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

2016 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 2017

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

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

March 31, 2017

CONTENTS

TABLES

APPENDICES

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PENSTEMON CONSERVATION TEAM ACTIVITIES

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

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

Work activities continued on the four established sub-committees as well as the development of two new sub-committees: Seed Management and Demographic Monitoring. These plans will be included in the 2017 Annual Report. Descriptions are given below for each workgroup and final Plans 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 activities from January 1 – December 31, 2016.

Mitigation Plan

There have been no updates to the Mitigation Plan (Penstemon Conservation Team 2015a) in 2016. To date, the Mitigation Plan sub-committee has reviewed only one stone collection project due to the lack of new development in 2016. The permittee was notified, through SITLA, of the requirements of the Agreement and Mitigation Plan.

Weed Management Plan

No changes were made to the Weed Management Plan (Penstemon Conservation Team 2015b). In 2016, surveys were conducted near roads and two-tracks along approximately 38 miles of roads within beardtongue conservation areas, although no treatment occurred directly within the conservation areas. No new populations of noxious weeds were documented during surveys.

Livestock Grazing Management Plan

No changes or updates to the Livestock Grazing Management Plan (Penstemon Conservation Team 2015c) were made in 2016. Pilot methods for assessing livestock grazing and weed impacts in beardtongue habitats were implemented in late summer 2015. These methods are being further adapted to meet multiple monitoring objectives and to prevent duplication of effort between the weed management, livestock grazing management, and demographic monitoring plans. Monitoring to meet some of the objectives of the plan is expected to continue in 2017.

Surface Disturbance Plan

In 2016, no changes were made to the plan (Penstemon Conservation Team 2015d), but the plan is being implemented. As a result, some disturbances were either avoided or properly documented as described in the Implementation of the Conservation Agreement sections below.

Seed Management Strategy

The *White River Penstemon and Graham's Penstemon Seed Management Strategy*, hereafter Strategy, fulfills the commitment to develop a seed bank, as described in Table 4 action 16 of the Agreement (PCT 2014), and provides standardized procedures for the development and implementation of seed collection and seed storage for Graham's and White River beardtongues. The purpose of the Strategy is to guide the development and implementation of an ex situ seed bank conservation strategy for Graham's and White River beardtongue species. The objectives of this Strategy are to 1) establish an ex situ seed bank for conservation, 2) identify and achieve the key principles for seed banking, 3) develop a timeline and strategy for completing future collections, and 4) provide the logistical details and protocols required for implementation. The ex-situ seed bank will provide seeds to meet long-term genetic conservation needs as well as restoration and research needs.

It should be noted that the Strategy was finalized by the Team in January 2017 and will be available on the SITLA website.

Draft Demographic Monitoring Plan

A draft Penstemon Range-wide Demographic Monitoring Plan was initiated in late 2016. The Demographic Monitoring Plan will be finalized in May 2017 and will be available on the SITLA website. Implementation of the plan fulfills the requirement as per the conservation plan to develop a long-term monitoring plan (p. 29).

The range-wide demographic monitoring plan was written by the interdisciplinary Penstemon Conservation Team Demographic Sub-committee and approved by the PCT. The monitoring plan has three management goals incorporating three monitoring objectives (Elzinga et al. 1998) and will take place in two phases. Phase one will involve the monitoring of pollinators on study plants and counts of plant frequency along transects. Phase two will involve counts of fruits and seeds on the study plants. Because of the importance of outcross pollination for these species (Dodge and Yates 2009, McCaffery et al. 2014), we will also monitor pollinator abundance and diversity of flower visitors in each plot.

Implementation of this monitoring plan is expected to begin in May of 2017 (pilot year) and will continue for the duration of the conservation agreement. Monitoring will be conducted by BLM staff from the Vernal Field Office and White River Field Office.

IMPLEMENTATION OF CONSERVATION AGREEMENT IN BEARDTONGUE HABITATS

BLM

In 2016, White River and Vernal BLM did not authorize any disturbance/permits in 2016 within the Conservation Units for their area.

Vernal BLM issued a mineral materials permit in 2016 near but outside a conservation area. The original proposal included disturbance within a conservation area, but the BLM instructed the permittee to move the staging area to outside the conservation area. Later field inspection by the BLM showed that disturbance associated with the staging area remained within the conservation area, though this was near a road and in an area that was previously lightly disturbed.

New disturbances were mapped from the mineral materials permits on both BLM and SITLA land from 2016 (see information in preceding and following paragraphs regarding these disturbances), and these data were provided to the subcommittee to update the disturbance shapefile. In addition, an area on SITLA land disturbed by the Red Leaf oil shale mine from 2015 was mapped to update the disturbance shapefile.

Vernal BLM maintains an MS excel workbook tracking projects in and near *Penstemon grahamii* and *P. scariosus* var. *albifluvis* habitat. A copy of updated 2016 activities is attached to this report (Appendix A).

SITLA

SITLA issued one stone collection permit in June 2016. The Lessee completed the required survey for beardtongues. No beardtongues were found during the survey in the leased conservation area. It was later determined through site investigation, that stone had been collected in un-approved areas. Based on this experience, SITLA has implemented new procedures for any future stone collection applicants:

1. Require a $5,000 bond for stone collection in Penstemon areas.
2. Do pre/post inspection of lands and GPS any impacts and require mitigation.
3. Require a Plan of Operation at the time of permit application, so potential overlap with conservation areas can be evaluated prior to issuance of a permit.

SITLA chose not to incorporate a Penstemon Conservation Area within a proposed lease expansion.

SITLA provided $19,997 in funding to support Penstemon Conservation Team activities in 2015, and $5,282 in 2016.

UINTAH COUNTY

All departments have been informed about designated Conservation Areas because Uintah county has an overlay zone for them to reference. For example, the road department contacted Jon Stearmer to ask what it would take to locate a crusher in a Conservation Area, and as a result, the crusher was voluntarily relocated to a different area.

Uintah County provided $15,000 in annual partner funding for the Utah Endangered Species Mitigation Fund (ESMF) Penstemon Conservation Action project in 2014, 2015, and 2016.

STATE OF UTAH

The State of Utah Division of Wildlife ESMF program has provided the following funding in support of the implementation of the Penstemon Conservation Agreement under the Penstemon Conservation Action project:

- FY2014: $15,000

- FY2015: $74,985
- FY2016: $84,039
- FY2017: $70,000

DATA MANAGEMENT STRATEGY

All reports, publications, data, and literature mentioned in this annual report will be compiled in the Penstemon Conservation Team Google Drive site, hosted by SITLA, and will be accessible to all conservation team members.

Disturbance shapefiles will be updated and managed by Uintah County.

BLM

Both the BLM WRFO and VFO compile and store their respective beardtongue survey data each year. At the end of each calendar year, these data are submitted to the Utah Natural Heritage Program (UNHP), Colorado Natural Heritage Program, and the USFWS. These data will also be provided to the Penstemon Conservation Team, along with the annual report, as a shapefile accessible to the team on the Google Drive site.

SWCA Environmental Consultants

All survey data collected as part of SWCA's ESMF Penstemon Conservation Action project are submitted annually to BLM and the UNHP. SWCA maintains a database of historic and recently collected beardtongue occurrences and shapefiles of the designated beardtongue conservation areas. SWCA also maintains geographic information systems (GIS) shapefiles of all individual beardtongue transplant locations, access routes, and any other pertinent spatial information needed to revisit monitoring or research sites. These data and reports will be provided to the team using Google Drive, with permission from the private stakeholders.

2016 FIELD SURVEY RESULTS

BLM

VERNAL FIELD OFFICE

In August and October of 2016, BLM Botanists surveyed four areas of BLM administered lands within the Uinta Basin for *Penstemon grahamii* and *Penstemon scariosus* var. *albifluvis*. All surveys were conducted in accordance with the Penstemon Conservation Agreement and in areas identified as gaps in the distribution of these two species. We documented 178 new *P. grahamii* during surveys in the Wrinkles Road area. We found no new locations of *P. grahamii* or *P. s.* var. *albifluvis* in any of our other survey areas. *Sclerocactus wetlandicus* and *Cryptantha grahamii* were also documented. See Appendix B for full report.

Utah Endangered Species Mitigation Fund Penstemon Conservation Action (SWCA)

Minimal surveys were conducted in 2016. A new occurrence of Graham's beardtongue was identified in Park Canyon in an Enefit conservation area. New occurrences of White River beardtongue were identified in Gilsonite Canyon on BLM managed lands.

ONGOING RESEARCH

BLM

The Colorado State Office and the White River Field Office (WRFO) are monitoring Graham's beardtongue on Raven Ridge. A macroplot has been monitored since 2005, with a sampling objective of detecting a 20% difference in mean population density while being 90% confident of detecting a true change and accepting a 10% chance of detecting a false change.

In 2016, WRFO completed partial monitoring of the Mormon Gap Population. See Appendix C for full report.

Brigham Young University

In 2014 and 2015, researchers collected leaf samples to test the relationship between four varieties of the species *Penstemon scariosus*, including var. *albifluvis* (Stevens 2016). See Appendix D for full 2016 report.

Utah Endangered Species Mitigation Fund Penstemon *Conservation Action (SWCA)*

The goal of the Penstemon Conservation Action project is to meet immediate information needs regarding the distributions, habitat conditions, and restoration potential for Graham's and White River beardtongues as required by the 2014 Beardtongue Conservation Agreement. This project was initiated in early 2014 (FY2014; SWCA 2014) and will continue through June 2017. Conservation activities performed under this project through 2016 and expected through June 2017 and are summarized in Table 1.

Table 1. ESMF *Penstemon* Conservation Action Project Surveys and Ongoing Research

Fiscal Year (Date Range)	Objectives	Proposed Activities	Outcomes
FY2014 (April 1– June 30, 2014)	• Survey USFWS, UNHP, and BLM priority areas. • Survey Utah Division of Wildlife Resources (DWR)–managed conservation areas. • Collect genetic material from White River beardtongue populations to support Brigham Young University (BYU) genetics research.	• Survey five target areas: ○ Willow Creek (BLM) ○ Agency Draw (BLM) ○ Kings Wells (DWR surface) ○ Bitter Creek (DWR surface) ○ White River North (SITLA) • Collect White River beardtongue leaf material	• Documented 2,127 individual beardtongue plants (1,974 White River beardtongue and 153 Graham's beardtongue). • Documented flower color, leaf width, and style lengths for White River beardtongue. • Collected White River beardtongue leaf material and voucher specimens from populations at Utah-Colorado border and western extent of range. • Submitted plant materials to BYU.

