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

2024 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 2025

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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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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 Coordinating 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/stewardship-project/penstemon-conservation-agreement.

Information included in this annual report summarizes Penstemon Conservation Team (PCT) activities from January 1 – December 31, 2024.

1.1 Mitigation Plan

There were no changes to the Mitigation Plan (PCT 2015a) in 2024.

1.2 Weed Management Plan

There were no changes to the Weed Management Plan (PCT 2015b) in 2024. 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 2024. 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 2024. Surface disturbance will be remapped in early 2025 as part of 5-year progress reporting.

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 from 2021 through 2024. The fifth year (2024) 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 the Seed Management Strategy in 2024. There have not been sufficient reproductive outputs in recent years for seed collections. Seed collections will be conducted opportunistically when a high flowering and fruiting year occurs.

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 as part of five-year progress reporting.

2 IMPLEMENTATION OF CONSERVATION AGREEMENT IN BEARDTONGUE HABITATS

2.1 BLM Vernal Field Office (Utah)

In 2024, 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 2024, 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. An oil and gas project was proposed in conservation areas 4 and 5 (see section 5.2).

2.3 SITLA

SITLA issued five oil and gas leases within Penstemon conservation Areas in 2024. Three oil shale leases (ML 54578 covering T11S, R17E, S16 within Conservation Unit 1; ML 54580 covering T12S, R21E, S26 within Conservation Unit 2; ML54452 covering T13S, R21E, S2 within Conservation Unit 2; and ML 54448 covering T11S R25E S32 within Conservation Unit 3) and one minerals lease with private surface ownership (ML 54447 covering T11S R25E S29

within Conservation Unit 3). No development of these leases occurred in 2024 or is planned at this time. SITLA currently administers $21,875.62 in the Penstemon Mitigation Fund on behalf of the Conservation Team.

2.4 PLPCO

Utah's Public Lands Policy Coordinating Office provided $487.73 in 2024 for field equipment for the Penstemon Conservation Team and monitoring activities associated with Agreement. PLPCO also provided in-kind support for monitoring and research activities associated with the Agreement in 2024.

2.5 Uintah County

Uintah County actively participated as a Team member in 2024.

2.6 Rio Blanco County

Rio Blanco County actively participated as a Team member in 2024.

2.7 State of Utah DNR

The State of Utah Department of Natural Resources WRI ESMF provided $12,866.74 in 2024 for support of the Penstemon Conservation Team and implementation of the Agreement.

2.8 Summary of Financial Contributions by Partnering Agencies

The Penstemon Conservation Team met via conference call one time in 2024. There were also several Population Monitoring subcommittee conference calls. The direct funds and in-kind contributions associated with these meetings and other Agreement-related activities are summarized in Table 1.

Table 1. 2024 Conservation Agreement Financial Contributions by Partner Agencies

Partner	Direct Funds	In-Kind (hours)
BLM - CO	--	280
BLM – VFO	--	240
BLM – WRFO	--	30
Utah DWR	$12,866.74	32
Manzanita Botanical Consulting	--	28
PLPCO	$487.73	60
Rio Blanco County, Colorado	--	4
SITLA	--	10
Uintah County, Utah	--	4
USFWS - CO	--	4
USFWS - UT	--	16
TOTAL	**$13,354.47**	**708 hours**

A similar level of participation by the Agreement partner agencies is expected in 2025.

3 CONSERVATION AGREEMENT UPDATES

There were no changes to the Penstemon Conservation Agreement and Strategy in 2024.

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 2024 were submitted to the Penstemon Conservation Team for inclusion in this and future annual reports.

5 2024 FIELD SURVEY RESULTS

No surveys for Graham's beardtongue and White River beardtongue were conducted in 2024.

5.1 BLM Vernal Field Office (Utah)

The BLM VFO did not conduct any surveys in 2024. An oil and gas project has been proposed that overlaps with conservation areas in conservation units 4 and 5. Project surveys and NEPA are being conducted by the BLM White River Field Office.

5.2 BLM White River Field Office (Colorado)

An oil and gas project has been proposed that overlaps with conservation areas in conservation unit 4 (Utah) and conservation unit 5 (Colorado). The BLM WRFO conducted pre-project surveys on the project area with a 300-foot buffer (775 acres) in the Weaver Ridge area in 2023. No occupied habitat was identified.

5.3 State of Utah

The Utah State University rare plant team did not conduct any surveys in 2024.

6 2024 SEED COLLECTIONS

No known seed collections took place in 2024 or are currently planned under the 2017 Seed Management Plan (PCT 2017b). There have not been sufficient reproductive outputs in recent years for seed collections. Seed collections will be conducted opportunistically when a high flowering and fruiting year occurs.

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. In 2023, Utah DNR, BLM VFO, and BLM Colorado botanists monitored 17 established monitoring plots and established 1 additional macroplot for White River beardtongue in conservation unit 6. The 2024 population monitoring results are detailed in Appendix A and summarized for each species in the following sections.

7.1.1 White River Beardtongue 2024 Monitoring Results

Utah DNR, BLM VFO, and BLM Colorado botanists revisited eight existing White River beardtongue macroplot monitoring sites in May 2024, and revisited two existing macroplot monitoring sites in conservation unit 6 in mid-June 2024. Disturbances included native ungulate hoofprints and dense livestock hoof prints at some sites, but there were not significant changes in disturbance at any of the sites. No direct damage to White River beardtongue plants was attributable to livestock or off-road vehicles.

7.1.2 Graham's Beardtongue 2024 Monitoring Results

Utah DNR, BLM VFO, and BLM Colorado botanists revisited eight existing Graham's beardtongue macroplots in May 2024. No additional macroplots are expected due to limited population densities and distributions in conservation units 1 and 5. Disturbances included native ungulate hoofprints and dense livestock hoof prints at some sites, but there were not significant changes in disturbance at any of the sites. No direct damage to Graham's beardtongue plants was attributable to livestock or off-road vehicles.

7.2 BLM Vernal Field Office

In 2024, the BLM VFO completed population monitoring in conservation units 1-4 and 6.

7.3 BLM Colorado

In May 2024, 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, the Utah State University Rare Plant Team, and Manzanita Botanical Consulting. 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, in conservation unit 5. The Colorado BLM and UNC team also provided significant assistance in monitoring the macroplot monitoring sites in Utah (conservation units 2-4).

7.4 State Partners (DWR, SITLA, PLPCO, Uintah County)

Manzanita Botanical Consulting (Utah DWR contractor) provided field support for the ongoing implementation of range-wide population monitoring in May and June 2024. The population monitoring year five (2024) 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 FY2024. 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 2024 with FY2024 WRI ESMF funding.

The White River beardtongue Enefit transplant location (PESCAL-1) was monitored on May 23, 2024 by Manzanita Botanical Consulting and VFO biologists. There has been a trend of slow attrition at this transplant population since it was installed in October 2014. Of the original 64 seedlings, twelve (18.8%) survived to May 2024, with 41.7% flowering and most plants in good condition. However, the population is being chronically impacted by livestock (sheep) and native ungulate browsing and trampling, with some individuals directly impacted by erosion that is exposing root caudices. Neither of the two seedlings detected in 2020 survived to 2024 and no new seedlings were found.

We revisited the PEGR-1 Red Leaf Resources (doing business as Green Leaf Carbon Technologies) Seep Ridge experimental site on May 24, 2024 by Manzanita Botanical Consulting. Eighteen of the original 100 seedlings installed in October 2015 survived to 2024, with 72.2% of the surviving plants in the shale plus Utelite (expanded shale product) treatment and 27.8% in the reclaimed soil plus Utelite treatment. In 2023, 27 seedlings were found adjacent to two large reproductive plants in the Shale + Utelite plot, with 18 (66.7%) surviving to 2024 and three new seedlings detected. There has been a downward trend in this experimental population since 2016, which appears to be largely due to impacts from high densities of invasive weeds that became established in the soil treatment plots (Soil, Soil + Utelite) starting in 2017. Nevertheless, the population stabilized at approximately 20 individuals in 2019 with slow attrition occurring since. Recent seedling recruitment has increased the total number of individuals in the plot to 39 but we expect only a fraction of the newly recruited seedlings to survive. Flowering by surviving individuals has clearly tracked precipitation, but this relationship has been confounded by deer browsing in 2023 and a cool spring in 2024. Although 61.1% of surviving individuals were reproductive in 2024, flower counts were not possible because all plants were in very early bud.

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, BLM Colorado botanists, and Team volunteers plan to revisit and monitor the 18 Penstemon macroplot monitoring sites in conservation units 1-5 in May 2025 and conservation unit 6 in June 2025. Additional 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 (10 macroplots) has been 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 macroplots).

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. Because restoration has not be needed in the first ten years of Agreement implementation, the plan is being treated as a working draft and will be updated with the Teams current state of knowledge as part of 10-year progress reporting.

8.5 Other Future Activities

Ongoing conservation-related research and activities are being conducted by the Agreement partner agencies. Expected 2025 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 2025) for 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 2025 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.

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———. 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.

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

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

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

Appendix A

2024 Penstemon Population Monitoring Report

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

2024 Population Monitoring Report

Graham's beardtongue (*Penstemon grahamii*) in flower in Conservation Unit 4. Photo by Phil Krening.

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March 31, 2025

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Contents

Tables

Figures

Introduction

The revised Penstemon Population Monitoring Plan was finalized in March 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, 2021). This report details the 2020-2024 population trend and disturbance monitoring results for the eight Graham's beardtongue (*Penstemon grahamii*) and ten White River beardtongue (*Penstemon scariosus* var. *albifluvis*) monitoring locations that have been established to date (Figure 1).

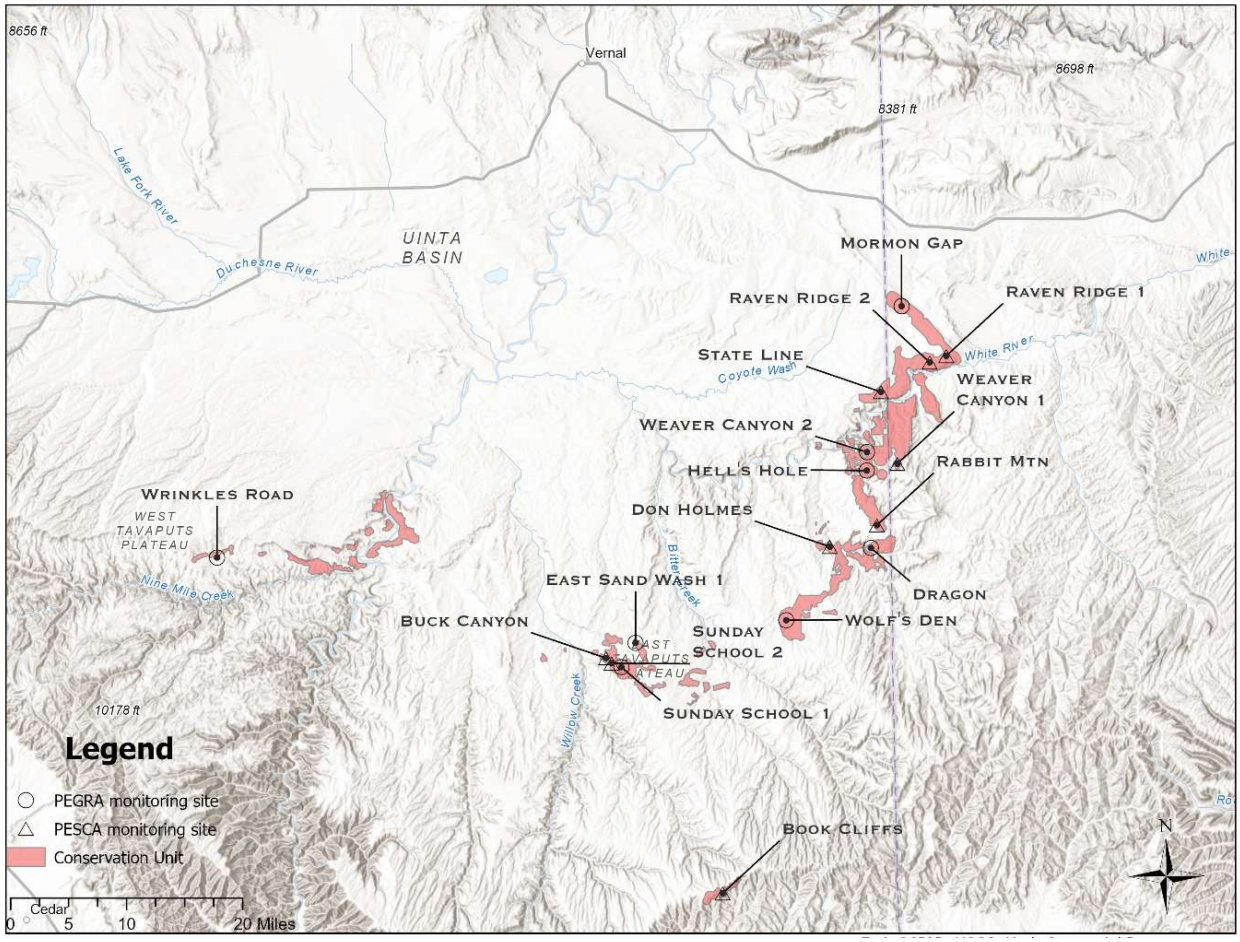


Figure 1. Graham's (PEGRA) and White River (PESCA) beardtongue population monitoring locations within PCA Conservation Units.).

