5 – Raven Ridge



e) Conservation Unit 6 – Book Cliffs

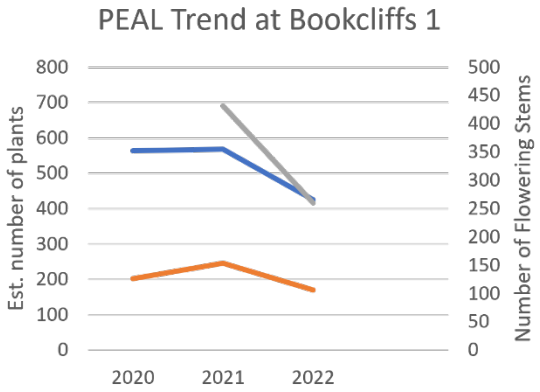
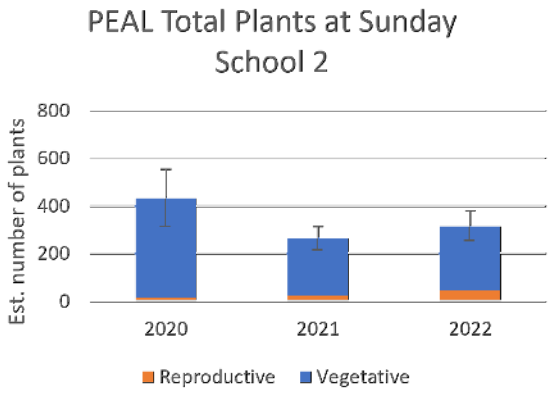
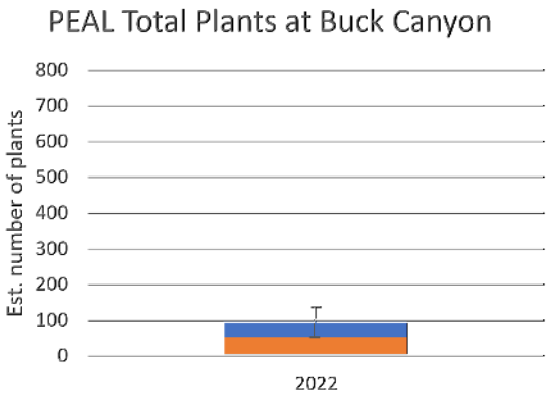


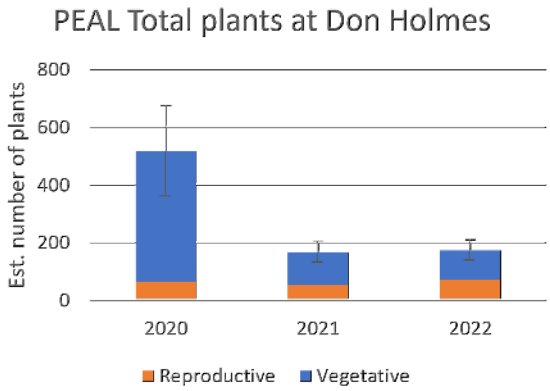
Figure 11d-e. White River beardtongue estimated abundance trend from establishment to 2022 for conservation unit 2 (a), unit 3 (b), and unit 4 (c) monitoring sites.