Table 1. ESMF *Penstemon* Conservation Action Project Surveys and Ongoing Research

Fiscal Year (Date Range)	Objectives	Proposed Activities	Outcomes
		and voucher specimens rangewide.	
FY2015 (July 1 2014–June 30, 2015)	• Continue distributional surveys. • Initiate disturbance ecology assessments. • Initiate restoration research.	• Survey extremes of range for both species, including range expansion for White River beardtongue in Grand County, Utah. • Seed collections. • Develop disturbance assessment methods. • Preliminary data collection. • Transplant experiments in private conservation areas.	• 70 White River beardtongue seedlings were transplanted into unoccupied habitat in an Enefit conservation area in October 2014 (PESCAL-1) The PESCAL-1 transplant cohort was monitored in June 2015 with 75% plant survival. • Surveys completed May–June 2015: ○ West Agency Draw (BLM) ○ Sand Wash ○ Buck Canyon (BLM) ○ Woods Canyon (BLM) ○ Atchee Ridge (BLM) ○ Book Cliffs (BLM Grand County) • Disturbance assessment plots were sampled in the Hells Hole grazing allotment in June 2015. • 2015 activities were limited by inaccessible roads, flooding, and fragile habitat conditions. Flowering was somewhat limited, and seed collection sites were not identified.
FY2016 (July 1 2015–June 30, 2016)	• Conduct limited distributional surveys. • Continue disturbance ecology assessments for both species in one or more priority locations. • Continue restoration research. • Monitor FY2015 transplants.	• Range expansion surveys for White River beardtongue. • Survey connectivity areas for both species. • Seed collections. • Disturbance assessment pilot study. • Monitor transplanted cohorts and experimental sites. •	• The PESCAL-1 transplant cohort was revisited in October 2015 to tag individual plants for ongoing monitoring. • No range expansions were identified for either species in FY2016. New beardtongue occurrences were documented in two locations: ○ Gilsonite Canyon (BLM) ○ Park Canyon (Enefit) • Distributional surveys for both species are needed in Bitter Creek Canyon. Surveys are also needed in Willow Creek Canyon, but these lands are not currently accessible • Four 35-seedling White River beardtongue cohorts (140 plants) were transplanted into Enefit conservation areas in October 2015 (PESCAL-2, PESCAL-3, PESCAL-4, and PESCAL-5). Distributional surveys for both species are needed in Bitter Creek Canyon. Surveys are also needed in Willow Creek Canyon, but these lands are not currently accessible • 100 Graham's beardtongue seedlings were transplanted into four soil treatments (25 plants per treatment) in a prepared experimental plot at a Red Leaf's Seep Ridge EPS site in October 2015. . The transplants were revisited in

Table 1. ESMF *Penstemon* Conservation Action Project Surveys and Ongoing Research

Fiscal Year (Date Range)	Objectives	Proposed Activities	Outcomes
			May 2016. Seedling survival was 99% with 42% of plants in flower. Weed densities were high in reclaimed soil treatments. • 13 Graham's beardtongue seedlings were transplanted into native shale habitat in a SITLA conservation area (PEGR-1). The transplants were revisited in May 2016. Seedling survival was 38.5% (5) with no plants flowering.
FY2017 (July 1 2016– June 30, 2017)	• Monitor Grahams beardtongue (Red Leaf, PEGR-1) and White River beardtongue (PESCAL-1 to PESCAL-5) transplants. • Update disturbance ecology assessment methods to meet multiple monitoring objectives. • Coordinate disturbance ecology monitoring priorities with Penstemon Conservation Team.	• Monitor transplanted cohorts (6) and experimental sites (1). • Conduct disturbance assessment in one or more priority areas. • Identify seed collection sites. • Assist with demographic monitoring plan implementation or other monitoring as needed.	• Seed collections were conducted for both species in July 2016. All collected seed has been submitted to Red Butte Garden for curation. • Continuation of disturbance assessment monitoring, identification of seed collection sites, and monitoring of transplants and experimental sites are expected in May–June 2017. • This project is not expected continue as an ESMF-funded project in FY2018. Ongoing conservation and research activities under the Penstemon Conservation Agreement are expected to continue with alternative funding sources.

The EMF Penstemon Conservation Action project will continue through FY2017 (June 30, 2017).

FUTURE SUBCOMMITTEE WORK

The following subcommittees will meet in 2017 to begin or continue working on their respective plans:

- Demographic monitoring
- Restoration

LITERATURE CITED

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

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SWCA Environmental Consultants (SWCA). 2014. *Annual Report to ESMF. FY2014* Penstemon *Conservation Action Initiation (Contract Number 1007): Graham's beardtongue (*Penstemon grahamii*) and White River beardtongue (*Penstemon scariosus *var.* albifluvis*) Distribution surveys.* Salt Lake City, Utah. 44 pp.

APPENDIX A

2016 BLM VFO Project Tracking for *Penstemon grahamii* and *P. scariosus* var. *albifluvis*

Entity	Year	Project Title	NEPA Number	When Signed? Or Process Stage	Disturbance in Penstemon Conservation Areas?	Which Conservation Areas?	Disturbance Type	Disturbance Amount	Shapefile received from contractor?	How many penstemon plants near project?	Species	Closest plant to disturbance (feet)	Notes
BLM	2016	Monument Ridge Fuels Treatment EA	DOI-BLM-UT-G010-2015-0072-EA	draft available	no	na	na	na	na	none	both	Graham's 1.9 miles NW	
BLM	2016	Boulevard Ridge Lop and Scatter EA	DOI-BLM-UT-G010-2016-0023-EA	draft available	no	na	na	na	na	none	both	Graham's 3.9 miles NW	
BLM	2016	Cowboy Canyon Stone Collection CX	DOI-BLM-UT-G010-2016-0068-CX	September 2016	no	na	na	na	na	none	Graham	Graham's 0.6 miles N	
BLM	2016	Nine Mile Special Recreation Management Area EA	Not sure	initial writing phase	none planned	Approx 3,672 acres of Unit 1 inside project boundary	na	na	na	412	Graham	Not sure; plants throughout project area	No disturbance proposed in CCA; Unit 1 is located within project area boundary
BLM	2016	November 2016 Competitive Oil and Gas Lease Sale EA	DOI-BLM-UT-G010-2016-0033-EA	Signed December 2016 (?)	potentially if leases are developed. Units 1 and 4 are in lease areas; 5,155 total acres	Units 1 BLM, Private , SITLA; Unit 4 BLM and Private	potential oil gas development	na	na	1,230 Graham's; 119 White River	Both	Not sure; plants throughout project area	
BLM	2016	Vitruvian Lease Reinstatement EA	DOI-BLM-UT-G010-2016-0075-EA	initial writing phase	no	na	na	na	na	none	Both	Graham's 4.8 miles W	
BLM	2016	Wrinkles Road East Stone Collection CX	DOI-BLM-UT-G010-2016-0074-CX	September 2016	yes	Unit 1 BLM	stone collection surface disturbance	0.3 acres	na	238	Graham	Graham's 0.06 miles (308 feet) W	Proponant was instructed to move "staging area" but did staging inside CCA

APPENDIX B

BLM VFO Conservation Agreement surveys for *Penstemon grahamii* and *Penstemon scariosus* var. *albifluvis* in Duchesne and Uintah Counties, Utah – 2016 Field Season Report

Conservation Agreement Surveys for *Penstemon grahamii* and *Penstemon scariosus* var. *albifluvis* in Duchesne and Uintah Counties, Utah

2016 Field Season Report

Prepared by:

BLM-VFO

Introduction

In August and October of 2016, BLM Botanists surveyed four areas of BLM administered lands within the Uinta Basin for *Penstemon grahamii* and *Penstemon scariosus* var. *albifluvis* (Figure 1). All surveys were conducted in accordance with the Penstemon Conservation Agreement and in areas identified as gaps in the distribution of these two species. We documented 178 new *P. grahamii* during surveys in the Wrinkles Road area. We found no new locations of *P. grahamii* or *P. s.* var. *albifluvis* in any of our other survey areas. *Sclerocactus wetlandicus* and *Cryptantha grahamii* were also documented.

Methods

Prior to field surveys, GIS analyses identified distribution gaps to focus survey efforts. Field crews walked these areas with handheld GPS devices and marked locations of any *Penstemon* spp. or other special status plants. Both individual plants and clusters of plants were marked. In addition, negative data were collected where target species were not found, but other plants were. These data were uploaded into the Vernal Field Office TES geodatabase and the negative data were provided to the Utah Natural Heritage Program.

Results

About 5,700 acres were surveyed in 2016 from four identified survey areas, from west to east: Wrinkles Road (1,200 acres, Figure 2), Nutters Hole (3,000 acres; Figure 3), Willow Creek North (about 500 acres; Figure 4), and Big Park (1,000 acres; Figure 5), though the entirety of these areas were not surveyed. All of the accessible suitable habitat (by foot) in Nutters Hole was surveyed in 2016; additional surveys in this area could potentially be conducted by UAVs (drones). Only the southern half of Willow Creek North and the eastern fourth of Big Park survey areas were surveyed. 2017 surveys can focus on the remainder of these polygons in addition to other target areas.

We found 178 new *Penstemon grahamii* north of Wrinkles Road (Figure 2). We did not find any new *P. s.* var. *albifluvis*. One previously known location for *P. grahamii* with three individuals in the Big Park polygon was relocated. New locations for *Sclerocactus wetlandicus* and *Cryptantha grahamii* were documented.