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. Two additional study sites have been added since 2021, one for Graham's beardtongue in conservation unit 4 and one for White River beardtongue in conservation unit 6. We do not anticipate identifying additional populations of Graham's beardtongue that are suitable for monitoring in Conservation Units 1 or 5. Therefore, the final target number of macroplots considered to be full implementation of the monitoring program 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. 2020-2024 Penstemon Range-wide Monitoring Implementation Progress

Conservation Unit	Species	Macroplots Established	2020 Plots	2021 Plots	2022 Plots	2023 Plots	2024 Plots	County
CU1 (Sand Wash)	PEGR	CU1-1 Wrinkles Road (2020-) ***CU1-2 – no plot expected***	1	1	1	1	1	Duchesne ***Duchesne***
CU2 (Seep Ridge)	PEAL	CU2-1 Sunday School 2 (2020-) CU2-2 Sunday School 3 (2022-)	1	1	2	2	2	Uintah Uintah
	PEGR	CU2-1 East Sand Wash (2020-) CU2-2 Sunday School 1 (2020-)	2	2	2	2	2	Uintah Uintah
CU3 (Evacuation Creek)	PEAL	CU3-1 Don Holmes (2020-) CU3-2 Rabbit Mountain (2020-)	2	2	2	2	2	Uintah Uintah
	PEGR	CU3-1 Dragon (2020-) CU3-2 Wolf's Den (2020-)	2	2	2	2	2	Uintah Uintah
CU4 (White River)	PEAL	CU4-1 Weaver Canyon (2018-) CU4-2 State Line (2021-)	1	2	2	2	2	Uintah Uintah
	PEGR	CU4-1 Hell's Hole (2020-) CU4-2 Weaver Canyon-2 (2021-)	1	2	2	2	2	Uintah Uintah
CU5 (Raven Ridge)	PEAL	CU5-1 Raven Ridge 1 (2017-) CU5-2 Raven Ridge 2 (2018-)	2	2	2	2	2	Rio Blanco Rio Blanco
	PEGR	CU5-1 Mormon Gap (2005-) ***CU5-2 – no plot expected***	1	1	1	1	1	Rio Blanco ***Rio Blanco***
CU6 (Book Cliffs)	PEAL	CU6-1 Book Cliffs 1 (2020-) CU6-2 Book Cliffs 2 (2023-)	1	1	1	2	2	Grand ***Grand***
		Total PEGR Plots	**7**	**8**	**8**	**8**	**8**	
		Total PEAL Plots	**7**	**8**	**9**	**10**	**10**	
		Total Range Wide Monitoring Plots	**14**	**16**	**17**	**18**	**18**	

This report summarizes the 2020 to 2024 population trend and habitat monitoring results for 18 macroplot monitoring sites distributed across the ranges of both species. We also include a brief discussion and management implications and recommendations based on the 2020-2024 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 2023-2025) annual total precipitation (inches) and annual average temperature (degrees Fahrenheit) data for each macroplot monitoring site, and 30-year average “normals" 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 dataset of ten years or more 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 fifth 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. In cases where additional transects were needed to meet power requirements those transects were added during the second sample interval. Additional power analyses were completed using the third and fourth years 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 evaluated 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 (X^2) tests (2x2 contingency tables) for 2020-2021, 2021-2022, and 2020-2024 averages and 2024 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 assessed 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 assessed 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 assessed 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

Annual population trend monitoring of Graham's beardtongue (*Penstemon grahamii*) and White River beardtongue (*Penstemon scariosus* var. *albifluvis*; syn. *P. albifluvis*) was completed in Conservation Units 1-5 during the week of May 20th, 2024, by biologists representing the Bureau of Land Management (Colorado State Office, Vernal Field Office, and White River Field Office), the University of Northern Colorado, and the Utah State University Rare Plant Team. Biologists from the BLM – Vernal Field Office completed sampling of P. albifluvis in Conservation Unit 6 on June 13th. Population trend, disturbance, and habitat composition results are summarized for each species and detailed for each monitoring site in the sections below.

Note on Interpreting population trends: Typically, monitoring time series of a decade or longer are necessary to fully capture the range of variability that a population can be expected to express based on demographic fluctuations and responses to different climate conditions (White 2019). 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 collection 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 trends appear to be increasing or decreasing over the short term.

For plots with longer datasets (more than 10 years) we're able to make comparisons to a reference period or "baseline density" – which is typically derived from the average of the first decade of monitoring, and the amount of variability observed over that time. This approach allows us to determine whether biologically meaningful changes, or departures from the recent historical past, have occurred during specific years and over time. Currently only one monitoring site (Mormon Gap) has a dataset of more than 10 years. In the case of Mormon Gap, the reference period was derived from the average of the first five years of data collection because a meaningful disturbance event impacted the site after that time. Five years of data likely represents close to the minimum required in order to make a meaningful pre/post assessment of the effects of an acute impact of this type.

Climate Summary

Following a favorable year climatically in 2023, the year preceding 2024 sampling consisted of hot and dry conditions across the study system (Table 2). Precipitation ranged from 71-94% of normal during the 12-months prior to 2024 population sampling while average temperatures ranged from 0.76-1.97°F above average for the year (PRISM Climate Group 2024, [1981-2010 30-year average]). The study sites in Conservation Units 4-6 experienced larger departures from normal than the westerly study sites in Conservation Units 1-3. While the year overall was hot and dry, the spring season (March-May) was cooler and wetter than average and likely contributed to delayed phenology. In particular, flowering of Graham's beardtongue seemed to be later than observed during the same time frame in previous years.

Table 2. June 2021-May 2024 Climate Summary for Penstemon Population Monitoring Locations*

Conservation Unit	Monitoring Location	2024 Total Precip (Inches)	% Of Normal	2024 Average Temp (Degrees F)	Departure From Normal (Degrees F)	Precip % Of Normal	Avg. Temp Departure from Normal (Degrees F)
CU1	Wrinkles Road	9.68	93.9%	49.04	+1.34	93.9%	+1.3
CU2	Sunday School 2	8.55	77.2%	48.88	+0.87	77.4%	+0.7
	Sunday School 1	8.55	77.2%	48.88	+0.87		
	East Sand Wash 1	8.56	73.9%	48.44	+0.64		
	Buck Canyon	8.55	81.6%	48.88	+0.28		
CU3	Dragon	7.93	72.4%	49.86	+1.66	73.4%	+1.2
	Rabbit Mtn	8.32	71.5%	49.08	+1.18		
	Wolf's Den	8.28	75.5%	49.26	+0.76		
	Don Holmes (Enefit)	8.00	74.0%	49.93	+1.33		
CU4	Hell's Hole	8.06	75.7%	50.00	+1.10	79.5%	+1.3
	Weaver Canyon 1	8.84	77.0%	48.78	+0.88		
	Weaver Canyon 2	8.06	82.4%	50.00	+1.20		
	State Line	7.67	82.8%	50.23	+1.93		
CU5	Mormon Gap	7.90	82.4%	50.07	+1.97	82.1%	+1.6
	Raven Ridge 1	8.73	81.7%	49.90	+1.20		
	Raven Ridge 2	8.01	82.1%	50.19	+1.69		
CU6	Book Cliffs	14.69	81.4%	45.73	+1.22	81.4%	+1.2

***The climate data summarized in Table 2 is consistent with conditions observed on the ground.**
Note: 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.

The majority of the population trend monitoring macroplots study sites were established during the summers of 2020 and 2021, during a period of moderate to exceptional drought conditions across the study region (National Integrated Drought Information System 2023; Figure 2).

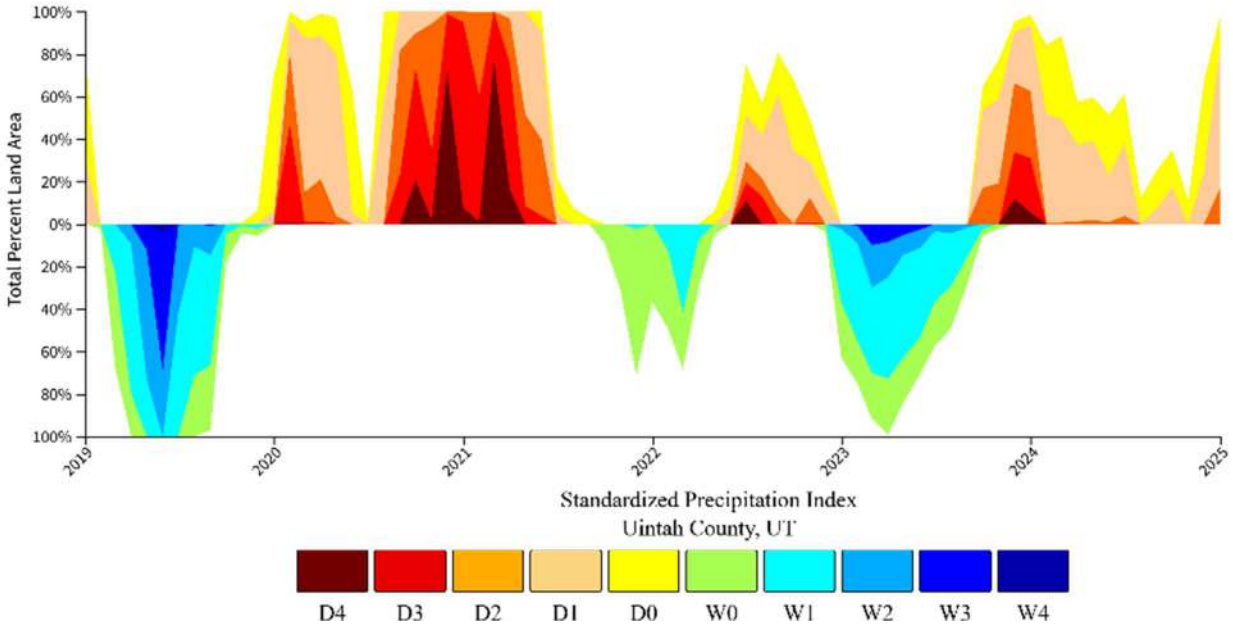


Figure 2. Historical Standardized Precipitation Index (SPI) – Uintah County, UT 2019-present. The SPI measures water supply, specifically precipitation. SPI captures how observed precipitation (rain, hail, snow) deviates from the climatological average over a given time period—in this case, over the 9 months leading up to the selected date. Red hues indicate drier conditions, while blue hues indicate wetter conditions. Data visualization provided by the National Integrated Drought Information System (NIDIS; drought.gov).

The year preceding 2021 sampling was particularly harsh, when total annual precipitation amounted to approximately half of normal (PRISM Climate Group 2021). Population trends documented at four monitoring sites established prior to 2020 (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 for both species. 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.

Graham's Beardtongue Population Trend

Population trend monitoring and supplemental habitat monitoring were completed at all eight Graham's beardtongue study sites in Conservation Units 1-5 between May 20 and May 24, 2024. Graham's beardtongue density has decreased by approximately 12% on average (from 0.2 plants/m^2 to 0.17 plants/m^2) since 2020, when the majority of the population trend monitoring sites were established (Table 3, Figure 3).

Table 3. 2024 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	N/A	2020	2020	2020	2020	2020	2021	2005
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)
2024 Estimated Total Plants	77	140	430	107	393	32	46	56
Percent Reproductive	0%	0%	0%	0%	4%	13%	13%	2%
Significant Change Since Establishment	No/Stable	**Significant Decrease**	**Significant Decrease**	No/Stable	No/Stable	No/Stable	No/Stable	**Significant Decrease**
*p-value**	> 0.5	**0.02**	**< 0.01**	> 0.5	> 0.5	> 0.5	> 0.5	**0.01**
2024 Mean Density (plants/m^2)	**0.06**	**0.09**	**0.36**	**0.13**	**0.33**	**0.13**	**0.04**	**0.08**

** p* values are the result of a two-tailed paired t test performed between 2024 and the year the site was established. A result of ≤ 0.05 is considered statistically significant.

Five of the eight sites are stable relative to their respective establishment dates while the other three sites have experienced statistically significant declines, including both study sites in Conservation Unit 2. Notably, reproductive frequencies were low across the study system in 2024 with the highest frequency of reproductive individuals occurring in Conservation Unit 4. No reproduction was documented in Conservation Units 1 & 2 (see Table 3).

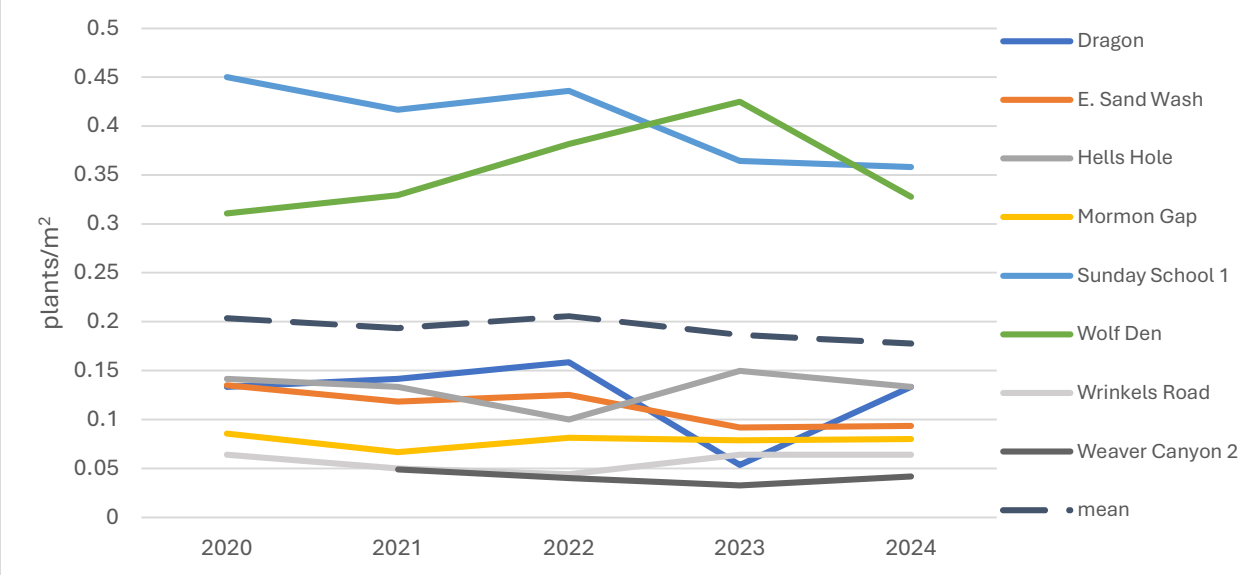


Figure 3. Range wide average and site-specific Graham's beardtongue population trends from 2020 to 2024. Note: Trend was defined as the change in mean plant density (avg. plants/m^2) between observations. The mean was defined using a ratio estimator whereby the total number of plants among all sites is divided by the average combined area of the sites (Stehman and Salzer 2001).