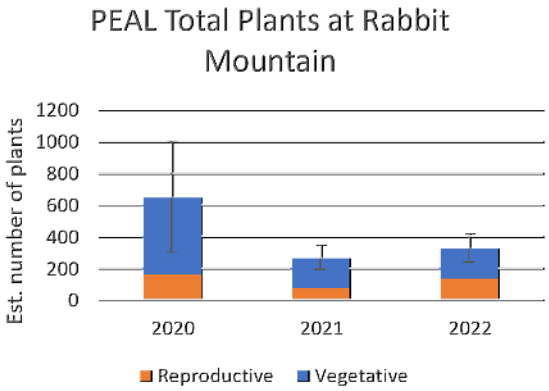
a) Conservation Unit 2 – Seep Ridge



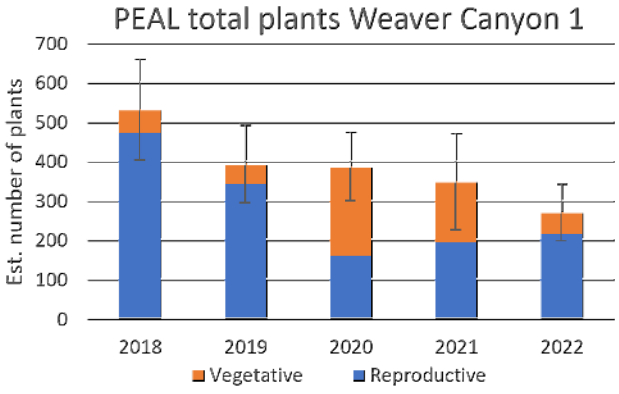


b) Conservation Unit 3 – Evacuation Creek





c) Conservation Unit 4 – White River



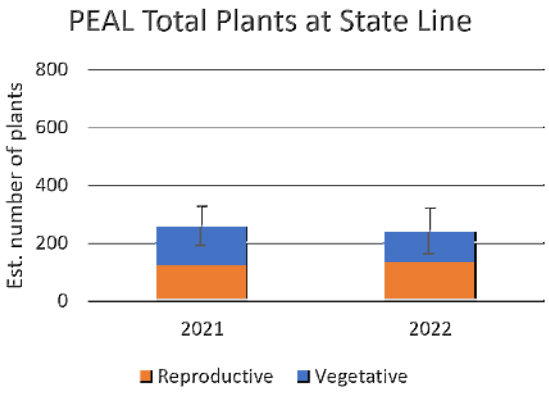
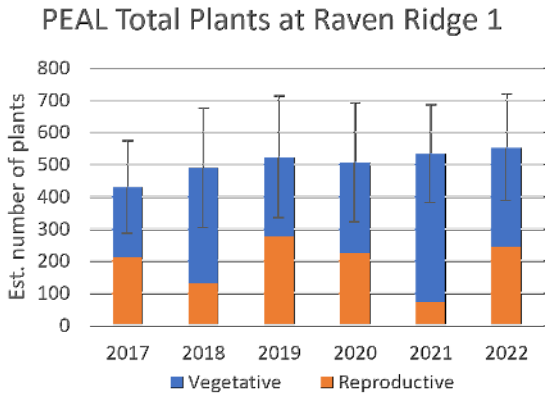
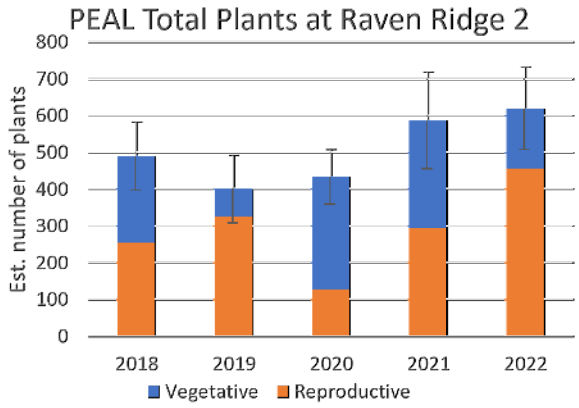


Figure 12a-c. White River beardtongue estimated total plants per year from establishment to 2022 for conservation unit 2 (a), unit 3 (b), and unit 4 (c) monitoring sites.

d) Conservation Unit 5 – Raven Ridge





e) Conservation Unit 6 – Book Cliffs

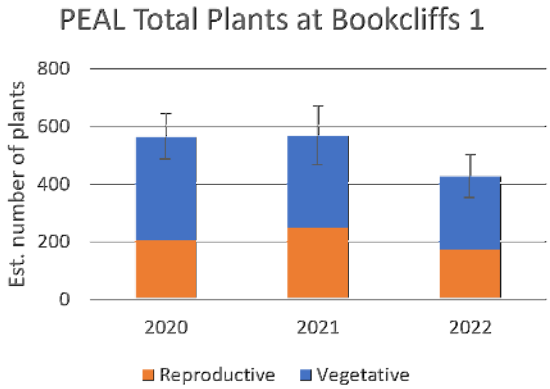


Figure 12d-e. White River beardtongue estimated total plants per year from establishment to 2022 for conservation unit 5 (d) and unit 6 (e) monitoring sites.