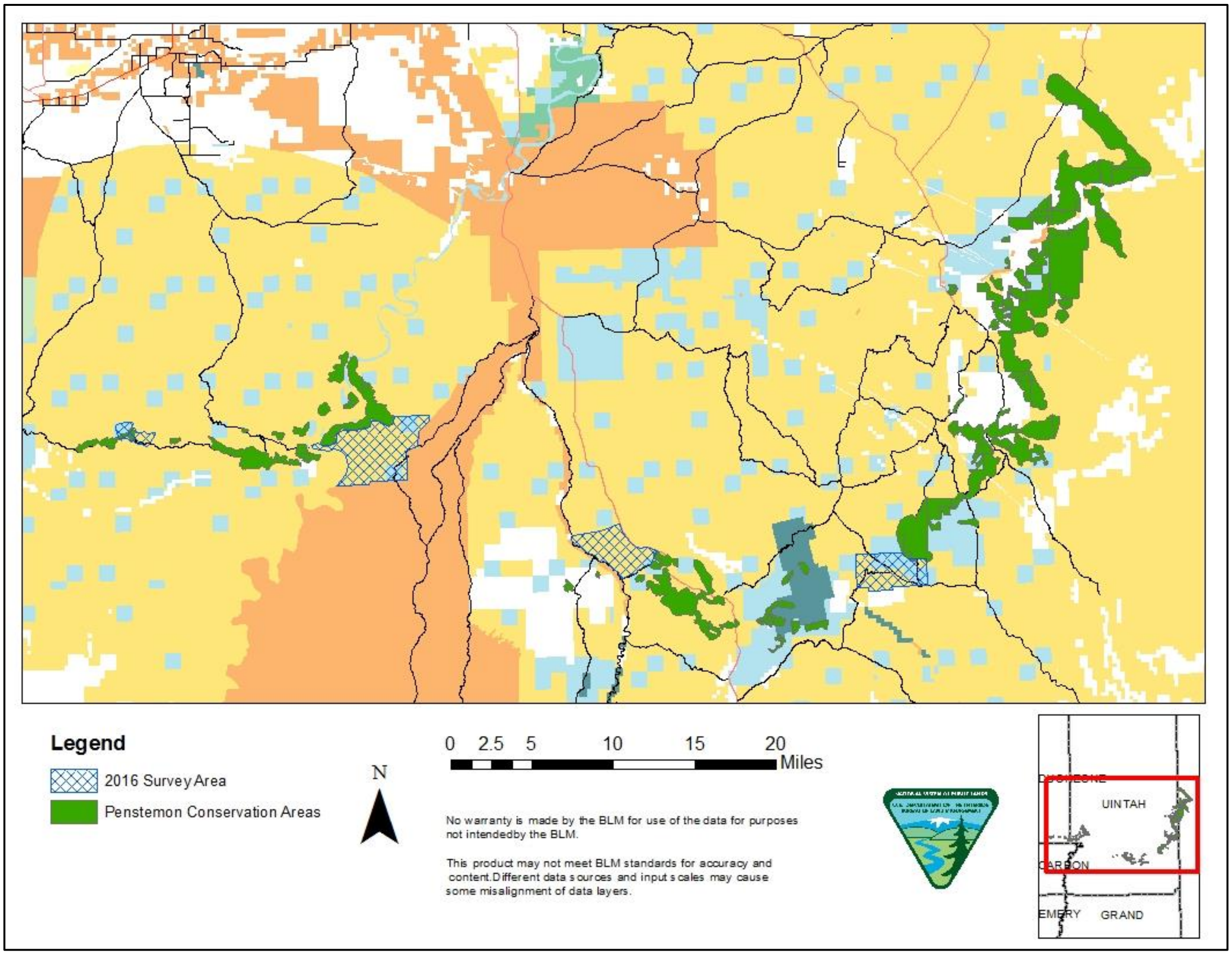

Figure 1. Overview map of the 2016 survey areas and Penstemon Conservation Agreement Areas.

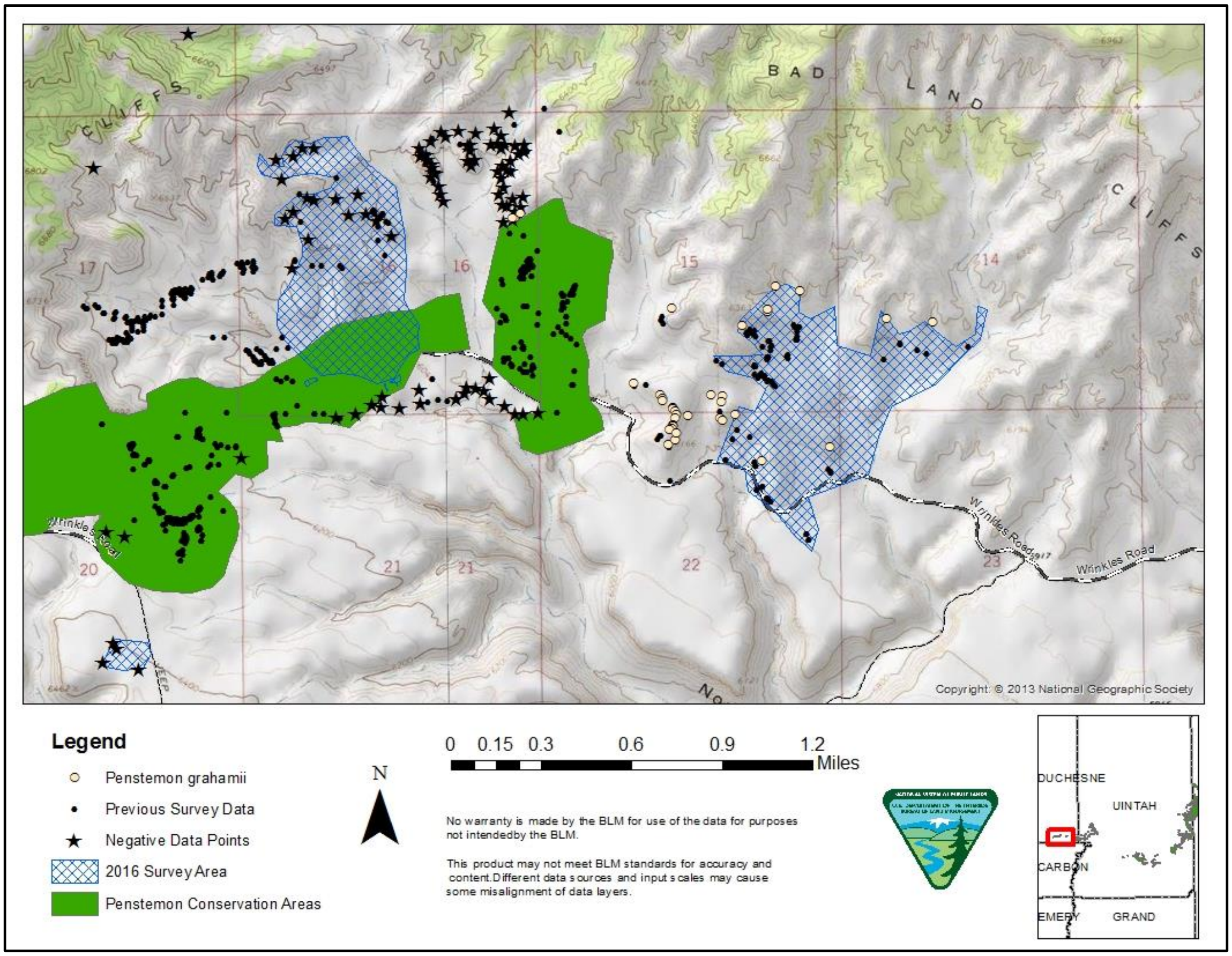

Figure 2. Map of the Wrinkles Road survey area. Colored dots indicate plants found, and black dots indicate existing data. Stars represent negative data in suitable habitat.

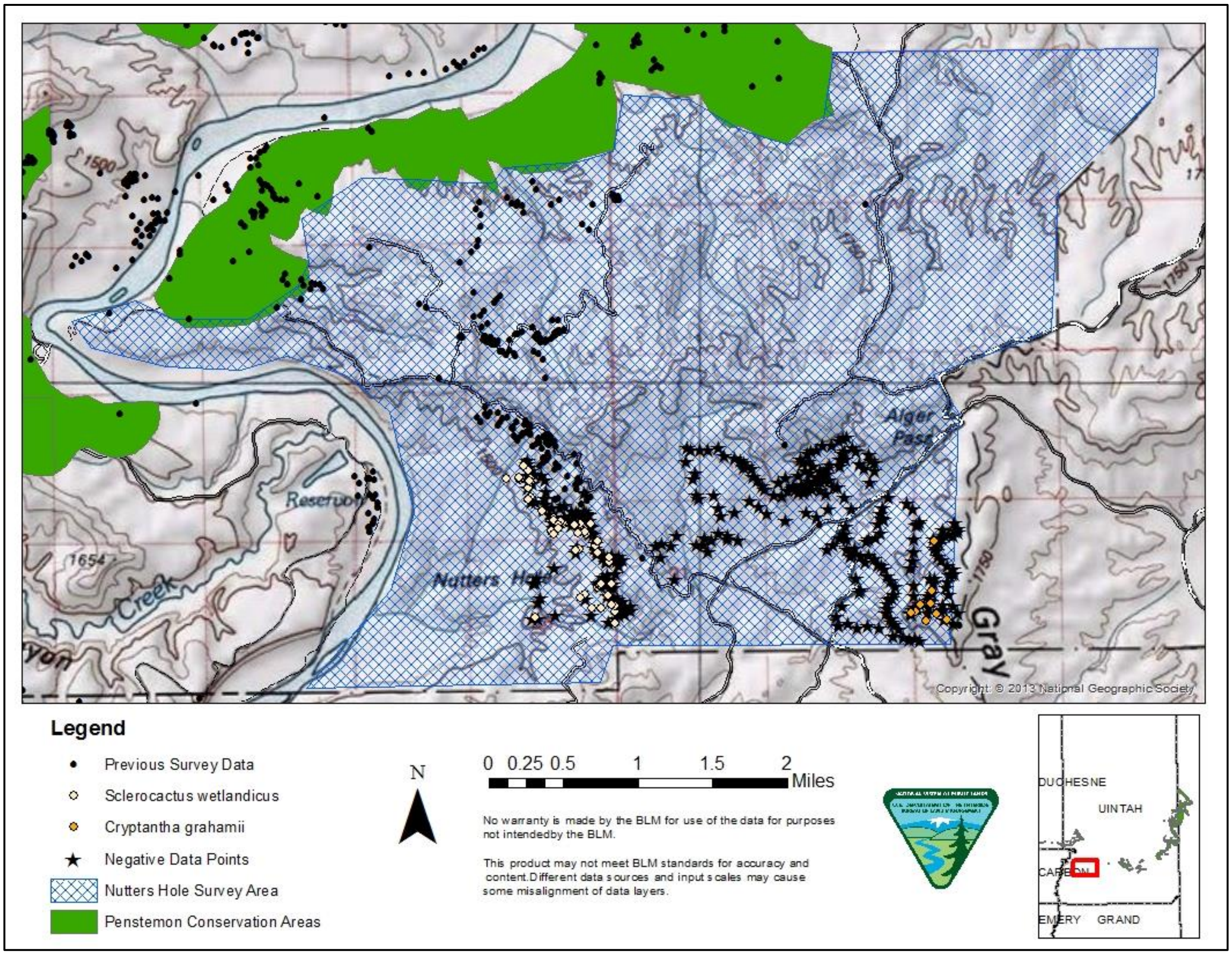

Figure 3. Map of the Nutters Hole survey area. Colored dots indicate plants found, and black dots indicate existing data. Stars represent negative data in suitable habitat.