Graham's Beardtongue Disturbance and Habitat Composition

In May 2024, we collected disturbance and habitat composition data at eight macroplot monitoring sites. In general, Graham's 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 Graham's beardtongue is also included in the forbs class. The average frequency for each of the cover types from 2020 to 2024 is shown in Figure 4.

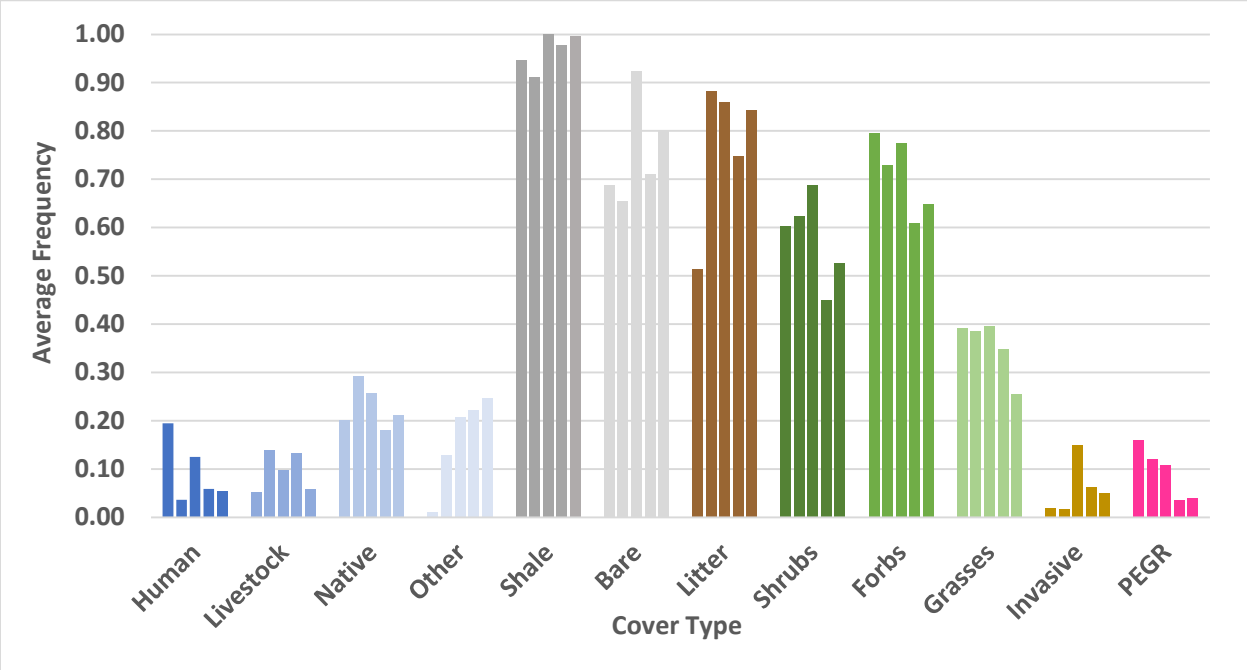


Figure 4. 2020-2024 average frequency by cover type for disturbance (human footprints, livestock and native hoof prints, and soil erosion or generalized soil disturbance), ground cover, native and invasive vegetation, and target species cover types in the Graham's beardtongue macroplots. Significant changes in 2024 livestock disturbance, native ungulate disturbance, and invasive weed frequencies versus the 2020-2023 average are marked with an asterisk(s) (*$p < 0.05$, **$p < 0.001$, ***$p < 0.0001$).

There have been no significant differences in average frequency for any cover type across Graham's beardtongue macroplot monitoring sites between years from 2020-2024 (chi-square and single factor ANOVA tests $p > 0.05$). However, although there have been no significant differences in disturbance frequencies between years, there are significant differences between the eight monitoring sites. Average 2020-2024 frequencies of livestock disturbance (hoof prints) have been high at the Weaver Canyon (36.0%), Sunday School 1 (14.2%), and Wrinkles Road (12.3%) sites and low at the other five sites (range 2.5% to 7.2%; single factor ANOVA $p < 0.0001$). Average 2020-2024 frequencies of native ungulate disturbance (hoof prints) also varied significantly between sites, with high disturbance at the Wolf's Den (68.9%), Sunday School 1 (34.9%), and East Sand Wash (29.1%) sites, and lower disturbance

levels at the other five sites (range 5.4% to 10.9%; single factor ANOVA $p < 0.0001$). Average 2020-2024 invasive species frequencies were highest at Mormon Gap (29.5%) with relatively high occurrences at Hell's Hole (15.0%), and low to nil levels at the other six sites (range 0.0% to 2.2%; single factor ANOVA $p < 0.05$).

Significant differences in disturbance levels between years at the macroplot level are addressed by macroplot monitoring site in the sections below. Year 5 disturbance and cover frequency 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

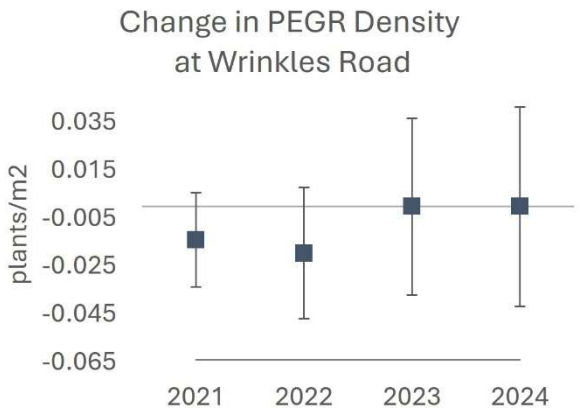
WRINKLES ROAD POPULATION TREND

Graham's beardtongue density remained stable between 2023 and 2024 (**Figure 5a**). Over the past two sampling intervals population density has been unchanged from when monitoring was established at the site in 2020 ($t(11)=0.0$, $p >0.5$) (2020: [M=1.9, SD=2.8], 2024: [M=1.9, SD=1.8]). Plant density at Wrinkles Road is among the lowest (0.06 plants/m^2) of the eight Graham's beardtongue macroplots and contained an estimated 77 plants in 2024 (**Figure 6a**).

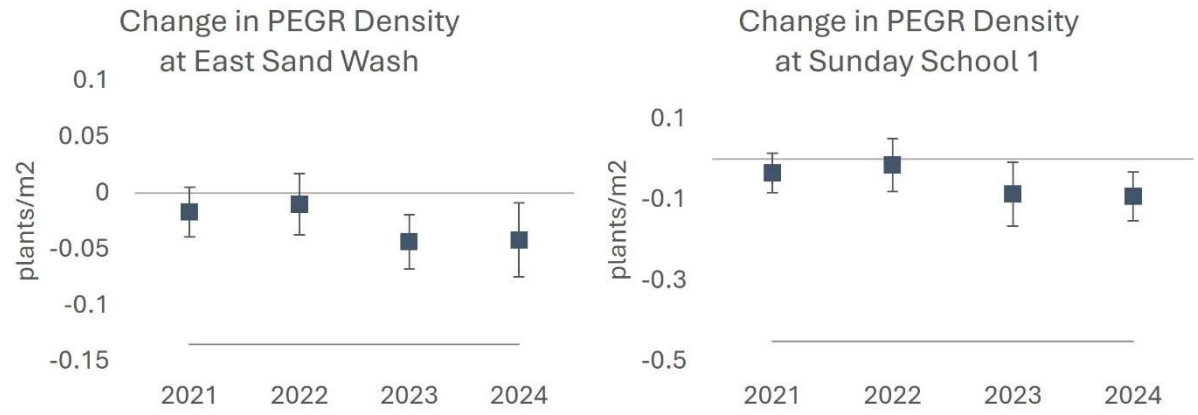
WRINKLES ROAD DISTURBANCE AND HABITAT COMPOSITION

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 were no significant changes in frequency of disturbance (livestock, native ungulate, or invasive species) in 2024 from 2020 to 2023 average frequencies ($\chi^2\, p < 0.05$). No invasive species have been detected in the plot to date. Frequency of disturbance, ground cover, and vegetation by cover class from 2020-2024 is illustrated in **Figure 7a**.

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)

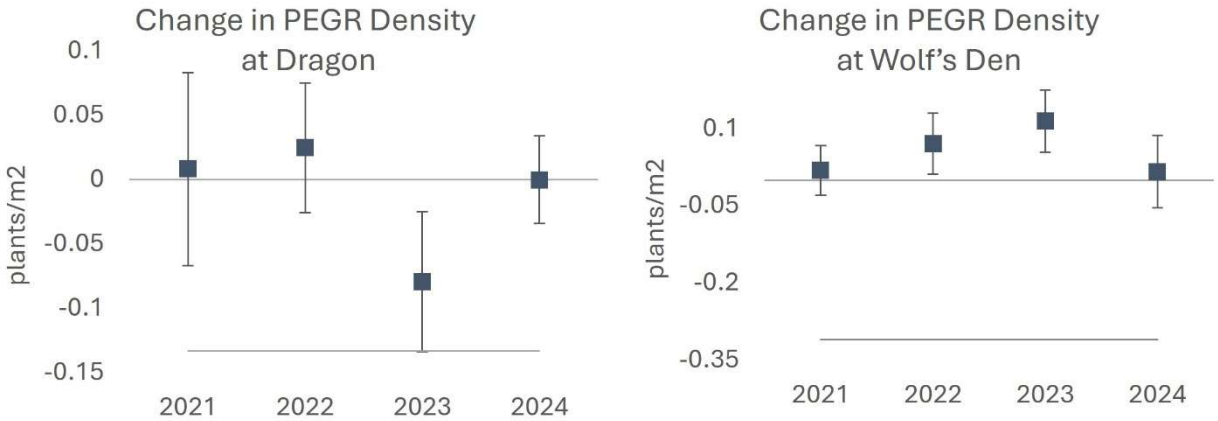
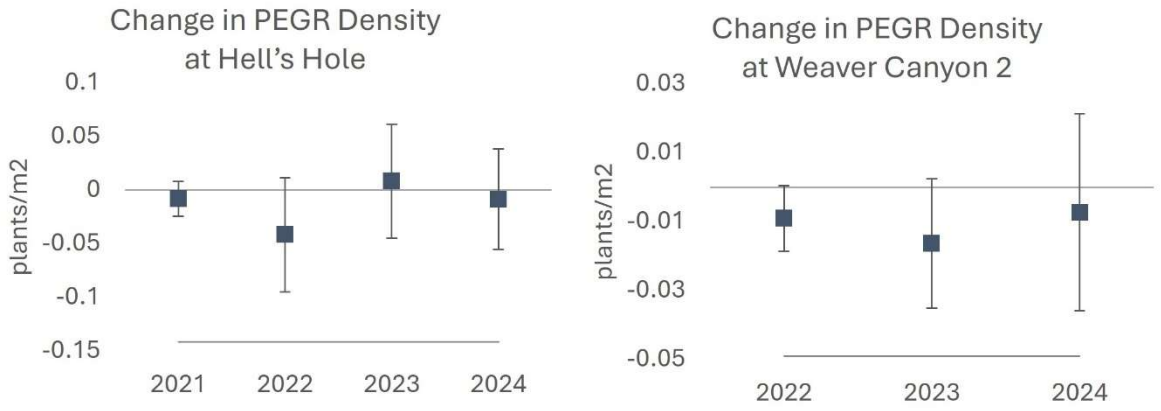


Figure 5a-c. Changes in Graham's beardtongue densities from establishment to 2024 for conservation unit 1 (a), unit 2 (b), and unit 3 (c) monitoring sites (error bars represent 90% confidence intervals).