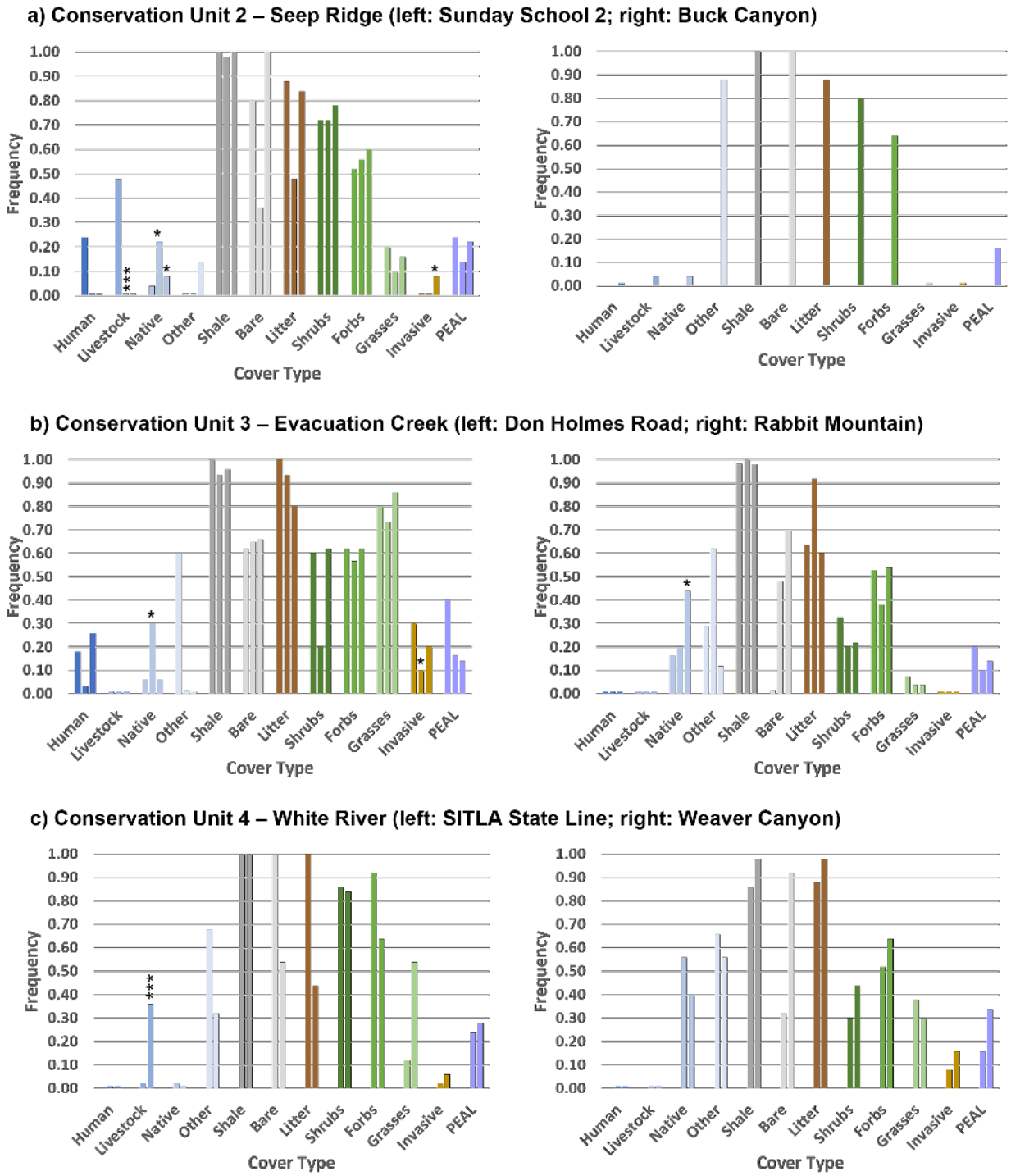
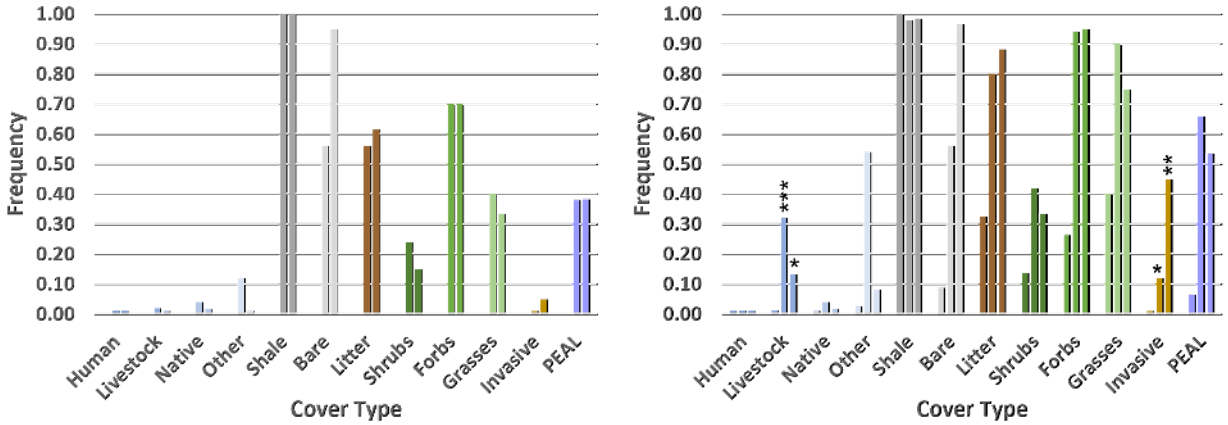