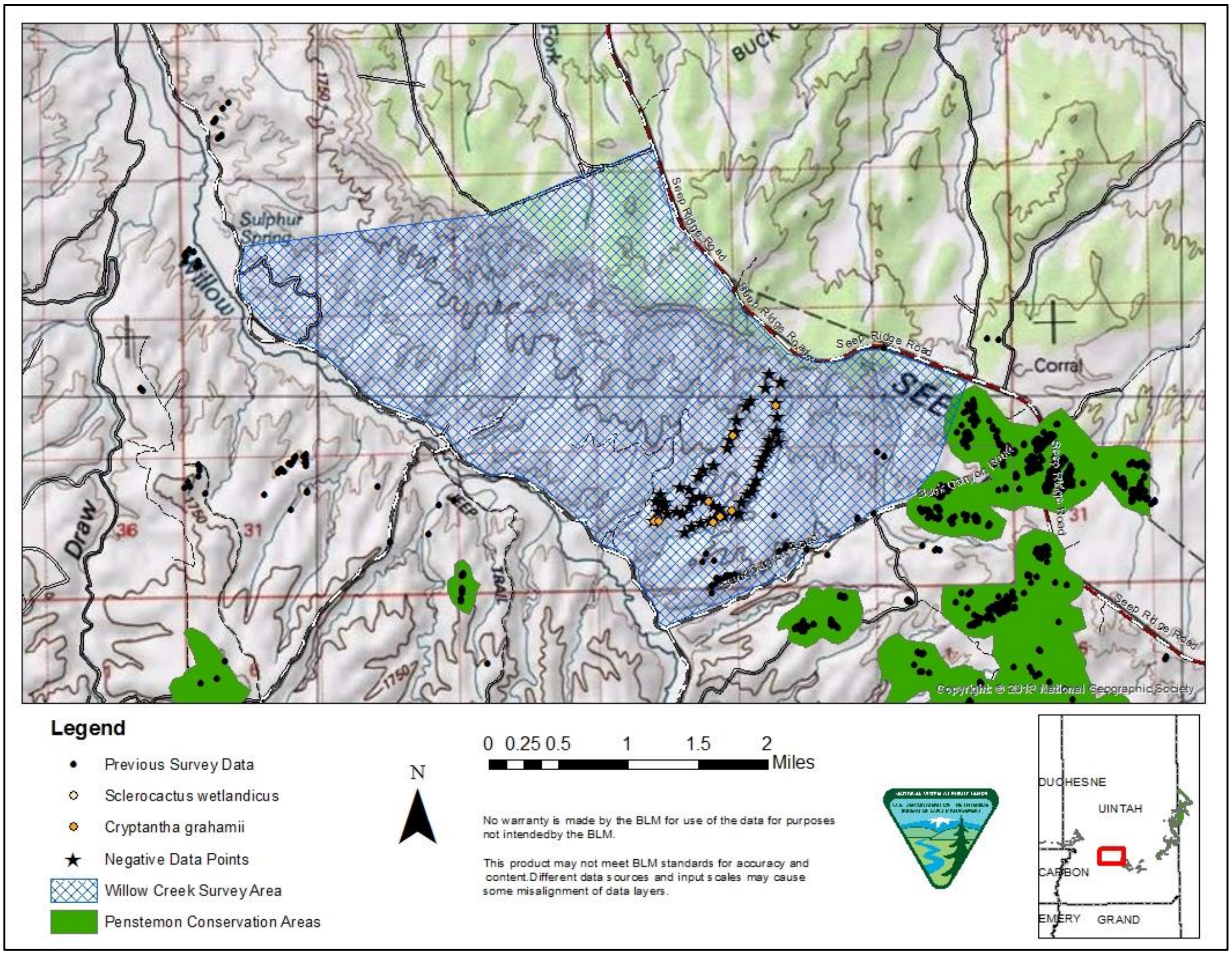

Figure 4. Map of Willow Creek North survey area. Light yellow dot represents three *Penstemon grahamii* individuals relocated during surveys. Black dots represent existing data, and black stars indicate negative data points.

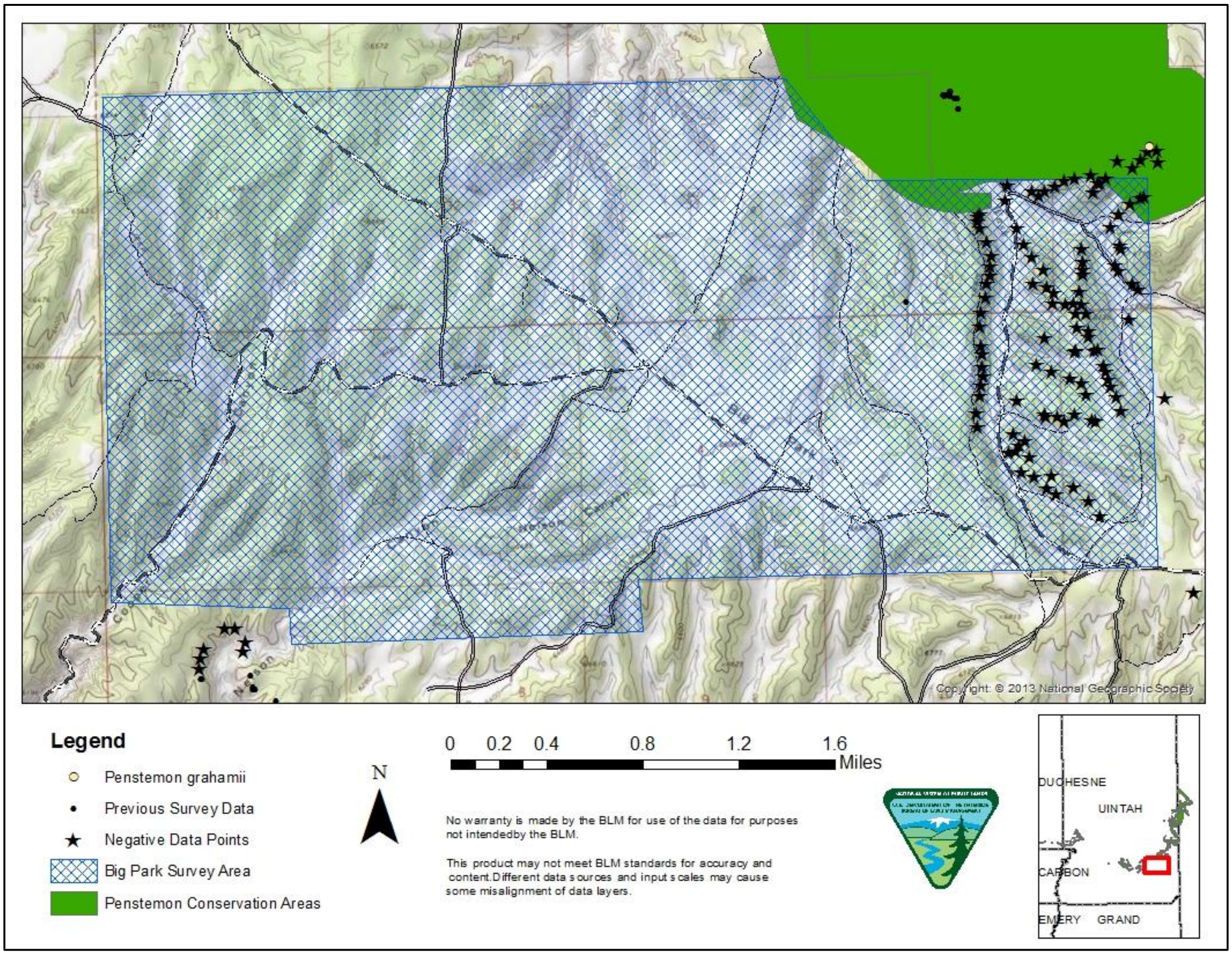

Figure 5. Map of the Big Park survey area. Colored dots indicate plants found, and black dots indicate existing data. Stars represent negative data in suitable habitat.

APPENDIX C

Penstemon grahamii Demographic Monitoring Summary at Raven Ridge/Mormon Gap

Penstemon grahamii – Demographic Monitoring Summary at Raven Ridge / Mormon Gap

Produced by: Phillip Krening

Conservation Specialist

BLM – Colorado State Office

1. Introduction –

The Mormon Gap population of Graham's Penstemon (*Penstemon grahamii*) at Raven Ridge has been the focus of various monitoring efforts since 1986. The population is the most studied population of *P. grahamii* in Colorado due to its relatively large size and accessibility.

The Mormon Gap population occupies characteristic *P. grahamii* habitat consisting of exposed Parachute Creek member of the Green River Formation near the eastern extent of the species known global range of distribution (Figure 1). Raven Ridge contains the majority of *P. grahamii* habitat on public land in Colorado. The entirety of the ridge is contained in the 4,980-acre Raven Ridge Area of Critical Environmental Concern (ACEC) which was established in 1985 and subsequently expanded in 1997.

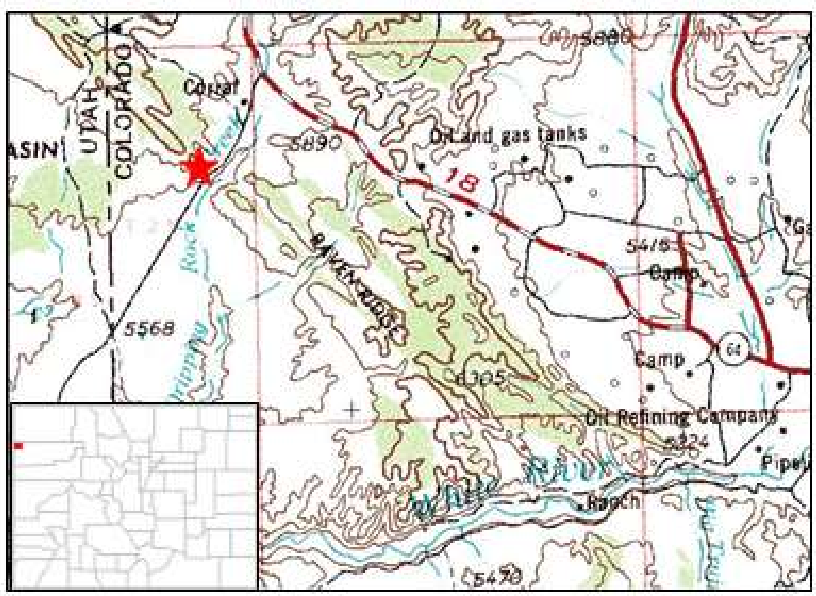

Figure (1C) Topographic map showing the location of Raven Ridge in Colorado. The red star marks the locality of Colorado monitoring site.

Figure 1. Location of Raven Ridge / Mormon Gap monitoring location.

2. Monitoring History –

Monitoring was initially established by the Bureau of Land Management (BLM) at the Mormon Gap *P. grahamii* population in 1986. Monitoring was completed as part of a multi-species monitoring effort focused on seven sensitive plant species found in the area. The original study design consisted of three gridded macroplots of varying sizes located at distinct *P. grahamii* population clusters on Raven Ridge. Plants were tagged and census counts were taken of each plot in order to determine mean density. Monitoring was completed annually from 1986 through 1990 when it was discontinued.

In 2005 the BLM reinitiated long-term monitoring at Plot 5 (North Unit South at Mormon Gap) location from the original study that concluded in 1990. The 2005 BLM study consisted of the original 20m x 35m (700m^2) macroplot. A census of the plot was taken in 2005 and 2008. All plants were tagged and their x/y coordinates recorded.

In 2009 the macroplot was divided into 20 1m x 35m transects and power analysis was performed in order to obtain statistical meaningful sampling results. Sampling has occurred annually since 2009 with the exception of 2013. Current methodology follows:

3. Methods –

The demographic monitoring methods summarized here were adapted from the BLM technical references *Measuring and Monitoring Plant Populations* (Elzinga et al., 1998) and the *Monitoring Manual for Grassland, Shrubland, and Savanna Ecosystems* (Herrick et al., 2005). Methods were selected to efficiently provide robust data. Monitoring is designed to determine if populations are increasing, decreasing, or stable by comparing differences in mean density. Understanding the demography and trend of these populations can then be used to inform land management decisions aimed at reducing or eliminating threats to the species and minimize the likelihood of, and need for, listing under the ESA (BLM, 2008).