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



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

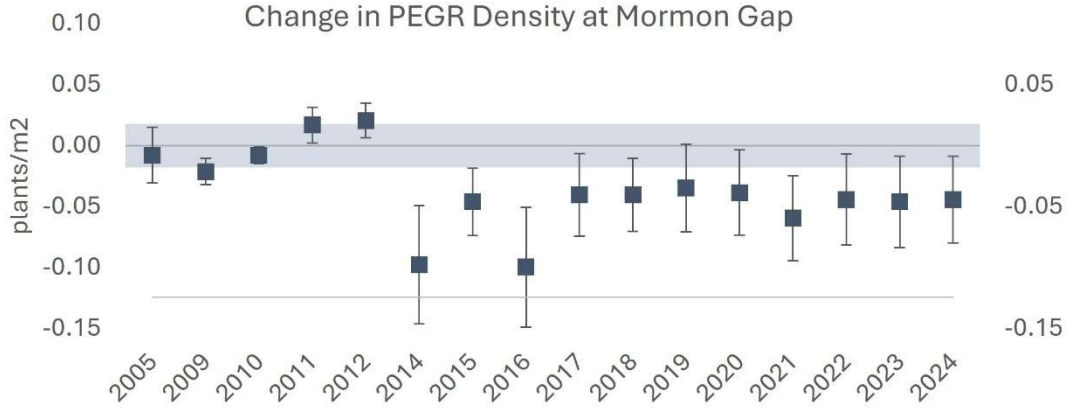
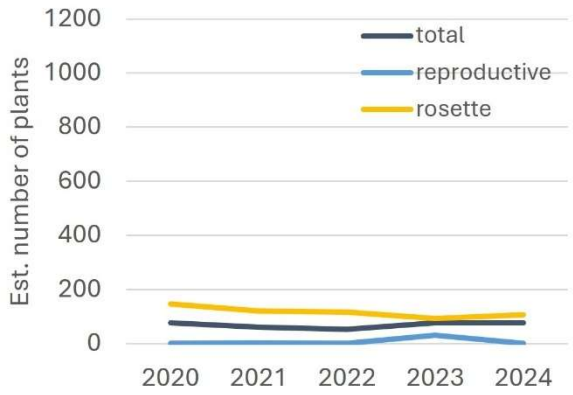
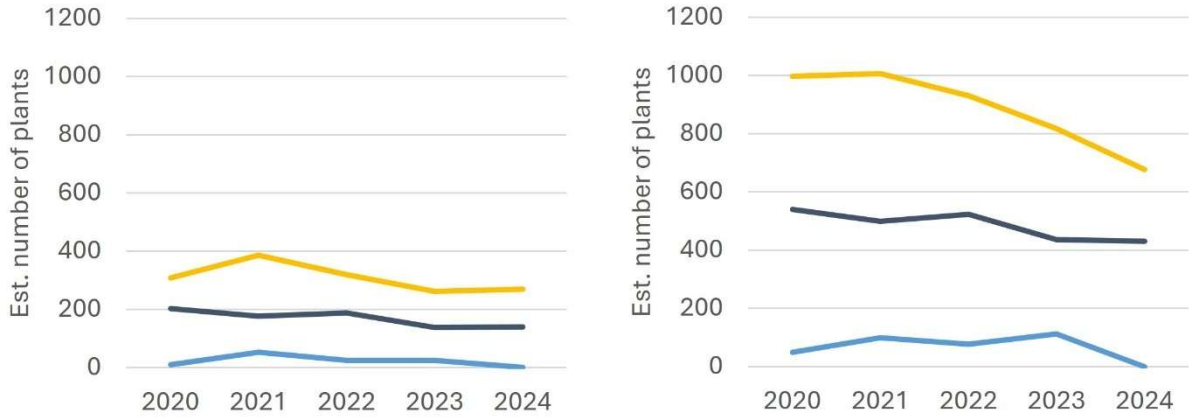


Figure 5d-e. Changes in Graham's beardtongue densities from establishment for conservation unit 4 (d), and from baseline (Mormon Gap baseline density is the average of the 2005 to 2012 observations) For conservation unit 5 (e) monitoring sites error bars represent 90% confidence intervals. Figure 5e shaded region denotes +/- 1 SD of the baseline. The horizontal line across the bottom of the x-axis represents a decline of 100%.

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)

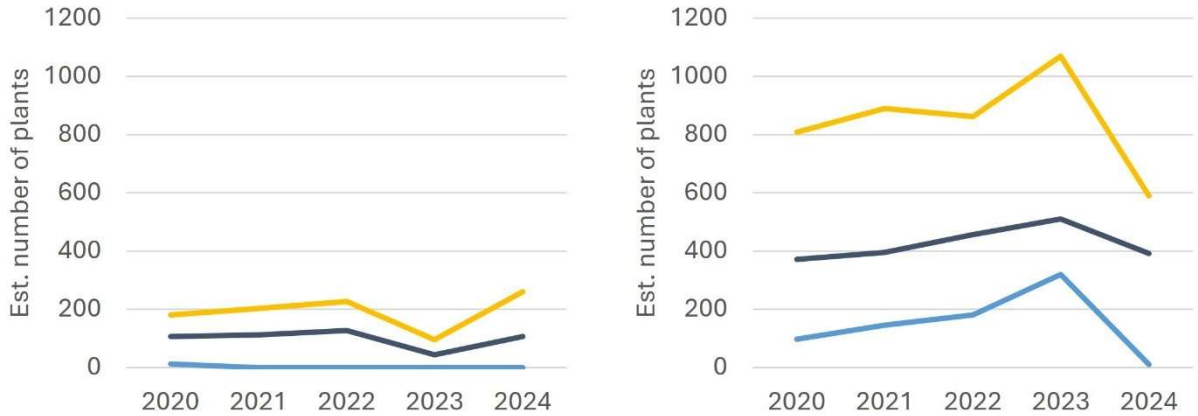
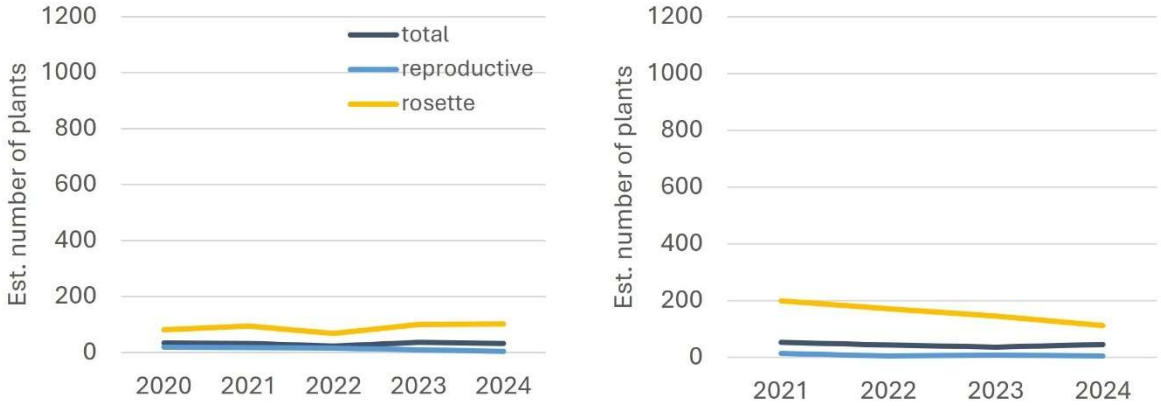


Figure 6a-c. Graham's beardtongue estimated abundance trend from establishment to 2024 for conservation unit 1 (a), unit 2 (b), and unit 3 (c) monitoring sites.

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



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

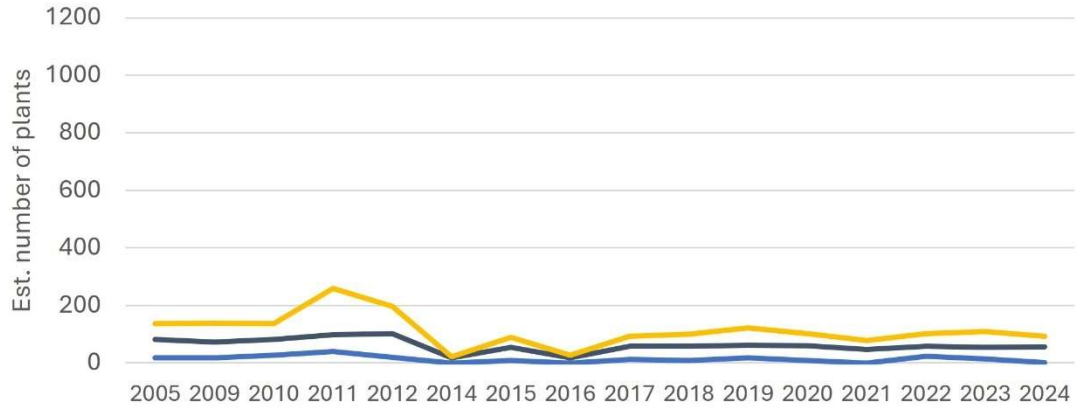
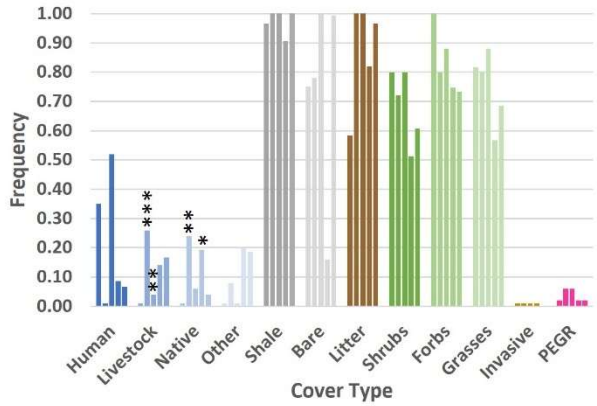
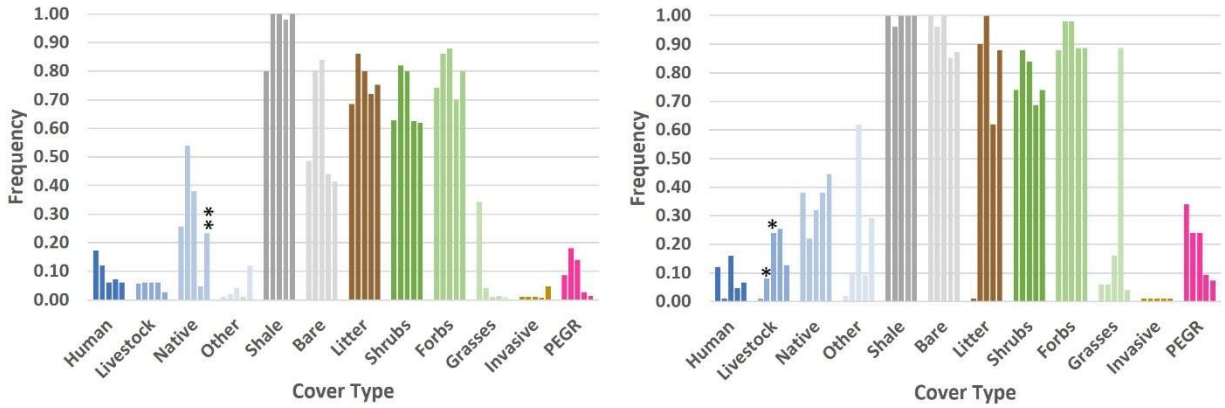


Figure 6d-e. Graham's beardtongue estimated abundance trend from establishment to 2024 for conservation unit 4 (d) and unit 5 (e) monitoring sites.

a) Conservation Unit 1 – Sand Wash (Wrinkles Road)



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)

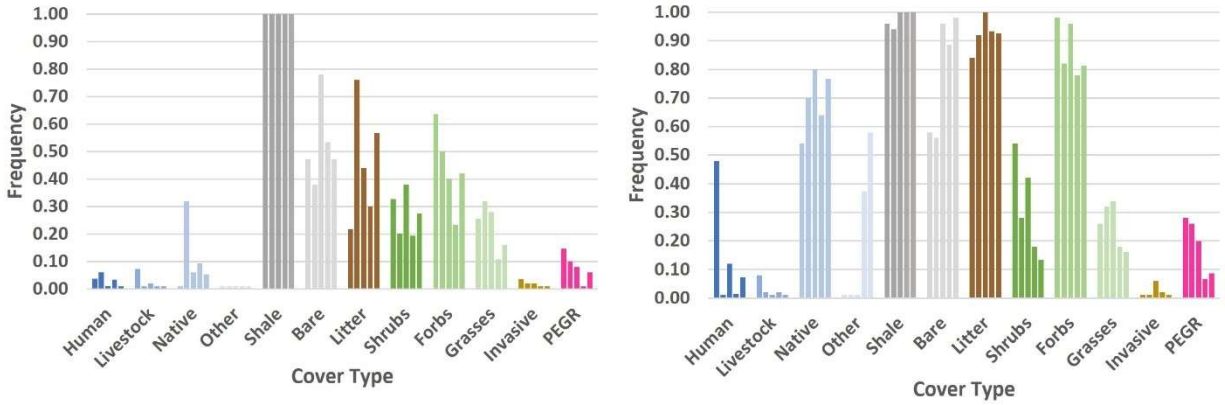
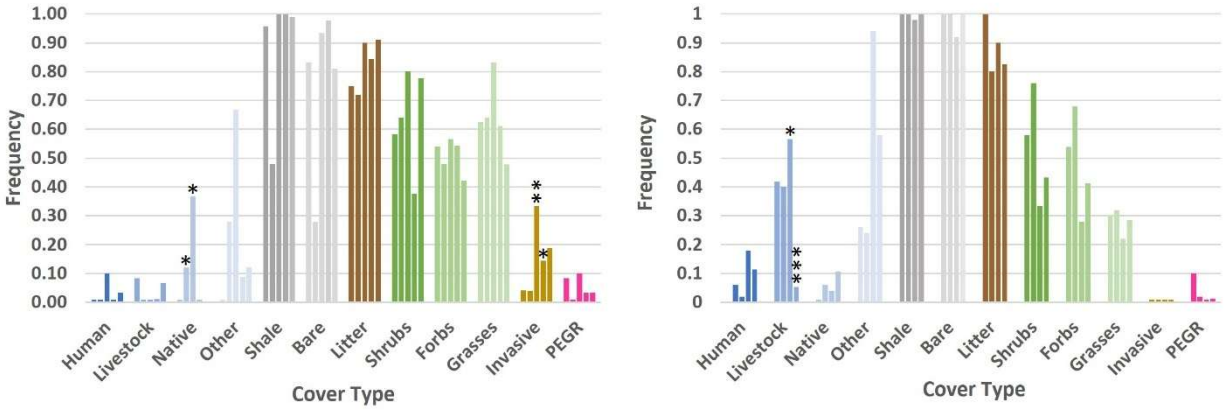


Figure 7a-c. 2020-2024 frequency of disturbance, ground cover, vegetation, and Graham's beardtongue at the conservation unit 1 (a), unit 2 (b), and unit 3 (c) monitoring sites. Significant changes in livestock disturbance, native ungulate disturbance, and invasive weed frequencies from the average of prior years' observations 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)



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

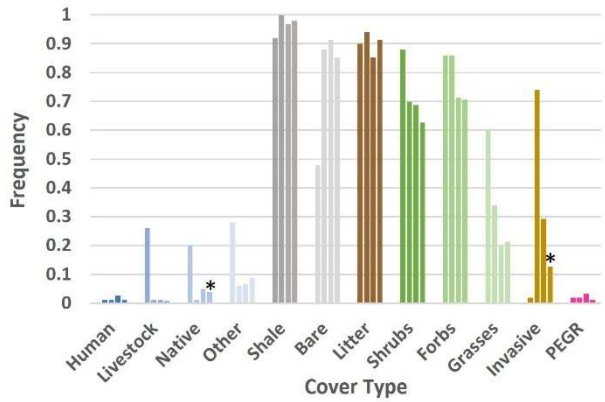


Figure 7d-e. 2020-2024 frequency of disturbance, ground cover, vegetation, and Graham's beardtongue at the conservation unit 4 (d) and unit 5 (e) monitoring sites. Significant changes in livestock disturbance, native ungulate disturbance, and invasive weed frequencies from the average of prior years' observations 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 remained stable between 2023 and 2024 at the East Sand Wash study site (**Figure 5b**). Plant density is approximately 30% lower than when the study site was established in 2020 ($t(11) = 2.68$, $p = 0.02$) (2020: [M=6.8, SD=3.3], 2024 [M=4.7, SD=3.2]). Plant density at East Sand Wash (0.09 plants/m^2) is below the average of the eight Graham's beardtongue monitoring sites and contained an estimated 140 plants in 2024 (**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 were no significant changes in livestock or invasive species disturbance from the 2020-2023 average to 2024. There was a significant increase in native ungulate disturbance (hoofprints) in 2024 from the 2020-2023 average frequency (χ^2 $p < 0.0001$). We documented UTV tire tracks in the plot in 2024 and there were widespread signs of UTV use throughout the area. No invasive species have been documented in the macroplot to date. Frequency of disturbance, ground cover, and vegetation by cover class from 2020 to 2024 is illustrated in **Figure 7b**.