Figure 13a-c. 2020-2022 frequency of disturbance, ground cover, vegetation, and White River beardtongue at the conservation unit 2 (a), unit 3 (b), and unit 4 (c) monitoring sites (black indicates zero detection)**.**

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



e) Conservation Unit 6 – Book Cliffs

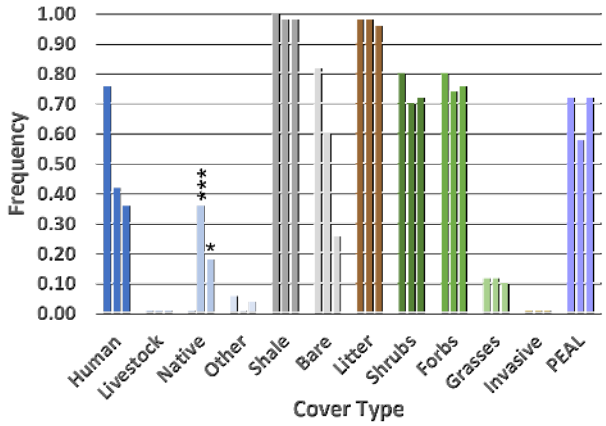


Figure 13d-e. 2020-2022 frequency of disturbance, ground cover, vegetation, and White River beardtongue at the conservation unit 5 (d) and unit 6 (e) monitoring sites.

Conservation Unit 3 (Evacuation Creek)

We established two macroplot monitoring sites in Conservation Unit 3 at Don Holmes Road and Rabbit Mountain in May 2020 and monitored the sites in 2021 and again in May 2022. No additional monitoring locations are planned.

DON HOLMES ROAD

DON HOLMES ROAD POPULATION TREND

White River beardtongue density remained stable at Don Holmes Road over the past two sampling intervals (**Figure 10b**; 2021: [M=4.21, SD=3.24], 2022: [M=4.4, SD=3.2]). In 2021 six additional transects were added to the macroplot due to the large disparity between the first two sampling intervals. Population density remains below that initial estimate from 2020. This decline is likely due to the loss of seedling individuals from 2020 to 2021 - a pattern observed at Rabbit Mountain as well (**Figure 11b**). The Don Holmes macroplot has the second lowest plant density of the nine White River beardtongue macroplots and contained an estimated 175 plants in 2022 (**Figure 12b**).