3.1 Sample Design:

Permanent sample units are preferred in monitoring long-lived perennial species especially when plants may exhibit unknown levels of dormancy (Elzinga et al., 1998; McCaffrey, 2013). Permanent sampling units should be used whenever possible due to their advantage in requiring fewer samples than temporary sampling units and being much more statistically robust when conducting analysis. This thereby increases the power of the data and increases monitoring efficiency.

3.2 Field Establishment and Data Collection Procedure:

Permanent sampling units were established within macroplot in 2009. In order to limit observer bias, transect locations were selected within the plot using a restricted random method (Elzinga et al., 1998). Ten-inch steel stakes are placed in the middle and at both ends of each transect. Where transect length exceeds 25 meters quarter points were established to ensure the accuracy of data collection. In order to accurately detect and document important recruitment and disturbance events monitoring is conducted on a yearly basis.

All plants within each 1 meter transect belt are tagged with an 8” nail and numbered aluminum tag in order to relocate individuals from year to year. X / Y coordinates are recorded in order to assist with relocation. All plants within each 1 meter transect belt are counted to determine mean density. Population trend is determined by calculating changes in mean density between and across years.

In order to address questions related to the life history of the species demographic metrics are recorded on an annual basis for each marked plant. Demographic metrics include but are not limited to:

reproduction, recruitment, and longevity of individuals. All plants falling within transects are counted and the number of vegetative and reproductive rosettes per plant documented. Other demographic metrics may be recorded including: number of inflorescences per plant/stem, flowers per inflorescence. The total diameter of rosettes may be recorded in addition to notes indicating evidence of browsing or herbivory and general condition of the plant.

3.5 Power Analysis:

Two years of data are required in order to preform sample size calculations. The number of sampling units within the macroplot will be adjusted during the third year of monitoring to accommodate the necessary number of samples required to obtain statistically meaningful results. The calculation used to determine the necessary number of samples to detect a specified amount of change in plant density between two time periods using permanent sample units is:

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

Where n is the necessary number of transects needed to detect a specified amount of change between two samples according to a specified power (Elzinga et al., 1998). Calculations are performed to meet a sampling objective that maximizes statistical power (≥ 0.8) of detecting at least a 20% absolute 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:

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

3.6 Landscape Level Power Analysis:

In order to extrapolate our results to the landscape level and understand range-wide trends a power analysis should be completed to determine the number of monitoring plots required to detect meaningful changes at the landscape level. Due to the permanent nature of our plot design the calculation for power analysis is the same for determining the necessary number of samples from within a macroplot (Herrick et al., 2005). No correction factor is applied due to the fact that we are sampling < 5% of the total species population.

3.7 Statistical Analysis:

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

Landscape level trends are determined by assessing the mean change in plant density across all monitoring plots between years.

All statistical transformations can be completed using Microsoft Excel.

4. Results –

Due to methodological differences, our ability to make direct comparisons between the original monitoring study (1986 – 1990) and the more recent data (2005 – 2016) is limited.

Based on the best available data, the Mormon Gap *P. grahamii* monitoring site (Site 5) exhibited a stable to increasing population trend between 1986 and 2012. Between 1986 and 1990 there were an average of 159 rosettes per monitoring year compared to an average of 185 rosettes during the five monitoring years that occurred between 2005 and 2012. While interannual variability in the number of rosettes is evident during this timeframe it appears that the population remained relatively stable during this 26 year period.

Between 2012 and 2014 (monitoring did not occur in 2013) the population experienced a significant decrease $t(14) = 9.16$, $p < 0.01$ in mean rosette density. This dramatic decrease has been attributed to a large number of livestock trailing through the population. Evidence of the disturbance was documented upon visitation to the site for monitoring in 2014.

Monitoring data from 2015 illustrated that the population was showing signs of recovery. We documented a significant increase $t(14) = 5.25$, $p < 0.01$ in mean rosette density between 2014 and 2015. Despite this increase, rosette density remains well below historical levels.

In 2016, annual monitoring took place at Raven Ridge in late August. Rosette density of *Penstemon grahamii* at this site is still below the 2005 level. At this time, discerning what environmental drivers may be affecting population dynamics at the Raven Ridge site remains a difficult task. In tracking the fates of the individual tagged plants since 2005, there may be evidence of prolonged dormancy (Lesica & Steele, 1994; McCaffrey, 2013). It appears that some plants may have disappeared for a year or two, then reappeared. Plans for 2017 are to continue the long-term demographic study, with a focus on determining if prolonged dormancy is a factor in our analysis of the life – history of this species.

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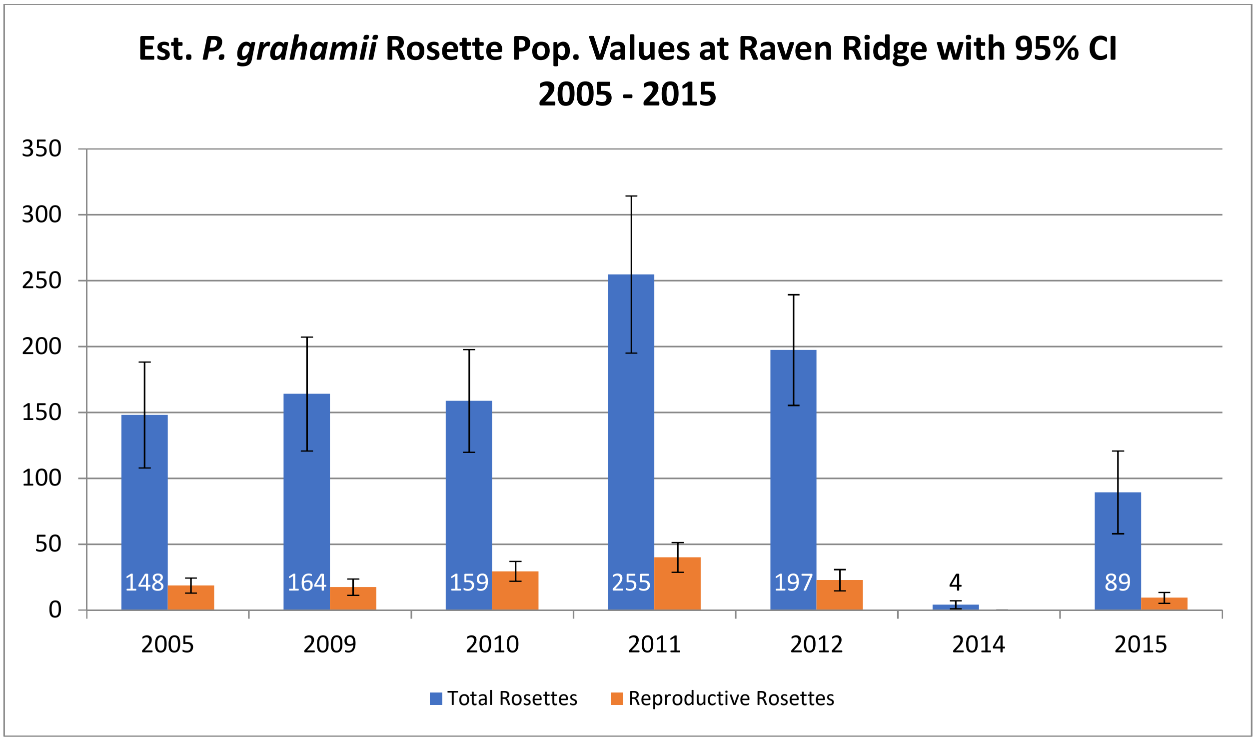

Figure 2. Total *P. grahamii* rosette estimates from the Raven Ridge / Mormon Gap study site 2005 – 2015.

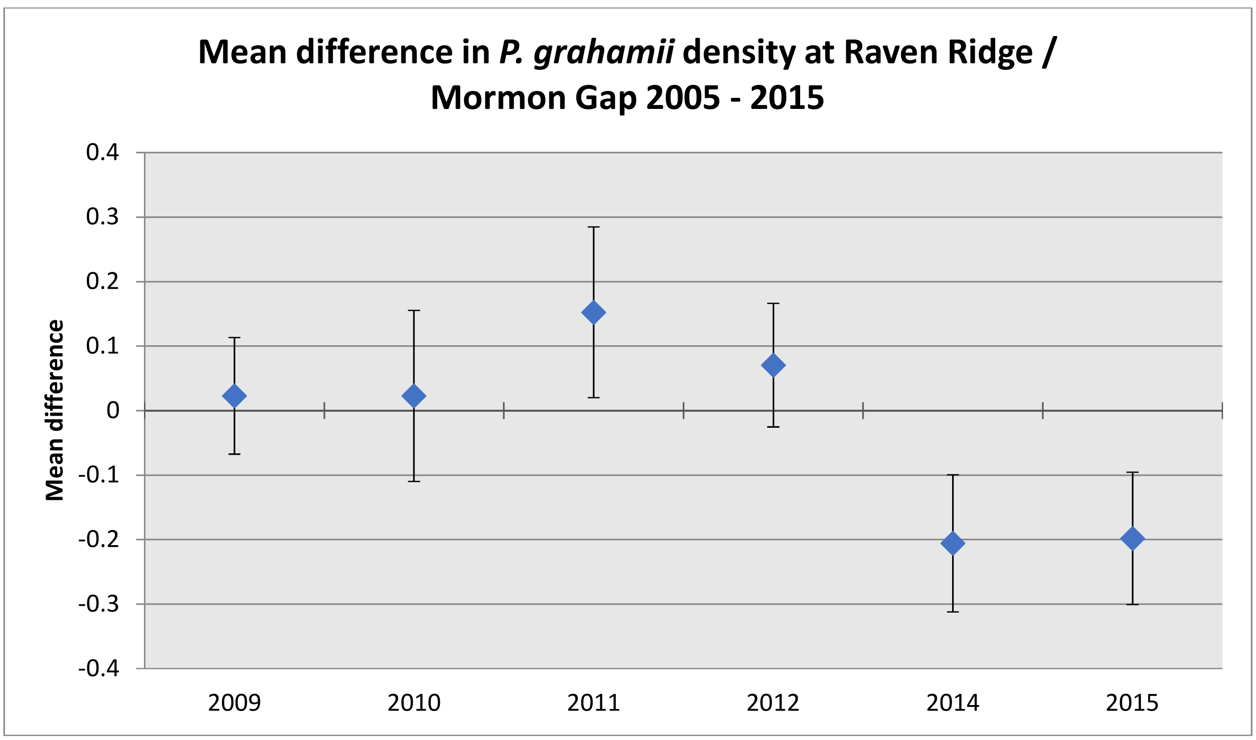

Figure 3. Mean difference in *P. grahamii* rosette density at Raven Ridge / Mormon Gap 2005 – 2015.