SUNDAY SCHOOL CANYON 1

SUNDAY SCHOOL CANYON 1 POPULATION TREND

Graham's beardtongue density remained stable at Sunday School Canyon 1 between 2023 and 2024 (**Figure 5b**). However, plant density has experienced a statistically significant decrease since monitoring was established at the site in 2020 ($t(11)=3.24$, $p<0.01$), declining by 20% over 5-years ([2020: (M=13.5, SD=5.1), 2024: (M=10.8, SD=4.7]). Plant density at Sunday School Canyon 1 (0.36 plants/m^2) is among the highest of the eight Graham's beardtongue study sites and contained an estimated 430 plants in 2024 (**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 were no significant changes in livestock, native ungulate, or invasive species disturbance in 2024 from the 2020 to 2023 average. However, we documented both horse (feral livestock) and deer (native ungulate) hoofprints, and elk sign, in the macroplot in 2024. Tire tracks were not observed in the plot in 2024. There was widespread evidence of erosion throughout the site. Frequency of disturbance, ground cover, and vegetation by cover class from 2020 to 2024 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 rebounded at the Dragon study site in 2024. Population density was identical to 2020, the year monitoring was established at the site ($t(11) = 0$, $p > 0.5$) (**Figure 5c**; 2020: [M=2.67, SD=2.39], 2024: [M=2.67, SD=1.72]). For a third straight year we failed to detect any reproductive individuals at the site (**Figure 6c**). Plant density at Dragon (0.13 plants/m^2) is below the average of the eight Graham's beardtongue macroplots and contained an estimated 107 plants in 2024 (see **Figure 3**).

DRAGON DISTURBANCE AND HABITAT COMPOSITION

The Dragon macroplot is on a relatively steep northeast facing slope with shale ledges. There were no significant changes in livestock or native ungulate disturbance in 2024 compared to the 2020-2024 average. Invasive weed frequency has been nil (2023-2024) or very low (2020-2022; range 2.0% to 4.0%). Frequency of disturbance, ground cover, and vegetation by cover class from 2020 to 2024 is illustrated in **Figure 7c**.

WOLF'S DEN

WOLF'S DEN POPULATION TREND

Graham's beardtongue density declined at Wolf's Den in 2024 after three consecutive years of increase (**Figure 5c**). Despite the decline, plant density remains in line relative to when monitoring was established at the site in 2020 ($t(11)=0.6$, $p >0.5$) (2020: [M=12.4, SD=6.2], 2024: [M=13.1, SD=9.1]). Wolf's Den has among the highest plant density (0.33 plants/m^2) of the eight Graham's beardtongue study sites and contained an estimated 393 plants in 2024 (**Figure 6c**).

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 2020-2024. It appears that the site is on a spring migration route. Frequency of disturbance, ground cover, and vegetation by cover class from 2020 to 2024 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 slightly at Hell's Hole between 2023 and 2024 (**Figure 5d**). The trend is stable relative to when monitoring was established at the site in 2020 ($t(5) = 0.49$, $p > 0.5$) (2020: [M=2.8, SD=1.8], 2024: [M=2.67, SD=2.07]). Plant density at Hell's Hole (0.13 plants/m^2) was below the average of the eight Graham's beardtongue monitoring plots and contained an estimated 32 plants in 2024 (**Figure 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 change in disturbance frequencies in 2024 compared to the 2020-2023 averages. Frequency of livestock disturbance has been absent or very low all years of observation (range 0.0% to 8.0%). Frequency of disturbance, ground cover, and vegetation by cover type from 2020 to 2023 is illustrated in **Figure 7d**.

WEAVER CANYON 2

WEAVER CANYON 2 POPULATION TREND

Graham's beardtongue density rebounded in 2024 following two consecutive years of decline (**Figure 5d**). Plant density was 15% lower in 2024 than when monitoring was established at the site in 2021 ($t(9)=0.7$, $p >0.5$) (2021: [M=2.7, SD=1.5], 2024: [M=2.3, SD=2.75]). Plant density at Weaver Canyon 2 (0.04 plants/m2) is the lowest of the eight Graham's beardtongue macroplots and contained an estimated 46 plants in 2024 (**Figures 3 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 (sheep hoofprints) at the site has been high from 2021 to 2023 (range 40.0% to 57.0%) but significantly declined in 2024 compared to 2021-2022 average frequency (χ^2 $p < 0.001$). Frequency of disturbance, ground cover, and vegetation by cover class from 2020 to 2023 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 2023. No additional monitoring locations are planned.

MORMON GAP

MORMON GAP POPULATION TREND 2005-2024

Monitoring has occurred during sixteen of the last twenty years at Mormon Gap (no data was collected in 2006, 2007, 2008, and 2013). The reference period for the site was defined as the average plant density observed from 2005 – 2012. A livestock trailing event impacted the population between the 2012 and 2014 sampling intervals, reducing plant density at the site by nearly half. Between 2005 and 2012 the site averaged 0.12 plants/m2, SD=0.018. The site has averaged 0.07 plants/m^2, SD=0.023 since - amounting to a reduction of 43% from the pre-disturbance baseline. All ten sampling intervals since the event have exceeded one standard deviation below baseline density (the average of 2005-2012). During four of these years (2014, 2015, 2016, and 2021) the 95% confidence interval does not include one standard deviation of the baseline density, suggesting that the decrease at the site is not only statistically significant ($t(14)=3.37$, $p<0.01$) but biologically meaningful as well (2005: [M=4.07, SD=3.94], 2024: [M=2.8, SD=2.76]; **Figure 5e**, Table 4).

Table 4. Change in Plant Density at Mormon Gap 2005-2024 Relative to 2005-2012 Baseline Density

Year	Average. plants/m^2	Percent change from baseline (0.12/m^2)	Change in density from baseline (0.12/m^2)	Average density
2005	0.12	-6.4%	-0.01	
*2009	0.10	-17.2%	-0.02	
2010	0.12	-6.4%	-0.01	0.12
2011	0.14	+13.5%	0.02	
2012	0.14	+16.6%	0.02	
*2014	0.03	-78.5%	-0.10	
*2015	0.08	-37.1%	-0.05	
*2016	0.02	-80.1%	-0.10	
*2017	0.08	-32.5%	-0.04	
*2018	0.08	-32.5%	-0.04	
*2019	0.09	-27.9%	-0.03	0.07
*2020	0.09	-31.0%	-0.04	
*2021	0.06	-47.9%	-0.06	
*2022	0.08	-35.6%	-0.04	
*2023	0.08	-37.1%	-0.05	
*2024	0.08	-35.6%	-0.04	

* years in which mean plant density exceeds one SD below baseline density

Plant density at Mormon Gap (0.08 plants/m^2) is among the lowest of the eight Graham's beardtongue monitoring sites (**Figure 6e**).

MORMON GAP DISTURBANCE AND HABITAT COMPOSITION

No disturbance or habitat composition data were collected at the Mormon Gap site in 2020. Nested frequency data have been collected for 50 quadrats from 2021 through 2024. There were significant declines in livestock disturbance and invasive plant frequencies in 2024 compared to the 2021-2023 average (χ^2 $p < 0.05$ for both comparisons). Frequency of disturbance, ground cover, and vegetation by cover class from 2021 to 2023 is illustrated in **Figure 7e**.

White River Beardtongue Population Trend

Population trend monitoring and supplemental habitat monitoring were completed at all ten White River beardtongue study sites in 2024. The eight sites in Conservation Units 2-5 were sampled from May 20 to 24, 2024 and the two sites in Conservation Unit 6 were sampled on June 13, 2024. White River beardtongue density has decreased by approximately 30% on average, from 0.57 plants/m^2 to 0.48 plants/m^2, since 2020 (averages do not include Book Cliffs 2). In general, White River beardtongue macroplot trends have been more variable than those of Graham's beardtongue over the duration assessed. Three study sites have experienced statistically significant declines since their inception dates, three study sites are below their benchmarks, two study sites have increased relative to their benchmarks, and one site has experienced a statistically significant increase (Table 5 and Figure 8).

Table 5. 2024 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	Book Cliffs 2
Date Established with Sample Size	2020	2022	2021	2020	2018	2021	2017	2018	2020	N/A
Macroplot Area (m^2)	840	600	800	1800	720	900	800	800	360	600
Transects (m)	17 (20m)	10 (20m)	19 (20m)	12 (50m)	12 (20m)	12 (25m)	12 (20m)	12 (20m)	12 (15m)	12 (30m)
2024 Estimated Total Plants	195	94	147	807	270	225	507	557	500	895
Percent Reproductive	8%	25%	51%	18%	91%	39%	25%	50%	28%	49%
Significant Change Since Establishment	**Sig. Decrease**	**Sig. Decrease**	Decrease	Increase	**Sig. Decrease**	Decrease	**Sig. Increase**	Increase	Decrease	N/A
*p-value**	**< 0.01**	**< 0.01**	0.22	0.28	**< 0.01**	0.07	**0.04**	0.10	0.09	N/A
2024 Mean Density (plants/m^2)	**0.23**	**0.16**	**0.18**	**0.45**	**0.38**	**0.25**	**0.63**	**0.70**	**1.39**	**1.49**

* *p* values are the result of a two-tailed paired t test performed between 2024 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.

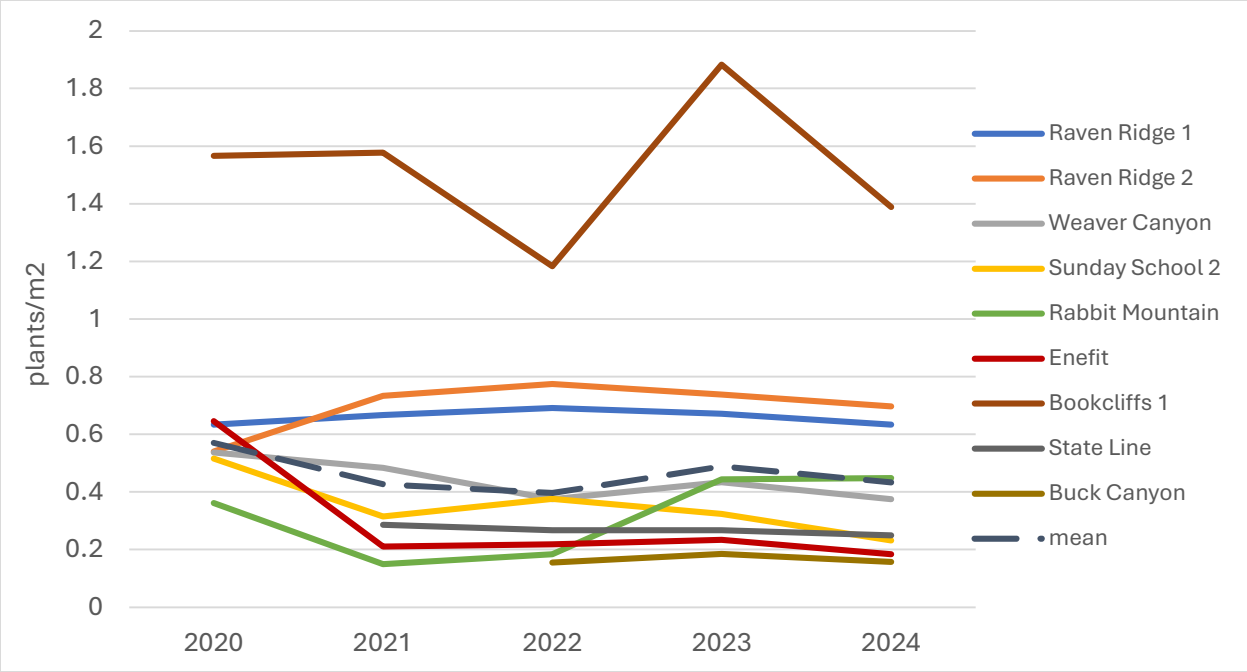


Figure 8. Range wide average and site-specific White River beardtongue population trends from 2020 to 2024. Note: Trend was defined as the change in mean plant density (avg. plants/m^2) between two observations. The mean was defined using a ratio estimator whereby the total number of plants among all sites is divided by the average combined area of the sites (Stehman and Salzer 2001).

White River Beardtongue Disturbance and Habitat Composition

In May and June 2024, we collected disturbance and habitat composition data at ten macroplot monitoring sites. 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 2024 is shown in Figure 9.