DON HOLMES ROAD DISTURBANCE AND HABITAT COMPOSITION

The Don Holmes Road White River beardtongue site is dominated by shale with scattered native forbs and shrubs and dense native bunchgrasses. There was a significant decrease in invasive species frequency ($\mathcal{X}^2$ $p < 0.05$) and a significant increase in native ungulate disturbance ($\mathcal{X}^2$ $p < 0.05$) from 2020-2021. There was a significant decrease in native ungulate disturbance ($\mathcal{X}^2$ $p < 0.05$) from 2021-2022. Frequency of disturbance, ground cover, and vegetation by cover class from 2020 to 2022 is illustrated in **Figure 13b**.

RABBIT MOUNTAIN

RABBIT MOUNTAIN POPULATION TREND

White River beardtongue density increased slightly at Rabbit Mountain in 2022 (**Figure 10b**; 2021: [M=7.5, SD=5.2], 2022: [M=9.2, SD=6]). Plant density at the site remains below that of when the site was established due to mortality among a group of seedlings present in several transects that did not persist from 2020 to 2021. The number of reproductive individuals as a proportion of the total population and the number of flowering stems both increased at the site in 2022 (**Figure 11b**). Rabbit Mountain has the lowest density of the nine White River beardtongue macroplots and contained an estimated 330 plants in 2022 (**Figure 12b**).

RABBIT MOUNTAIN DISTURBANCE AND HABITAT COMPOSITION

The Rabbit Mountain site occurs on a wide gently sloping shale barren with sparse vegetation and scattered large pinyon trees. There was a significant increase in native ungulate disturbance ($\mathcal{X}^2$ $p < 0.05$) from 2021-2022. No invasive plant species have been detected in the plot to date. Frequency of disturbance, ground cover, and vegetation by cover class from 2020 to 2022 is illustrated in **Figure 13b**.

Conservation Unit 4 (White River)

We revisited the Weaver Canyon macroplot monitoring site for the fifth year and the State Line macroplot on SITLA land for the second year in May 2022. No additional monitoring locations are planned.

WEAVER CANYON

WEAVER CANYON POPULATION TREND

White River beardtongue density has exhibited a statistically significant decrease ($t(11)=6.87$, $p<0.01$) at Weaver Canyon 1 since the macroplot was established in 2018. The population is approximately half the size when compared to 2018 (**Figure 10c**). Reproductive individuals as a proportion of the population total remains high and the number of flowering stems rebounded in 2022 following limited output the previous year (**Figure 11c**). There is no evidence that land-use activities are driving the observed decrease at the site. Plant density at the Weaver Canyon 1 macroplot approximates the average of the nine White River beardtongue monitoring sites and contained an estimated 270 plants in 2022 (**Figure 12c**).

WEAVER CANYON DISTURBANCE AND HABITAT COMPOSITION

Disturbance and habitat composition data were not collected in 2020. There were no significant changes in livestock disturbance, native ungulate disturbance, or invasive species frequency from 2021-2022. Frequency of disturbance, ground cover, and vegetation by cover class from 2020 to 2022 is illustrated in **Figure 13c**.

STATE LINE

STATE LINE POPULATION TREND

White River beardtongue density decreased slightly at State Line relative to the previous year (**Figure 10c**; 2021: [M=7.2, SD=4.6], 2022: [M=6.7, SD=5.3]). The decline was not found to be statistically significant and is likely representative of the inherent variability expressed by wild populations. Power analysis using 2021 and 2022 data indicated that the initial series of 12 transects is sufficient to be 80% certain of detecting at least a 13% change in plant density at the site. No additional transects were added. The State Line macroplot has below average plant density and contained an estimated 240 plants in 2022 (Table 4).

STATE LINE DISTURBANCE AND HABITAT COMPOSITION

There was a significant increase in livestock disturbance ($\mathcal{X}^2$ $p < 0.0001$) from 2021-2022. Invasive plant species frequencies are low and no native ungulate hoofprints, but large amounts of droppings have been observed to date. Frequency of disturbance, ground cover, and vegetation by cover class from 2020 to 2022 is illustrated in **Figure 13c**.