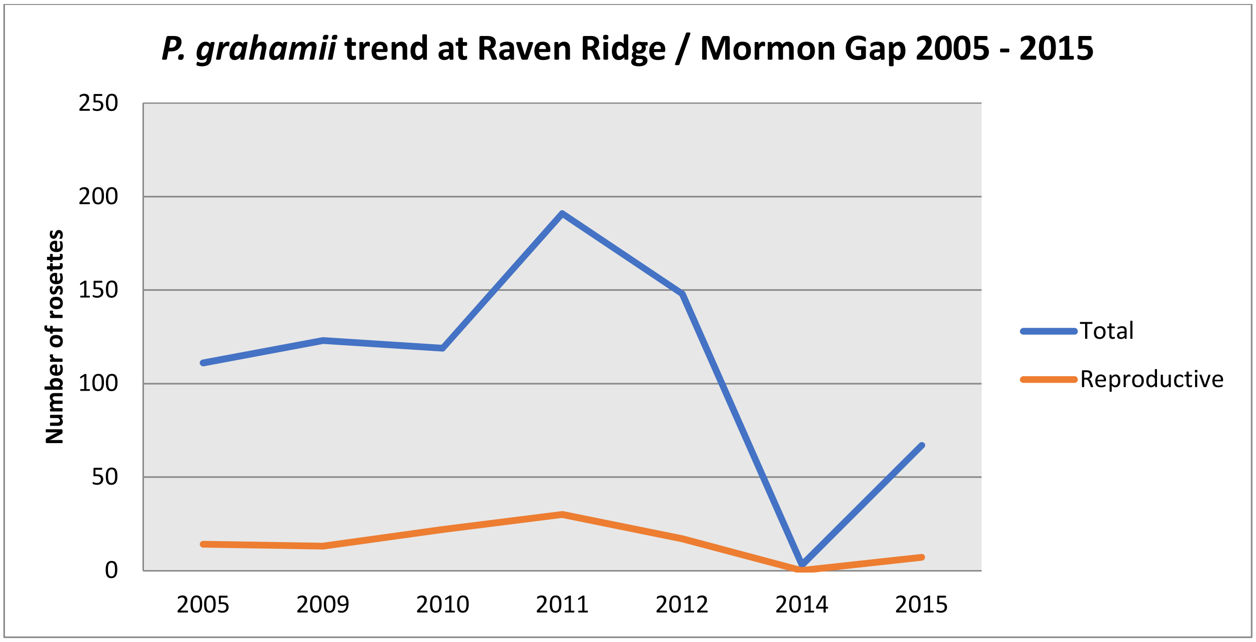

Figure 4. Population trend of *P. grahamii* rosettes at the Raven Ridge / Mormon Gap study site 2005 – 2015.

APPENDIX D

Molecular Characterization of White River Beardtongue *Penstemon scariosus* var. *albifluvis*

Performance Report
For the Period July 1, 2015 through August 31, 2016

Agreement Number: L14AC00346

Title: BLM VFO Molecular Characterization of White River Beardtongue, *Penstemon Scariosus* var. *albifluvis*

Recipient Organization: Brigham Young University

Recipient Principal Investigator/Project Manager: Mikel R. Stevens

Date of this Report: September 23, 2016

Submitted by: Mikel R. Stevens

A. <u>Goals and Accomplishments</u>

Abstract:
This summary report is of what we have, and are still learning regarding *Penstemon scariosus*, with a focus on the variety *albifluvis*. Using our molecular markers developed for this study we found evidence that the traditional *P. scariosus* var. *albifluvis* may need to be returned to its original species taxonomic designation of *P. albifluvis*. It also must be pointed out that the broader *Penstemon scariosus* study is still on going. During the 2015 year of analyzing our data we discovered a putative *P. scariosus* population near Tabiona, Utah which was clearly unique by both measuring its morphological characteristics and with our molecular markers. Because we were so unsure of that unusual find we deliberately withheld those samples from the remaining samples used to arrive at the study results we are reporting here. Initially, we were concerned that there was an error in with the Tabiona samples. During the 2016 field season we returned to that region and collected well over an additional dozen sample locations and also collected additional population locations of *P. gibbensii* from across Wyoming and Colorado to assist us in our understanding of the Tabiona genotype in relationship to *P. scariosus* complex. These additional samples are being molecularly and statistically analyzed now. We believe we will be able to develop a scientifically peer reviewed paper later this year or early next year which will discuss the results reported here in context with what we are discovering now. During this study we also found that *P. fremontii* var. *glabrescens* should be a distinct species which we named *P. luculentus.*

Taxonomic Clarification of two *Penstemon* Species of the Uinta Basin of Colorado and Utah

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Brigham Young University, Provo, UT

Introduction:

Noel Holmgren and others have stated that "*P. scariosus* exhibits a complex range of variability" (Holmgren, 1984; Neese and Atwood, 2008). Although, Neese and Atwood (2008) stated that variety *albifluvis* is more distinct than the three other reported members of this species. Curiously, it was originally described as a distinct species (England, 1982); however, in 1984 Noel Holmgren listed it as a variety of *P. scariosus* (Holmgren, 1984).

Variety *albifluvis* is found almost exclusively on the oil shale ledges of the Green River Formation. In the last few years, there has been an ever increasing interest in recovering the oil found in those formations (Robinson, 2007). Because of its unique limited habit and the increasing interest to recover the hydrocarbons found in this Green River Formation it was considered a candidate species for listing as an endangered species under the Endangered Species Act of 1973 (Ashe, 2013). To illustrate the potential clash between the oil shale recovery efforts and the preservation of *P. scariosus* var. *albifluvis* one only need to drive along Dragon Road south of Bonanza, UT (see photos of the exact opposite sides of the dirt road, Fig. 1A&B).

Collecting *Penstemon* for Study:

Early summer 2013 we initiated a study of *P. scariosus* by sampling tissue of eight unique plants from multiple locations across the range of the species (see Fig. 2). Early spring 2014 we searched multiple herbarium databases where we found records suggesting that *P. scariosus* geographic range was mildly larger than we had previously thought. In the Brigham Young University S. L. Welsh Herbarium samples, we found several curious *Penstemon* specimens labeled as *P. scariosus*. These specimens were from Piceance Basin, Colorado. The specimens were unusual for a couple of reasons. First, they were somewhat outside the well-documented range of *P. scariosus*; and, second, although they keyed out to *P. scariosus* using A Utah Flora, the specimens had hirtellous stems, a trait not found in *P. scariosus*. These observations were enough to have us include the Piceance Canyon region in our planned collections. We concluded that if these plants were indeed part of the *P. scariosus* complex they needed better characterization.

In addition to the unique Piceance Canyon population we also found several other populations of *P. scariosus* in Wyoming which we were unaware of. However, one new record of a *P. scariosus* population was unusual in that it was reported to be on the Book Cliffs ridge in Grand County, Utah. These old herbarium records were about 20 miles south of all known *P. scariosus* var. *albifluvis* populations. Furthermore, there were no other records of any other *P. scariosus* in over 50 miles of this putative remote population. Late June 2014 we collected one reblooming sample from this population and it keyed out as *P. scariosus* var. *albifluvis*.

We essentially completed our *P. scariosus* complex sample collections late spring and early summer 2014. We were assisted with the collections of *P. scariosus* var.

albifluvis by individuals connected with the BLM Vernal, UT office. In total, we collected material from 17 field locations of *P. scariosus* var. *albifluvis*, 8 of *P. scariosus* var. *cyanomontanus*, 25 of var. *garrettii*, 9 of var. *scariosus*, and 11 locations of the unusual *Penstemon* found in Piceance Canyon, Colorado.

To gain an improved understanding of the extent of the Book Cliff *P. scariosus* var. *albifluvis* population(s) we returned to that location in early June 2015. Following which we continued searching, wherever legally possible, for additional remote locations of this taxon across the entire range of the Book Cliffs. We were able to conduct an extensive survey along the Utah and Colorado Book Cliffs ridge for *P. scariosus* with the assistance of four BYU undergraduates and a small grant from Uinta County, Utah and Rio Blanco County, Colorado. In our search we found that the Book Cliffs *P. scariosus* var. *albifluvis* population extended along the ridge in Grand County, Utah, mostly on southern exposures with a few plants scattered on the very top of the ridge for approximately three air miles. Thousands of plants were found in a narrow band (from a few feet wide to upwards to ~100 ft. at the widest point) along a Green River shale geological formation for that distance. This geology is very similar to where this taxon has historically been found to occur, at lower elevations closer to the White River. We did not expect the population on the Book Cliffs to be so extensive. However, that was our only discovery of new/expanded *P. scariosus* var. *albifluvis* populations. For the remaining four days we searched, with no avail, on accessible sites following the Book Cliffs to their eastern terminus north of Rifle, Colorado. The only population of *P. scariosus* var. *albifluvis* encountered remained those already described above. The results of our search does not mean that there are no new populations to be discovered in this region. There may be populations on private land or tribal land where we were unable to access or on difficult to access public lands. However, it should also be noted that we did find habitat that looked to be ideal for *P. scariosus* var. *albifluvis* in several locations but when searched there were no plants found.

Clues of a Misclassified *Penstemon*:

After studying all of our Piceance Canyon samples morphology we realized that it was indeed unique compared to *P. scarious*. Furthermore, we learned that it had already been described as *P. fremontii* var. *glabrescens* (Dorn and Lichvar, 1990). However, this clarification came as a surprise in that we found *P. fremontii* var. *fremontii* within less than 100 yards of populations of variety *glabrescens* in Piceance Canyon. We were never able to locate any identifiable hybrids between the two taxa and they were easily distinguishable by their morphological characteristics. Moreover, their overall morphology reminded us more of *P. scariosus*, which is why it is not surprising that the BYU herbarium samples were identified as *P. scariosus* by their collectors rather than a variety of *P. fremontii*. Thus, with all these discoveries in mind we concluded that this taxon needed better characterization. Consequently, we decided to utilize our molecular tools to study this taxon (*P. fremontii* var. *glabrescens*) along with our *P. scariosus* samples.

***Penstemon* DNA "Fingerprinting":**

To best explain how we approached the DNA molecular studies of our samples we will use the analogy of "fingerprinting." That is, like human fingerprints, each individual plant has its own unique DNA "fingerprint" which can be studied. However, this "fingerprinting" analogy breaks down when we learn that it is impossible to tell who the parents of person are by comparing the fingerprint of a child to that of her parents, because, a fingerprint pattern is not inheritable. There simply is not a way to identify a family relationship by comparing the parents and their child's fingerprints. On the other hand, we can readily identify genetic relationships using DNA since we inherit half of our DNA "fingerprint" from our mother and the other half from our father. Therefore, our unique DNA "fingerprint" is an exclusive combination of half of our mothers DNA "fingerprint" and half or our fathers molecular "fingerprint."