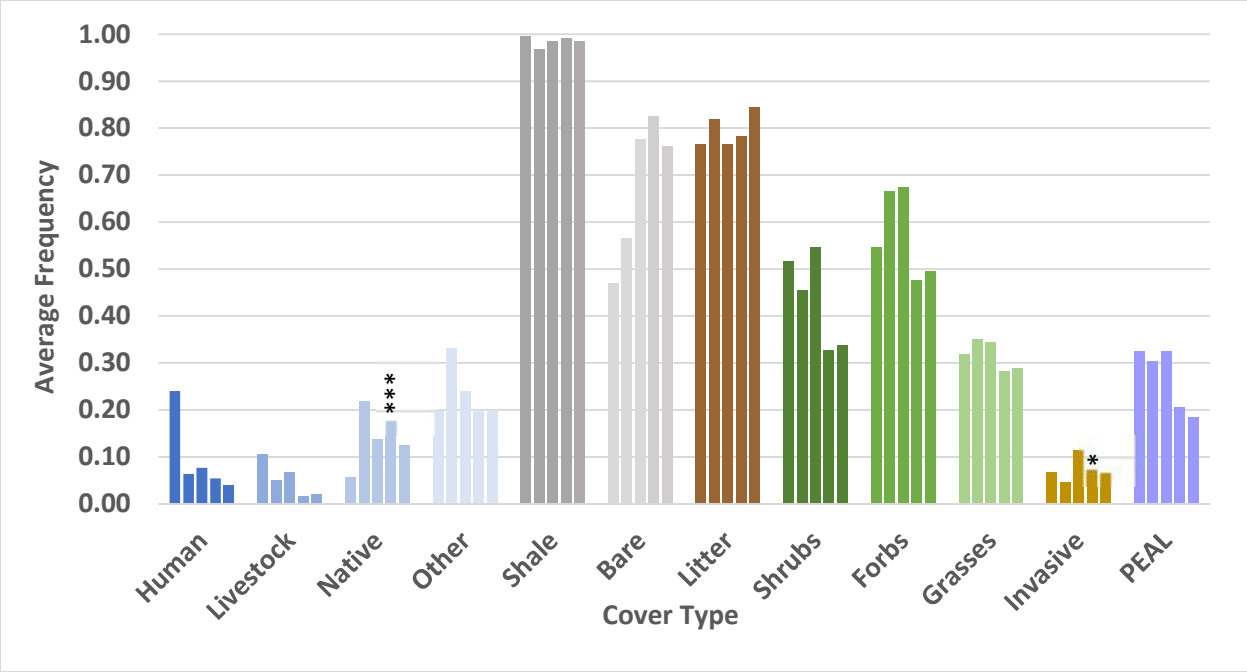


Figure 9. 2020-2024 average frequency by cover type for disturbance (human footprints, livestock and native hoof prints, and soil erosion or generalized soil disturbance), ground cover, native and invasive vegetation, and target species cover types in the White River beardtongue macroplots. Significant changes in 2024 livestock disturbance, native ungulate disturbance, and invasive weed frequencies versus the 2020-2023 average are marked with an asterisk(s) (*$p < 0.05$, **$p < 0.001$, ***$p < 0.0001$).

There were no significant differences in average frequency for any cover type across the White River beardtongue macroplot monitoring sites in 2024 (chi-square and single factor ANOVA tests $p > 0.05$). However, there were significant differences between the ten monitoring sites. Frequencies of invasive species are high at the Book Cliffs 2 site (48.3%) and are relatively high at Don Holmes Road (14.9%), Raven Ridge 2 (14.3%), and Weaver Canyon (11.6%). Invasive species frequencies at the other six sites range from nil to 8.6% (single factor ANOVA $p < 0.001$). There is not a significant difference in either livestock or native ungulate disturbance between sites (single factor ANOVA $p > 0.05$).

Significant differences in disturbance levels between years at the macroplot level are addressed by macroplot monitoring site in the sections below. Year 5 disturbance and cover frequency results are summarized for each monitoring macroplot following the population trend results.

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. No additional monitoring locations are planned.

SUNDAY SCHOOL CANYON 2

SUNDAY SCHOOL CANYON 2 POPULATION TREND 2020-2024

White River beardtongue density has decreased by 26% at Sunday School Canyon 2 since 2021 ($t(16)=3.56$, $p <0.01$) (**Figure 10a**). 2021: [M=6.3, SD=3.7], 2024: [M=4.7, SD=2.8]). The decrease is more pronounced (55%) when compared to 2020 - the year monitoring was established at the site. Plant

density at Sunday School 2 (0.23 plants/m2) is below the average of the ten sites and contained an estimated 195 plants in 2024 (**Figure 11a**).

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 increase in invasive species frequency (χ^2 $p < 0.05$) in 2024 compared to the 2020-2023 average. Frequency of disturbance, ground cover, and vegetation by cover class from 2020 to 2024 is illustrated in **Figure 12a**.

BUCK CANYON

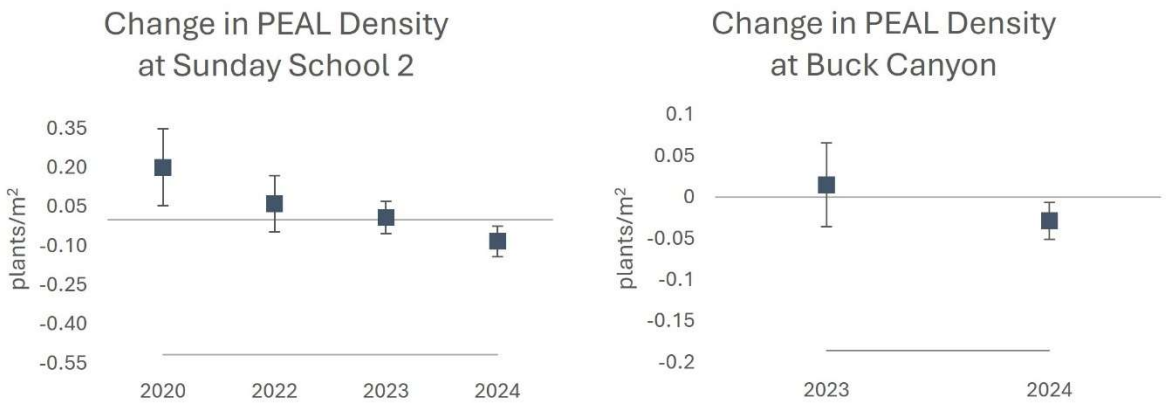
BUCK CANYON POPULATION TREND 2022-2024

White River beardtongue density decreased by 15% at Buck Canyon between 2023 and 2024 ($t(13) = 3.44$, $p < 0.01$) (**Figure 10b**; 2023: [M=3.7, SD=2.8], 2024: [M=3.1, SD=2.4]). Plant density at Buck Canyon (0.16 plants/m^2) is the lowest of the ten White River beardtongue monitoring sites and contained an estimated 94 plants in 2024 (**Figure 11b**).

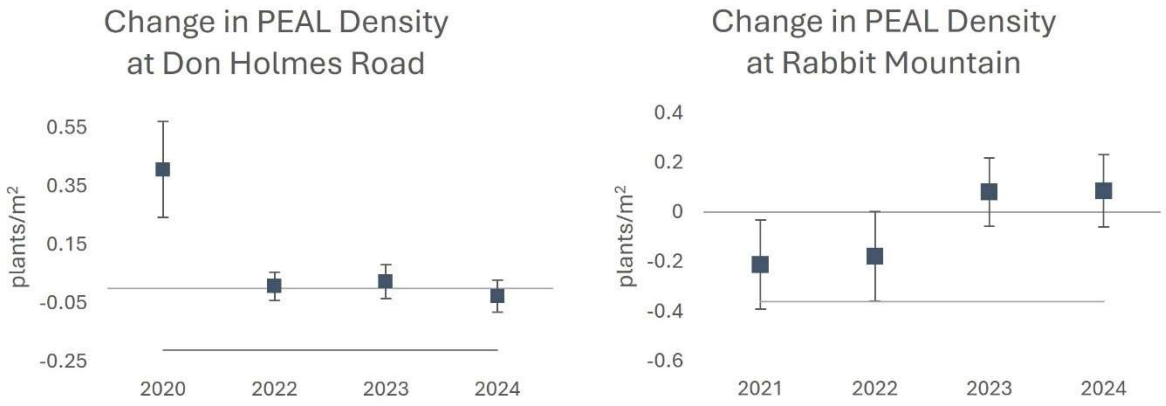
BUCK CANYON DISTURBANCE AND HABITAT COMPOSITION

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. There was a significant decrease in native ungulate disturbance (χ^2 $p < 0.05$) in 2024 compared to the 2022-2023 average frequency. Frequency of disturbance, ground cover, and vegetation by cover class from 2022 to 2024 is illustrated in **Figure 12b**.

a) Conservation Unit 2 – Seep Ridge (left: Sunday School 2; right: Buck Canyon)



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



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

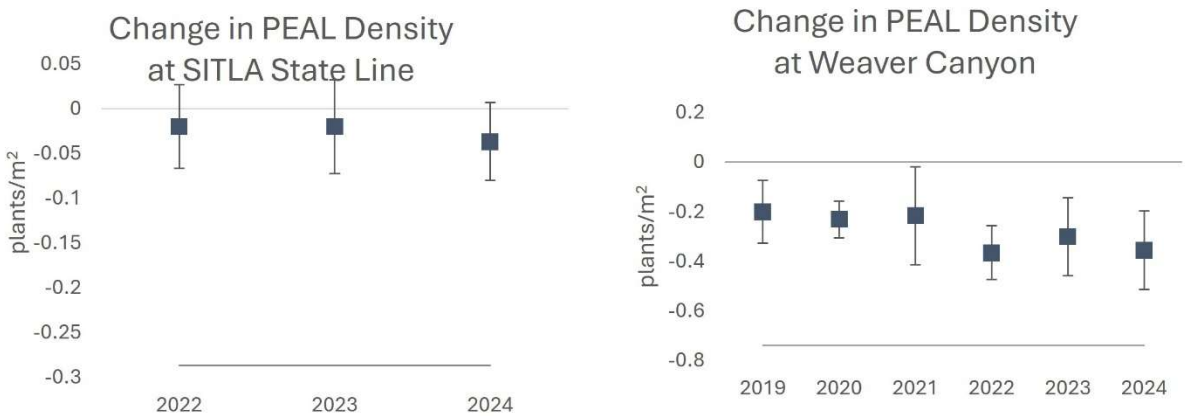
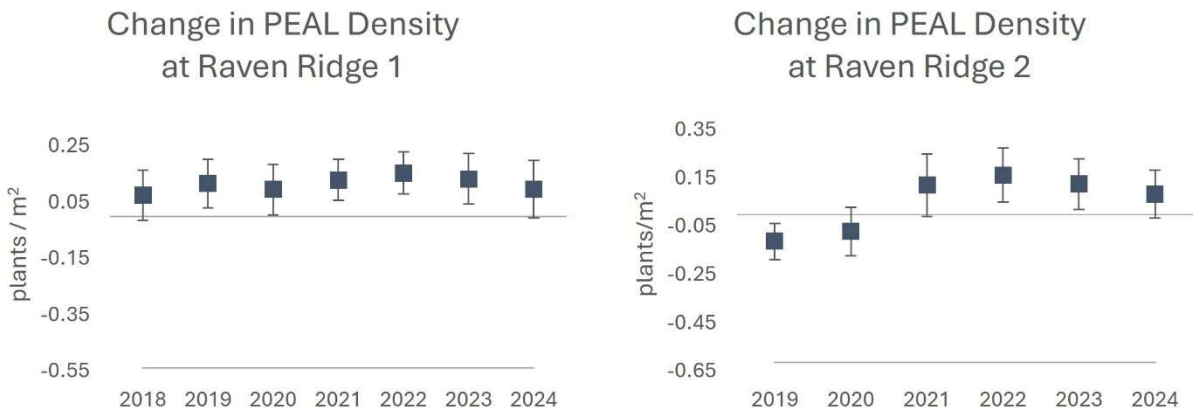


Figure 10a-c. Changes in White River beardtongue densities from establishment to 2024 for conservation unit 2 (a), unit 3 (b), and unit 4 (c) monitoring sites (error bars represent 90% confidence intervals).

d) Conservation Unit 5 – Raven Ridge



e) Conservation Unit 6 – Book Cliffs (left: Book Cliffs 1; no change data for Book Cliffs 2)