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 at Raven Ridge 1 has expressed a statistically significant increase ($t(11)=5.21$, $p<0.01$) since monitoring was established at the site (**Figure 10d**; 2017: [M=10.75, SD=6.81], 2022: [M=13.8, SD=7.9]). Reproduction as a proportion of the population total and the number of flowering stems both increased in 2022 from the previous year (**Figure 11d**). The Raven Ridge 1 macroplot maintains one of the highest plant densities of the nine White River beardtongue monitoring sites and contained an estimated 553 plants in 2022 (**Figure 12d**).

RAVEN RIDGE 1 DISTURBANCE AND HABITAT COMPOSITION

Nested frequency data were not collected in 2020, instead a pilot method was used at the site that is not comparable here. There were no significant changes in livestock disturbance, native ungulate disturbance, or invasive species frequency from 2021-2022. Frequency of disturbance, ground cover, and vegetation by cover class from 2020 to 2022 is illustrated in **Figure 13d**.

RAVEN RIDGE 2

RAVEN RIDGE 2 POPULATION TREND 2018-2020

White River beardtongue density has exhibited a statistically significant increase ($t(11)=3.12$, $p=0.01$) at Raven Ridge 2 since monitoring was established at the site (**Figure 10d**; 2018: [M=12.25, SD=5.36], 2022: [M=15.5, SD=6.5]). Reproduction as a proportion of the population total and the number of flowering stems both increased this year following limited output over the previous two sampling intervals (**Figure 11d**). Raven Ridge 2 has the second highest plant density of the nine White River beardtongue macroplots and contained an estimated 620 plants in 2022 (**Figure 12d**).

RAVEN RIDGE 2 DISTURBANCE AND HABITAT COMPOSITION

There was a significant increase in livestock disturbance (χ^2 $p < 0.0001$) from 2020-2021 following by a significant decrease (χ^2 $p < 0.05$) from 2021-2022. There were significant increases in invasive species frequency from both 2020-2021 an 2021-2022 (χ^2 $p < 0.05$ and $p < 0.001$, respectively). Native ungulate disturbance has been very low all years of observation. Frequency of disturbance, ground cover, and vegetation by cover class from 2020 to 2022 is illustrated in **Figure 13d**.

Conservation Unit 6 (Book Cliffs)

We established one macroplot monitoring site, Book Cliffs 1, in Conservation Unit 6 in June 2020. Surveys to locate a second Book Cliffs macroplot monitoring location took place in 2021, but a suitable site has not been identified to date. Reconnaissance will continue in 2023.

BOOK CLIFFS

BOOK CLIFFS 1 POPULATION TREND

White River beardtongue density at Book Cliffs 1 experienced a statically significant decline ($t(11)=6.1$, $p<0.01$) over the past two sampling intervals (**Figure 10e**; 2021: [M=23.7, SD=11.7], 2022: [M=17.8, SD=8.5]). The timing of monitoring is likely at least partly the cause of the observed decline. Sampling was completed in late-July in 2022 – approximately a month later than the previous two years. Despite the observed decline the Book Cliffs 1 macroplot maintains the highest plant density of the nine White River beardtongue study sites and contained an estimate 426 plants in 2022 (**Figures 11e and 12e**).

BOOK CLIFFS 1 DISTURBANCE AND HABITAT COMPOSITION

There was a significant increase in native ungulate disturbance (χ^2 $p < 0.0001$) from 2020-2021 following by a significant decrease (χ^2 $p < 0.05$) from 2021-2022. No livestock disturbance or invasive plant species have been detected in the plot to date. Frequency of disturbance, ground cover, and vegetation by cover class from 2020 to 2022 is illustrated in **Figure 13e**.

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. One new macroplot monitoring site (Buck Canyon) was established for White River beardtongue in Conservation Unit 2 in 2022. The addition of the Buck Canyon site brings the range wide implementation of White River beardtongue monitoring to within one of our target of 10 macroplots (2 per Conservation Unit) across the species range. The final White River monitoring site is slated to be installed in Conservation Unit 6 in 2023. No additional Graham's beardtongue monitoring sites are anticipated at this time leaving the total number for the species at 8.