The DNA "fingerprinting" technology we choose to develop and use in our *P. scariosus* study (Anderson et al., 2016; Johnson et al., 2016) is the same methodology used by the court system which can precisely demonstrate that the person was the perpetrator of a crime. It is also the same method that can be used to determine the paternity (father) of a person. There are two names which are used for this common molecular "fingerprinting" methodology, one name is, simple sequence repeats (SSRs), and the other name is "microsatellites." Each SSR (microsatellite) is a short DNA sequence found at a reliably specific location on a chromosome. The way we identify any given microsatellite, without error, is using a molecular biology laboratory procedure called a PCR (polymerase chain reaction). When we use the PCR procedure under the correct conditions, the resulting DNA fingerprints are relatively quickly deciphered when interpreted by someone trained in the field.

The first question we addressed in our DNA fingerprinting studies was the suspicious relationship between *P. fremontii* var. *fremontii* and variety *glabrescens*. Finding these two taxa, living within yards of each other, with no apparent hybrids between the two, as well as being able to readily morphologically distinguish between them, allowed us to set up a testable scientific hypothesis.

Study of the *P. fremontii* Varieties:

We learned that there is not a close genetic relationship between *P. fremontii* var. *fremontii* and var. *glabrescens*. Or for that matter, *P. fremontii* var. *glabrescens* is not closely related to any other suspected *Penstemon* of the region. Using our SSR fingerprint data as support, as well as our morphological observations, we concluded that this taxon should be considered a species in its own right. We presented the statistical results of all of our molecular studies, as well as a map, and related background information regarding the redefinition of this interesting taxon in a recently publish paper (Johnson et al., 2016). Because the name *P. glabrescens* has already been used for a *Penstemon* in southern Colorado and northern New Mexico we cannot elevate the variety name to a species for this taxon's name (Pennell, 1920). Therefore, we renamed it *P. luculentus*. This name is derived from the Latin word for "*luculentus,*" meaning brilliant or bright. The name was chosen to reflect the brilliant blue flower color, which is particularly striking in the field in contrast to the whitish or tan shale background typically associated with this species (Fig. 3A&B).

Results of the Study of the *P. scariosus* Complex:

Once we determined that *P. fremontii* var. *glabrescens* needed to be described as a distinct species we turned our attention to understand how various populations of the *P.*

scariosus complex were related to each other. Since the majority of our funding focus was on improving our understanding of the genetic diversity of *P. scariosus* var. *albifluvis* we secured samples at more sites across a smaller geographic range than the other members of the *P. scariosus* complex. However, our study did include samples from the known perimeter of *P. scariosus* along with samples interlaced throughout its range (Table 1; Fig. 2, 4, and 5).

Once securing our tissue samples we initiated the molecular and data analysis aspects of the study. We found that there were no clear delineations between varieties *cyanomontanus*, *garrettii*, and *scariosus*. That is, using the SSRs molecular markers, we could not find distinctive genetic population alignments with the present variety definitions with any sort of statistical confidence and the recognitions of var. *cyanomontanus* is questionable. Our data clearly agree with what Holmgren (1984) specifically suggested about distinguishing a variety with *cyanomontanus* morphological characteristics as a taxon was questionable. However, the SSR marker results clearly suggest that *P. scariosus* var. *albifluvis* is statistically more distinct from the rest of the *P. scariosus* complex. Our results also suggest that its closest relative may be *P. scariosus* accessions north of Roosevelt, Utah (Fig. 2 [sample #36]). Nevertheless, it is rather distinct compared to the rest of *P. scariosus*. However, even with these finding being so clear we are collaborating with Andi Wolfe, a recognized *Penstemon* authority from Ohio State University, to evaluate these same samples with a much more comprehensive molecular marker technique to see if these new test collaborate our results. When we complete both molecular testing methods, we are working on now we will prepare one, or more, manuscript(s) for peer review and publication in reputable scientific journal(s). It should be pointed out that in 2016 we collected very compelling evidence that there may be a new taxon that has traditionally been classified as either var. *garrettii* or var. *scariosus* in the region of Tabiona, UT. We have now collected many samples from a number of populations of these unusual *Penstemon* and their data will be included in future analysis of *Penstemon scariosus* and publications of those results.

To better visualize what we learned about the *P. scariosus* complex from our SSR marker data which we collected from 2013-15 we have created a map where each *P. scariosus* collection location is represented as a pie chart of the percent of shared, or distinctive aspects of their genetic relationships (Fig. 2). When comparing all of our samples to the presently named four varieties of *P. scariosus* we can statistically identify three related “groups” with significantly different genetic “fingerprints.” We assigned a color to each of those three groups (red, green, and blue [Fig. 2]). Using this visualization method, it becomes evident when studying this map that *P. scariosus* var. *albifluvis* is distinctive (the mostly green pie charts [Fig. 2]), both with its molecular fingerprint and its geographic isolation. We again performed the same statistical method (STRUCTURE) analyzing strictly the *P. scariosus* var. *albifluvis* accessions (Fig. 4) and a separate STRUCTURE analysis of the remaining *P. scariosus* samples (Fig. 5). The results of those analysis assisted us in “teasing out” a more refined understanding of the population genetic structures of the non *P. scariosus* var. *albifluvis* samples collected in 2013-15.

The dendrogram (Fig. 6) of our preliminary analysis clearly suggest that all varieties of *P. scariosus* and *P. gibbensii* are related to each other. Using the data that we have generated and analyzed thus far suggest that var. *albifluvis* is most closely related to var. *scariosus* and the southwestern accessions of var. *garrettii.* Variety *albifluvis* is more distantly related to the more eastern accessions of var. *garrettii*, all of var. *cyanomontanus* and *P. gibbensii* (Table 1 and Fig. 5). Additionally, our data suggest that there is a lower level of genetic diversity within var. *albifluvis* than the amount of diversity found within and between the three remaining putative varieties of *P. scariosus* (Fig. 2 and 5).

We are in the midst of a study of revisiting the question of how to use morphological characteristics to see if we can accurately distinguish between the historically defined remaining three varieties of the *P. scariosus* complex. If we are successful, in finding more definitive, than the presently used morphological plant characteristics, it would allow us to recommend a revision of the descriptions of the apparent varieties within *P. scariosus*. Our objective is to find morphological characteristics that more accurately reflects the results of our molecular study.

Finally, we should report on the identification of the unusual accessions we have collected in 2016 near Tabiona, UT. These samples are identified in the field by the fact that mature plants are rather robust, both in their leaf, and flower size, compared to the var. *garrettii* of the region. Because the "unknown" does key out to be *P. scariosus* it is a prominent hypothesis of ours that it may indeed be a member of *P. scariosus*; however, if it is a *P. scariosus*, it may be independent of all presently identified members of the species. We have collected over 15 accessions of this "unknown" *Penstemon* from the Red Creek area east of Fruitland on the southwestern corner to the community of Strawberry, UT on the southeastern corner to several miles east of Tabiona on northeastern corner and up all the canyons surrounding both Tabiona and Hanna, UT on the northwestern corner. At this time, we are unclear as to the true edges of this "unknown." All of the "unknown" samples have a very similar morphological appearance and a molecular marker fingerprint. We are working on the further understanding of the uniqueness of this new "unknown" *Penstemon*. We believe that the reason for this new "unknown" being previously overlooked is twofold. First, it clearly keys taxonomically out to be *P. scariosus* and second, it appears to be a very narrow endemic of the geography described above.

Conclusion:

Using multiple herbarium records, we were able to delineate where *P. scariosus* has been found historically. We drove thousands of miles and walked for many hours collecting samples from over 70 locations for genetic comparison. The study of the herbarium records and field samples led to the discovery of an important population of *P. scariosus* var. *albifluvis*, a problem with the classification *P. fremontii* var. *glabrescens* that suggested a need to be more carefully studied, and the discovery of a potentially new "unknown" *Penstemon* taxon. For this study we developed a special set of *Penstemon* SSR markers to study *P. scariosus* and *P. fremontii* DNA fingerprints which we published in a peer reviewed journal using solely undergraduate students (Anderson et al., 2016). Using these markers we found evidence that the traditional *P. scariosus* var. *albifluvis* may need best be treated as its original taxonomic designation of *P. albifluvis* (England, 1982). We also found that *P. fremontii* var. *glabrescens* (Dorn and Lichvar, 1990) was a distinct species which we named *P. luculentus.* We accomplished that study and published that peer reviewed article with the same undergraduates (Johnson et al., 2016). We are now working to identify how *P. scariosus*, *P. albifluvis*, *P. gibbensii*, and the new “unknown” *Penstemon* are all related to each other.

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Figure 1A. *Penstemon scariosus* var. *albifluvis* is found among the brush and in the open areas on the east side of the road. Finding this plant so close to the edge of a road is unusual.

Figure 1B. Directly opposite of Fig. 1A (west side of road) is an oil shale research site. Note, that we expanded the view of the sign in the lower right of the photo so that it can be more easily read.

Figure 2. This map is of the northeastern corner of Utah and adjacent areas in Wyoming and Colorado (note the US location in lower left panel of the figure). The individual colored pie charts are where our 2013-2015 sample collections were made. These collections also represent the reported range of what has been described as *Penstemon scariosus*. The colors of the pie charts represent the percent of genetic diversity which we found in our study. The region outlined in black is considered to be where *P. scariosus* var. *albifluvis* is to be found. The region outlined in green is considered to be where *P. scariosus* var. *cyanomontanus* is to be found. The region outlined in blue is considered to be where *P. scariosus* var. *garrettii* is to be found. The region outlined in red is considered to be where *P. scariosus* var. *scariosus* is to be found. The key to each accession sample number is found in Table 1. Note that the green pie charts are essentially geographically isolated from all other *P. scariosus*.