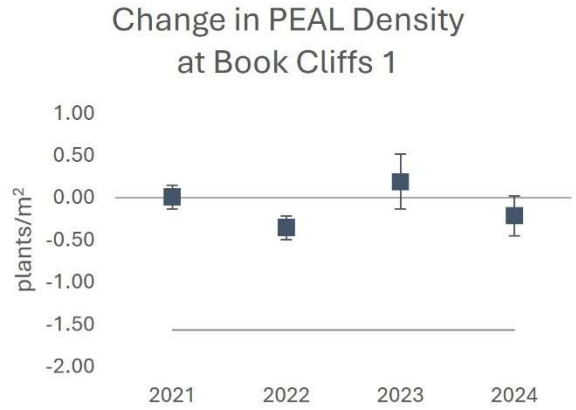
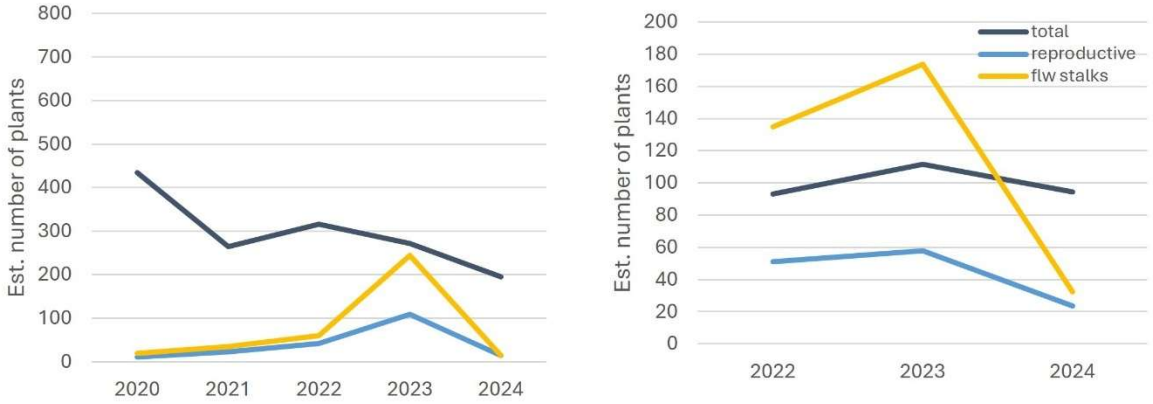
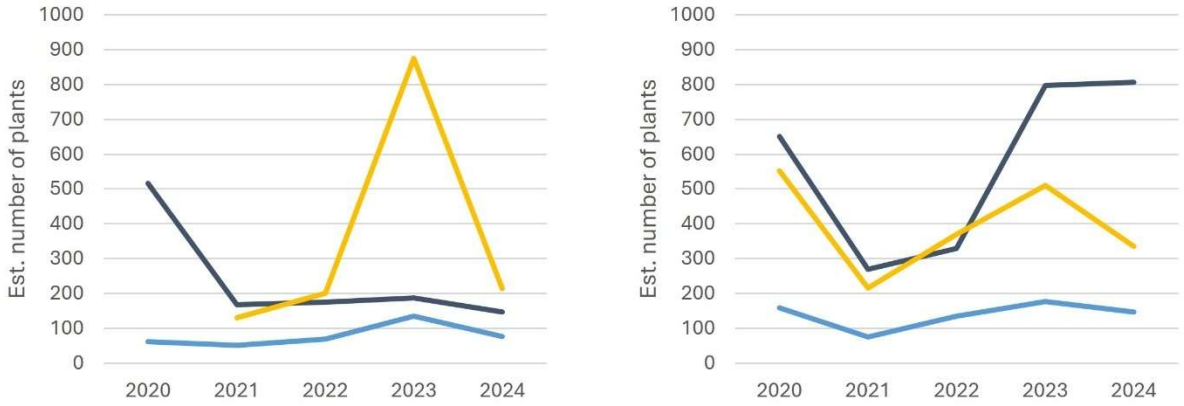


Figure 10d-e. Changes in White River beardtongue densities from establishment to 2024 for conservation unit 5 (d) and unit 6 (e) monitoring sites (error bars represent 90% confidence intervals).

a) Conservation Unit 2 – Seep Ridge (left: Sunday School 2; right: Buck Canyon)



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



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

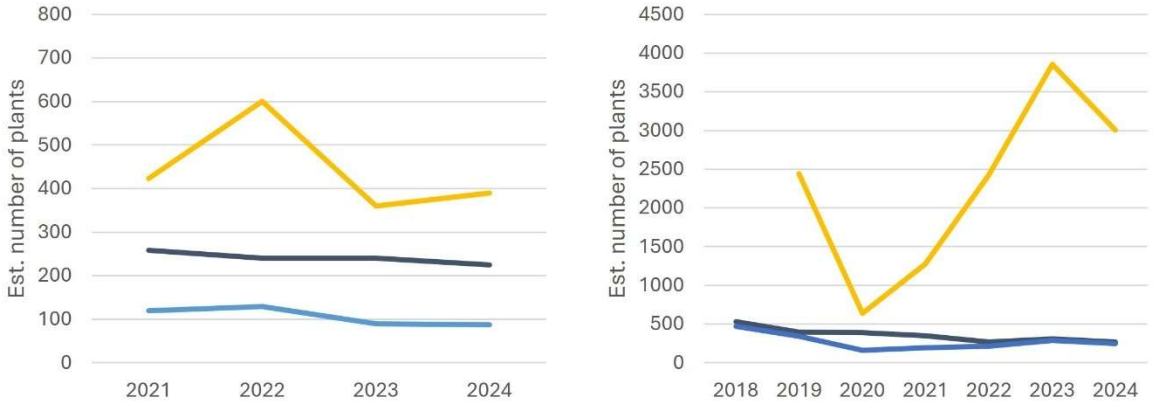
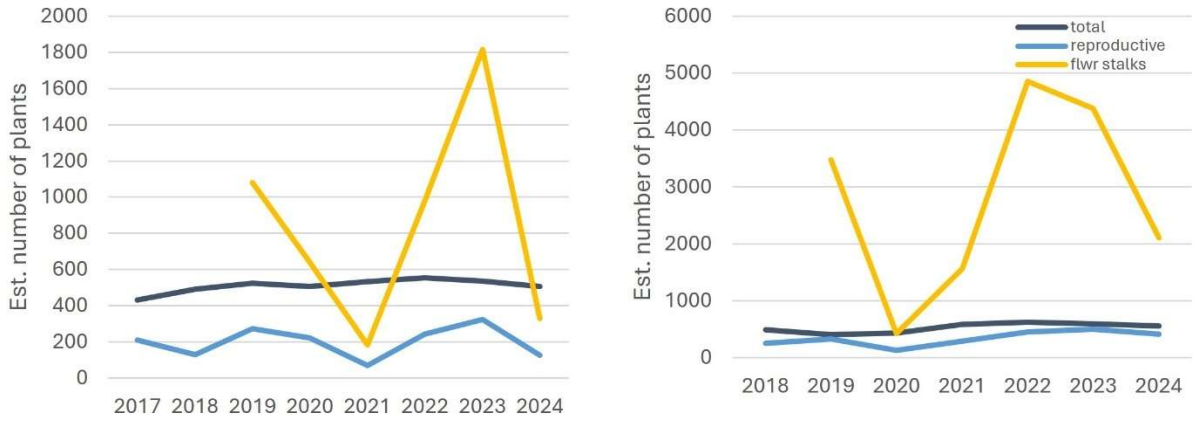


Figure 11a-c. White River beardtongue estimated abundance trend from establishment to 2024 for conservation unit 5 (d) and unit 6 (e) monitoring sites.

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



e) Conservation Unit 6 – Book Cliffs (left: Book Cliffs 1; no estimated plant number for Book Cliffs 2)

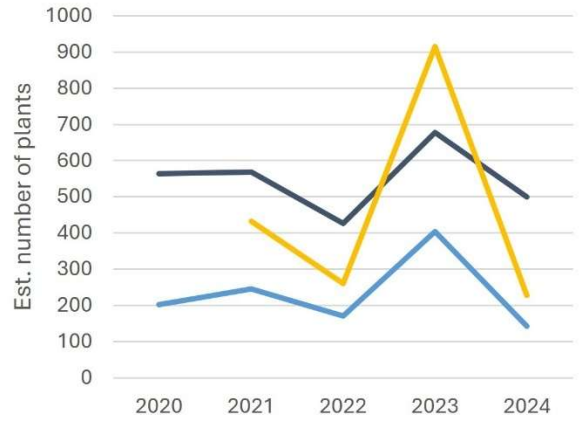
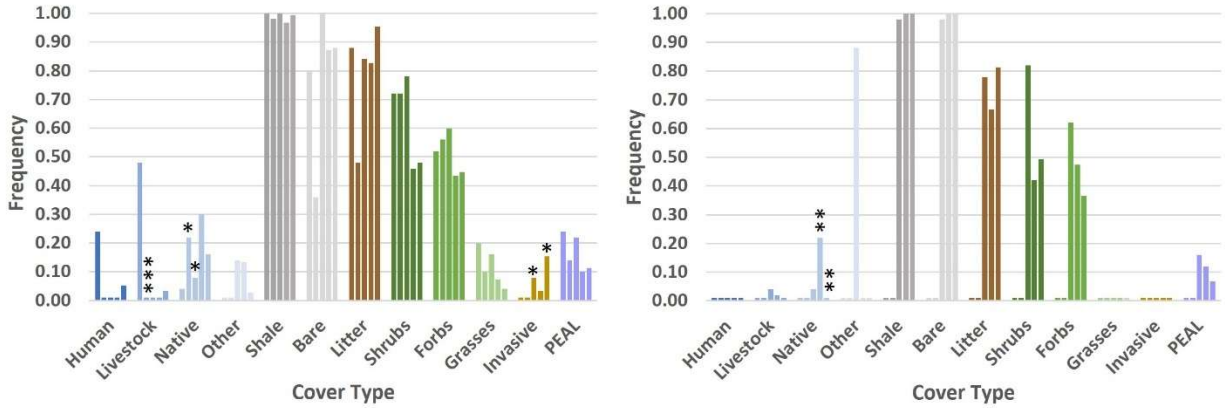
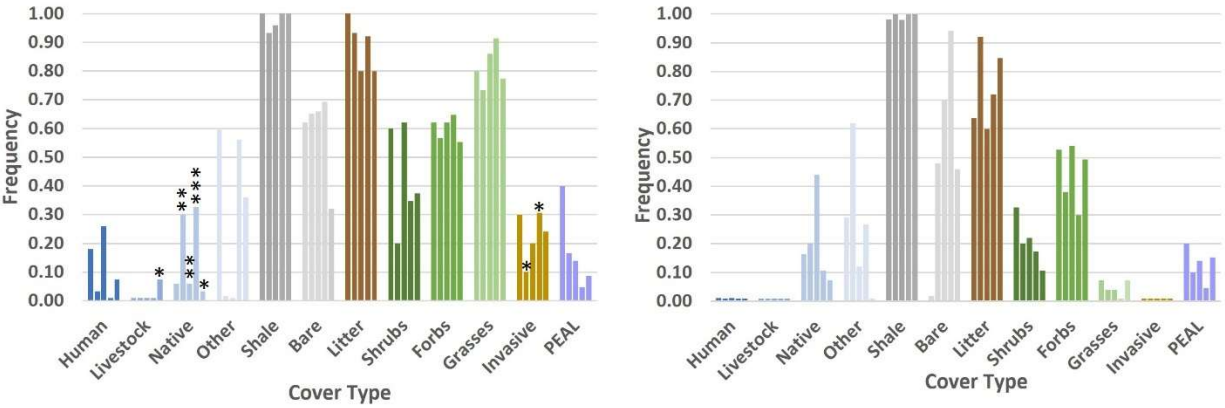


Figure 11d-e. White River beardtongue estimated abundance trend from establishment to 2024 for conservation unit 2 (a), unit 3 (b), and unit 4 (c) monitoring sites.

a) Conservation Unit 2 – Seep Ridge (left: Sunday School 2; right: Buck Canyon)



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



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

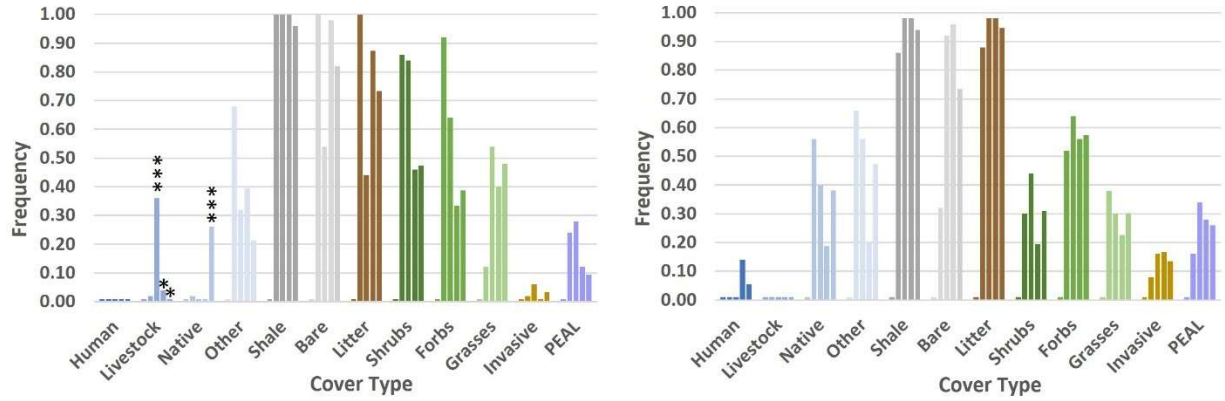
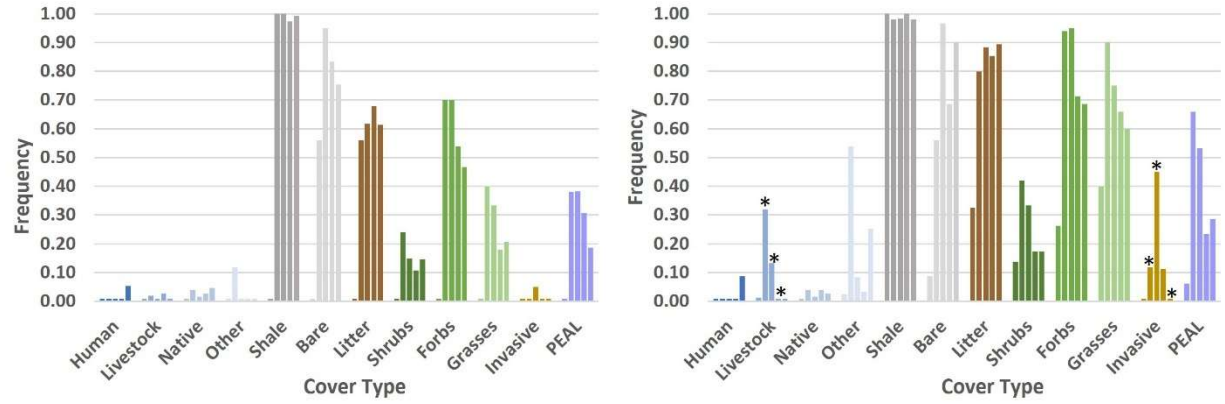


Figure 12a-c. 2020-2024 frequency of disturbance, ground cover, vegetation, and White River beardtongue at the conservation unit 2 (a), unit 3 (b), and unit 4 (c) monitoring sites. Significant changes in 2024 livestock disturbance, native ungulate disturbance, and invasive weed frequencies versus the 2020-2023 average are marked with an asterisk(s) (*$p < 0.05$, **$p < 0.001$, ***$p < 0.0001$).