Population Trend

In general, 2022 was a better year for both species than the previous. We observed stable to increasing trends range wide for both Graham's and White River beardtongue. The moderation of drought conditions over the twelve months preceding sampling likely played a role in the favorable outcomes. With three years of data collected across the range of both species it is already apparent that there are meaningful differences between the two species in terms of their respective adaptive strategies and life histories. While both species appear to be relatively resilient to drought, Graham's beardtongue seems to be particularly able to withstand excessively hot and dry conditions – like those observed in 2020 and 2021. The low levels of variability in the trend at the eight Graham's beardtongue study sites over the past three sampling intervals is indicative of a species that expends most of its resources on survival rather than reproduction. This adaptive strategy is not uncommon among flora native to arid regions where available moisture is the primary factor limiting population growth. It is likely that Graham's beardtongue individuals are long-lived and require several to many years to exceed the resource threshold required to reproduce. In such a case, recruitment and mortality episodes are infrequent and population growth slow. Demographic observations from the Mormon Gap study site since 2005 have also indicated that Graham's beardtongue individuals are able to remain dormant for at least one growing season under unfavorable conditions.

By contrast, it is likely that White River beardtongue individuals are shorter lived and quicker to flower than Graham's beardtongue and also rely on more frequent recruitment events to sustain populations over time. We have observed large patches of seedlings at both the Rabbit Mountain and Don Holmes study sites since 2020. While survival among these seedlings was low during the hot and dry period of observation it does demonstrate that that White River beardtongue likely exhibits larger fluctuations in population trend. This strategy would be consistent with a species that is more susceptible to the negative impacts of drought over the short term as demonstrated by the larger fluctuations in plant density observed at our White River beardtongue monitoring sites.

Disturbance and Habitat Composition

The 2020 to 2022 monitoring results demonstrate that shale habitats across all six conservation units are largely intact, but that livestock disturbance, native ungulate activity, and invasive plant species are potential threats in some locations. We noted an increase in native ungulate activity in the plots in 2021 followed by decreased livestock and native ungulate disturbance in 2022. It is likely that livestock and native ungulate movements are influenced by drought and seasonal climate fluctuations. However, we

noted an increase in invasive plant species frequencies at multiple sites in 2022. Disturbance created by livestock and ungulate hooves can create opportunities for invasive annual plant species to become established in habitats where they weren't present previously .

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 2022) or other available climate datasets.

Recommendations

We recommend the addition of one more macroplot monitoring location for White River beardtongue in conservation unit 6. While additional Graham's beardtongue macroplot monitoring sites in conservation units 1 and 5 are desired, the very sparse distribution of the species at the western and eastern extremes of its range (respectively) has limited options for the establishment of additional sites.

Our disturbance and habitat composition monitoring methods have been effective, but refinements to specific disturbance categories should be considered to increase our ability to detect not only livestock and other disturbances, but to quantify any post-disturbance changes to the habitat. The nested quadrat monitoring methods are being revised in 2023 to add two additional nested tiers (0.5 and 0.25 square meters) within the current 1-meter square quadrat plots. The additional nested quadrat tiers will allow quantification of finer-scaled frequency data and increased analysis options (Smith et al. 1986, 1987; Heywood and DeBacker 2007).

We further recommend that given the limited number of potential monitoring sites for both species, that incorporation of limited demographic monitoring sites within or adjacent to existing macroplot monitoring sites be considered. Demographic data could be used to enhance the application of the density data and our understanding of density-climate interactions.

Literature Cited

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

Heywood, J.S., and M.D. DeBacker. 2007. Optimal sampling designs for monitoring plant frequency. *Rangeland Ecology and Management* 60(4):426-434.

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.

Smith, S.D., S.C. Bunting, and M Hironaka. 1986. Sensitivity of frequency plots for detecting vegetation change. *Northwest Science* 60(4):279-286.

Smith, S.D., Bunting, and M Hironaka. 1987. Evaluation of the improvement in sensitivity of nested frequency plots to vegetational change by summation. *Great Basin Naturalist* 47(2):299-307.

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