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



e) Conservation Unit 6 – Book Cliffs (left: Book Cliffs 1; right: Book Cliffs 2)

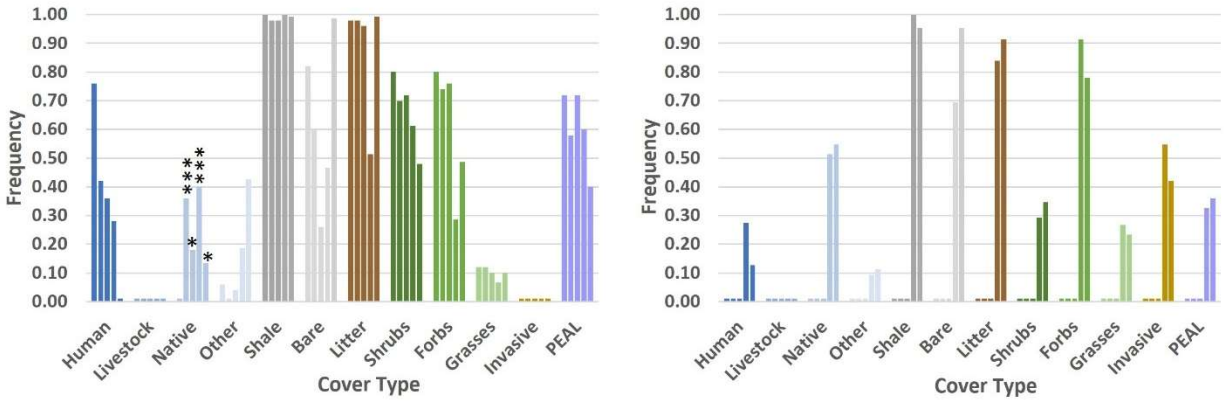


Figure 12d-e. 2020-2024 frequency of disturbance, ground cover, vegetation, and White River beardtongue at the conservation unit 5 (d) and unit 6 (e) monitoring sites. Significant changes in 2024 livestock disturbance, native ungulate disturbance, and invasive weed frequencies versus the 2020-2023 average are marked with an asterisk(s) (*p < 0.05, **p < 0.001, ***p < 0.0001).

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 from 2020 to 2024. No additional monitoring locations are planned.

DON HOLMES ROAD

DON HOLMES ROAD POPULATION TREND 2020-2024

White River beardtongue density decreased by 21% at Don Holmes (Enefit) between 2023 and 2024 but remains stable when compared to the 2021 benchmark density ($t(18)=1.28$, $p=0.21$) (2021: [M=4.2, SD=3.2], 2024: [M=3.7, SD=2.9]) (**Figure 10b**). Sampling year 2021 is used as the benchmark year because transects were added to the macroplot to achieve an appropriate sample size given the large decline between the first two samples. The decline from the first year of data collection is likely due to mortality among seedling individuals, a pattern consistent with other White River beardtongue study sites in Conservation Unit 3 (Rabbit Mountain) and is not representative of a significant acute impact to the site resulting in the loss of mature plants (**Figure 11b**). Plant density at Don Holmes (0.18 plants/m^2) is among the lowest of the nine White River beardtongue monitoring sites and contained an estimated 147 plants in 2024.

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 were significant increases in livestock disturbance (χ^2 $p < 0.05$) and a significant decrease in native ungulate disturbance (χ^2 $p < 0.05$) in 2024 compared to the 2020-2023 average. Frequency of disturbance, ground cover, and vegetation by cover class from 2020 to 2024 is illustrated in **Figure 12b**.

RABBIT MOUNTAIN

RABBIT MOUNTAIN POPULATION TREND 2020-2024

White River beardtongue density remained stable at Rabbit Mountain between 2023 and 2024 (**Figure 10b**). During three of the five sampling events clusters of small vegetative individuals have been recorded in certain transects at Rabbit Mountain. Overall, population density was higher in 2024 than when the plot was established in 2020 ($t(11)=1.19$, $p=0.28$) (2020: [M=18.1, SD=23.1], 2024: [M=22.4, SD=16.4]). Plant density at Rabbit Mountain (0.45 plants/m^2) approximated the average of the ten White River beardtongue monitoring sites and contained an estimated 807 plants in 2024 (**Figure 11b**).

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 were no significant changes in livestock or native ungulate disturbance frequencies in 2024 compared to the 2020-2023 average. 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 2024 is illustrated in **Figure 12b**.

Conservation Unit 4 (White River)

We revisited the Weaver Canyon macroplot monitoring site for the seventh year and the State Line macroplot on SITLA land for the fourth year in May 2024. No additional monitoring locations are planned.

WEAVER CANYON

WEAVER CANYON POPULATION TREND 2020-2024

White River beardtongue density has decreased by 49% at Weaver Canyon 1 since monitoring was established at the site in 2018 ($t(11)=4.18$, $p<0.01$) (2018: [M=14.8, SD=8.5], 2024: [M=7.5, SD=4.9]). Reproductive individuals as a proportion of the population total (91%) and the number of flowering stems per plant ($\mu=12.2$) both remain high (**Figure 10c**). There is no evidence that land-use activities are driving the observed decrease at the site. Plant density at Weaver Canyon 1 (0.38 plants/m^2) was slightly below the average of the ten White River beardtongue monitoring sites and contained an estimated 270 plants in 2024 (**Figure 11c**).

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 in 2024 from the 2021-2023 average. Frequency of disturbance, ground cover, and vegetation by cover class from 2021 to 2024 is illustrated in **Figure 12c**.

STATE LINE

STATE LINE POPULATION TREND 2021-2024

White River beardtongue density decreased slightly from 2023 to 2024 at the State Line study site (**Figure 10c**). Overall, population density is 13% lower than when monitoring was established at the site in 2021 ($t(11)=1.06$, $p=0.34$) (2021: [M=7.2, SD=4.6], 2024: [M=6.3, SD=4.9]). Plant density at State Line (0.25 plants/m^2) is below the average of the ten White River beardtongue monitoring sites and contained an estimated 225 plants in 2024 (**Figure 11c**).

STATE LINE DISTURBANCE AND HABITAT COMPOSITION

There was a significant decrease in livestock disturbance (χ^2 $p < 0.05$) in 2024 compared to the 2021-2023 average; however, there was a large significant increase in native ungulate disturbance (χ^2 $p < 0.001$) in 2024. Invasive plant species frequencies remain low. Frequency of disturbance, ground cover, and vegetation by cover class from 2021 to 2024 is illustrated in **Figure 12c**.

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 2017-2023

White River beardtongue density decreased by 6% at Raven Ridge 1 between 2023 and 2024 (**Figure 10d**). Overall, plant density has increased by 18% since monitoring was established at the site in 2017 ($t(11)=2.36$, $p=0.04$) (2017: [M=10.75, SD=6.81], 2024: [M=12.7, SD=8.3]). Plant density at Raven Ridge 1 (0.63 plants/m^2) is above the average of the ten White River beardtongue monitoring sites and contained an estimated 507 plants in 2024 (**Figure 11d**).

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 in 2024 from the 2021-2023 average. Frequency of disturbance, ground cover, and vegetation by cover class from 2021 to 2023 is illustrated in **Figure 12d**.

RAVEN RIDGE 2

RAVEN RIDGE 2 POPULATION TREND 2018-2023

White River beardtongue density declined by 6% at Raven Ridge 2 from 2023 to 2024 (**Figure 10d**). Overall, plant density is higher than when monitoring was established in at the site in 2018 ($t(11)=1.81$, $p=0.10$) (2018: [M=12.25, SD=5.36], 2024: [M=13.9, SD=5.9]). Plant density at Raven Ridge 2 (0.70 plants/m^2) is above the average of the ten White River beardtongue monitoring sites and contained an estimated 557 plants in 2024 (**Figure 11d**).

RAVEN RIDGE 2 DISTURBANCE AND HABITAT COMPOSITION

There were significant decreases in both livestock disturbance frequency (χ^2 $p < 0.05$) and invasive plant frequency (χ^2 $p < 0.001$) in 2024 compared to the 2020-2023 average. Native ungulate disturbance has been very low all years of observation (range 0% to 4.0% frequency). Frequency of disturbance, ground cover, and vegetation by cover class from 2020 to 2024 is illustrated in **Figure 12d**.

Conservation Unit 6 (Book Cliffs)

We established one macroplot monitoring site, Book Cliffs 1, in Conservation Unit 6 in June 2020 and a second macroplot in June 2023. No additional monitoring locations are planned.

BOOK CLIFFS

BOOK CLIFFS 1 POPULATION TREND

White River beardtongue density decreased by 26% at Book Cliffs 1 between 2023 and 2024 (**Figure 10e**). Despite exhibiting a fair amount of interannual variability, overall plant density has remained stable at the site since monitoring was established in 2020 ($t(11)=1.91$, $p=0.09$) (2020: [M=23.5, SD=9.2], 2024: [M=20.8, SD=13.4]). Plant density at Book Cliffs 1 (1.39 plants/m^2) is among the highest of the ten White River beardtongue monitoring sites and contained an estimated 500 plants in 2024 (**Figures 8 and 11e**).

BOOK CLIFFS 1 DISTURBANCE AND HABITAT COMPOSITION

There was a significant decrease in native ungulate disturbance (χ^2 $p < 0.05$) in 2024 compared to the 2020-2023 average. No livestock disturbance or invasive plant species have been detected in the plot to date. Human disturbance has been detected in prior years (fossil digging, stake removal). Frequency of disturbance, ground cover, and vegetation by cover class from 2020 to 2024 is illustrated in **Figure 12e**.

BOOK CLIFFS 2 POPULATION TREND

The Book Cliffs 2 study site had the highest White River beardtongue density (1.49 plants/m^2) of the ten sites in 2024 and contained an estimated 895 plants. Power analysis for the site will be completed at the time of 2025 data collection.

BOOK CLIFFS 2 DISTURBANCE AND HABITAT COMPOSITION

There were no changes in livestock, invasive species, or native ungulate disturbance in 2024 compared to 2023. Frequency of disturbance, ground cover, and vegetation by cover class from 2023 to 2024 is illustrated in **Figure 12e**.

Discussion

The *Conservation Agreement and Strategy for Graham's beardtongue and White River beardtongue* aims to identify, avoid, and mitigate potential threats to Graham's and White River beardtongues and their habitats, to promote the long-term persistence of both species, and negate the need for listing either species under the Endangered Species Act.

Population monitoring is central to the process of evaluating the efficacy of the conservation agreement over its lifespan. To that end, eighteen permanent monitoring sites have been established by the PCT across the six conservation units defined by the agreement and inform our understanding of population trends of both Graham's and White River beardtongue across their respective ranges. In addition to assessing the trend of beardtongue populations at these sites, additional quantitative data on vegetation composition and disturbance helps provide context for the population trends observed within conservation units designated for the benefit of the species. The conservation agreement addresses potential threats to both species including the direct impacts to plant populations and their habitat from a variety of land-uses including energy development, livestock grazing, road construction and maintenance, and off-road vehicle use, and indirect threats from a variety of other factors, including drought, that can compound deleterious effects on beardtongue populations.

Population Density

During five years of observation since the reimplementation of the Population Monitoring Plan in 2020 we have observed a 12% decrease in Graham's beardtongue density and a 30% decrease in White River beardtongue density on average. Given the fact that monitoring time series of a decade or longer are typically required to discern meaningful population trends, we are not able to draw substantive conclusions related to the biological significance of the observed decreases in plant density at this time. Disturbance resulting from land-use activities has been documented at several monitoring sites during the period of observation. However, these instances alone likely don't account entirely for the observed decreases in plant density across the ranges of the two species. Additional years of monitoring through the end of the agreement will aid in defining baseline plant densities and the amount of variability that should be expected for populations to exhibit in response to population cycles and climatic variation.

Disturbance and Habitat Composition

The 2020 to 2024 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 potentially contributing to declines in density at some locations. We documented increased native ungulate activity in the plots in 2021, decreased native ungulate disturbance in 2022, and significant increases in native ungulate disturbance in three macroplots (Buck Canyon, Don Holmes Road, Book Cliffs 1) in 2023. There were no significant changes in disturbance in 2024. As stated above, while there have been no significant differences in disturbance between years, there are significant differences between sites. It appears that higher levels of livestock and soil disturbance are associated with reduced beardtongue densities. However, despite locally high frequencies of native ungulate hoofprints for both species, regression analyses showed a significant positive interaction between Graham's beardtongue density and native ungulate disturbance frequency (R^2 0.479, $p < 0.0001$). White River beardtongue density responded similarly with a neutral to positive interaction with native ungulate disturbance and a weak negative interaction with livestock disturbance. It is likely that both livestock and native ungulate

movements are influenced by seasonal and interannual climate fluctuations. Further, disturbance can create opportunities for invasive annual plant species to become established in habitats where they weren't present previously.

Summary

Our dataset is beginning to demonstrate 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 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 relatively long-lived (~10-years) and require several to many years to exceed the resource threshold required to reproduce. In such 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 has generally been low such events demonstrate 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. Detailed examination of interactions between drought, plant density, habitat composition, and disturbance will be performed once longer-term datasets become available.

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 2023) or other available climate datasets.

Recommendations

We do not recommend the addition of macroplots for either species at this time. 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) limits the possibility of identifying additional monitoring sites.

We recommend the continued annual sampling of the full suite of monitoring sites for both species for the duration of the Conservation Agreement. Doing so will allow us to have a full decade of observed annual transitions at most monitoring sites and provide us with the ability to speak to meaningful trends observed over the duration of the Agreement.

We recommend continuing with the nested quadrat monitoring methods that were implemented in 2023. 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 as time and resources allow. Demographic data could be used to enhance the application of the density data and our understanding of density-climate interactions.

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