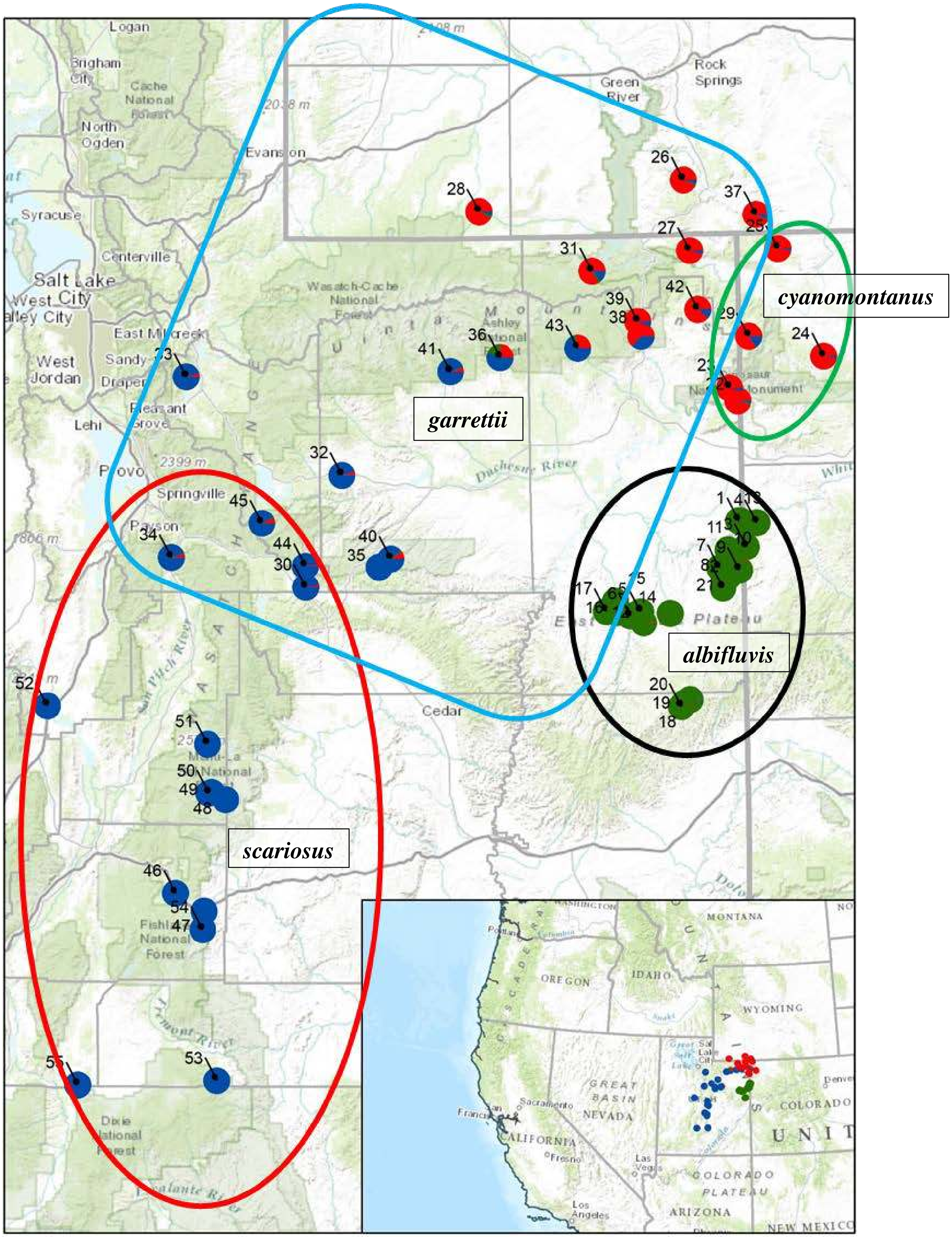

cyanomontanus
garrettii
albifluvis
scariosus
Logan
Brigham City
Cache National Forest
North Ogden
Evanston
Syracuse
Centerville
Salt Lake City
West Valley City
East Millcreek
Sandy
Draper
West Jordan
Lehi
Pleasant Grove
Provo
Springville
Payson
Green River
Rock Springs
Wasatch-Cache National Forest
Uinta Mountains
Ashley National Forest
Duchesne River
Dinosaur National Monument
Cedar
Fishlake National Forest
Fremont River
Dixie National Forest
Escalante River
San Pitch River
Manti-La Sal National
MONTANA
OREGON
IDAHO
WYOMING
GREAT BASIN
NEVADA
CALIFORNIA
COLORADO
COLORADO PLATEAU
ARIZONA
NEW MEXICO
Portland
Sacramento
Fresno
Las Vegas
Los Angeles
Denver

Figure 3A. This photo represents a typical population of *Penstemon luculentus* (formally *P. fremontii* var. *glabrescens*) in the habitat where it is regularly found in Piceance Basin. The "brilliant" or "bright" blue blossoms against the tan shale background are normal for this species. Populations of this species can be found frequently along Highway 5 which takes off Highway 13 to enter the top of Piceance Canyon about 20 miles north of Rifle, CO.

Figure 3B. A close up photo of blossoms of *Penstemon luculentus* (formally *P. fremontii* var. *glabrescens*).

Table 1. The *Penstemon scariosus* samples and their identifications used in this study and their mapping coordinates.

STRUCTURE ID[a]	Sample ID[b]	Location Name	Longitude	Latitude	Variety
1	Museum238757	East of Bonnanza, Uinta Co., UT, USA	-109.0685106	40.0358374	*albifluvis*
2	SCA014	Southeast of Bonnanza, Uinta Co., UT, USA	-109.0994667	39.8990500	*albifluvis*
3	CO-01	Bayless Pad Site, Uinta Co., UT, USA	-109.0370278	39.9480278	*albifluvis*
4	CO-02	(Finger Ridge) Bunte Point, Uinta Co., UT, USA	-108.9898513	40.0278961	*albifluvis*
5	UT-01	Buck Canyon, Uinta Co., UT, USA	-109.503127	39.7370932	*albifluvis*
6	UT-02	Willow Creek, Uinta Co., UT, USA	-109.547829	39.7234258	*albifluvis*
7	UT-03	Watson, Uinta Co., UT, USA	-109.1568024	39.8794561	*albifluvis*
8	UT-04	Atchees Ridge, Uinta Co., UT, USA	-109.1428611	39.8122222	*albifluvis*
9	UT-05	Rabbit Mount/Dragon RD, Uinta Co., UT, USA	-109.0700556	39.8707778	*albifluvis*
10	UT-06	No Name, Uinta Co., UT, USA	-109.0909722	39.9028611	*albifluvis*
11	UT-07	Hells Hole Road, Uinta Co., UT, USA	-109.1169167	39.9397500	*albifluvis*
12	UT-08	Sunday School, Uinta Co., UT, USA	-109.4903486	39.6996887	*albifluvis*
13	SWCA-01	White River North, Uinta Co., UT, USA	-109.0614922	40.0360149	*albifluvis*
14	SWCA-02	Bitter Creek, Uinta Co., UT, USA	-109.3742796	39.7297946	*albifluvis*
15	SWCA-03	Willow Creek, Uinta Co., UT, USA	-109.6115463	39.7742903	*albifluvis*
16	SWCA-04	Upper Agency Draw, Uintah Co., UT, USA	-109.6055909	39.7355881	*albifluvis*
17	SCA029	Along JP Man RD, Uinta Co., UT, USA	-109.65245	39.7397833	*albifluvis*
18	SCA036	Book Cliffs Ridge, Grand Co., UT, USA	-109.29595	39.4395833	*albifluvis*
19	SCA052	Book Cliffs Ridge, Grand Co., UT, USA	-109.32149	39.4273100	*albifluvis*
20	SCA053	Book Cliffs Ridge, Grand Co., UT, USA	-109.33345	39.4163200	*albifluvis*
21	SCA054	Along Dragon RD, Uinta Co., UT, USA	-109.11768	39.8505400	*albifluvis*
22	SCA009	Blue Mountain, Uinta Co., UT, USA	-109.06105	40.4383333	*cyanomontanus*
23	SCA010	Blue Mountain, Uinta Co., UT, USA	-109.09585	40.4820833	*cyanomontanus*
24	SCA011	Along Douglas MT RD, Moffat Co., CO, USA	-108.6786833	40.5811167	*cyanomontanus*
25	SCA012	Diamond Peak, Moffat Co., CO, USA	-108.86855	40.9457667	*cyanomontanus*
26	SCA040	North of Little Mountain Peak, Sweetwater Co., WY, USA	-109.2810333	41.1828833	*garrettii*

STRUCTURE ID[a]	Sample ID[b]	Location Name	Longitude	Latitude	Variety
27	SCA043	Goslin Mountain, Daggett Co., UT, USA	-109.2597667	40.9456833	*garrettii*
28	SCA044	North of Lone Tree, Uinta Co., WY, USA	-110.1887	41.0861500	*garrettii*
29	SCA047	Oilfield Reservoir area, Moffat Co., CO, USA	-109.00685	40.6541500	*garrettii*
30	SCA008	Price Canyon, Utah Co., UT, USA	-110.9577667	39.8286667	*garrettii*
31	SCA013	South of Manila, Daggett, Co., UT, USA	-109.69263	40.8822500	*garrettii*
32	SCA015	East of Fruitland, Duchesne Co., UT, USA	-110.7992	40.2043500	*garrettii*
33	SCA016	Midway, Wasatch Co., UT, USA	-111.4827	40.5342167	*garrettii*
34	SCA018	Northeast of Birdseye, Utah, Co., UT, USA	-111.5436	39.9272167	*garrettii*
35	SCA034	Argyle Canyon, Duchesne Co., UT, USA	-110.6385333	39.8956333	*garrettii*
36	SCA035	Northwest of Whiterocks, Duchesne Co., UT, USA	-110.1016833	40.5958667	*garrettii*
37	SCA039	Pine Mountain, Sweetwater Co., WY, USA	-108.9625	41.0618167	*garrettii*
38	SCA041	along HWY 191 North of Vernal, Uintah Co., UT, USA	-109.4805833	40.6615000	*garrettii*
39	SCA042	along HWY 191 North of Vernal, Uintah Co., UT, USA	-109.4939	40.7115167	*garrettii*
40	SCA045	Sowers Canyon, Duchesne Co., UT, USA	-110.5871333	39.9226333	*garrettii*
41	SCA046	Southwest of McKune Lake, Duchesne Co., UT, USA	-110.3212333	40.5501333	*garrettii*
42	SCA048	Head of Warner Draw, Uintah Co., UT, USA	-109.2282167	40.7480167	*garrettii*
43	SCA049	Red Cloud Loop, Uintah Co., UT, USA	-109.7607667	40.6246500	*garrettii*
44	SCA050	Cat Peak, Utah/Wasatch Co., UT, USA	-110.9594333	39.8991000	*garrettii*
45	SCA051	Willow Creek Guard Station area, Wasatch Co., UT, USA	-111.1497667	40.0433833	*garrettii*
46	SCA001	Along Meadow Creek, Sevier Co., UT, USA	-111.51715	38.8006667	*scariosus*
47	SCA002	Post Hollow South of Emery, Sevier Co., UT, USA	-111.3941167	38.7402333	*scariosus*
48	SCA004	West of Ferron, Sanpete Co., UT, USA	-111.3036	39.1150167	*scariosus*
49	SCA005	Further West of Ferron, Sanpete Co., UT, USA	-111.36415	39.1406667	*scariosus*
50	SCA006	Further West of Ferron, Sanpete Co., UT, USA	-111.375311	39.1368690	*scariosus*
51	SCA007	West of Orangeville, Sanpete Co., UT, USA	-111.38229	39.3021200	*scariosus*
52	SCA017	North of Scipio, Juab Co., UT, USA	-112.0759167	39.4259833	*scariosus*

STRUCTURE ID[a]	Sample ID[b]	Location Name	Longitude	Latitude	Variety
53	SCA030	South of Grover, Wayne Co., UT, USA	-111.3486667	38.1806500	*scariosus*
54	SCA031	Near Deer Peek South of Emery, Sevier Co., UT, USA	-111.4000333	38.6787833	*scariosus*
55	SCA032	Northeast of Antimony, Piute Co., UT, USA	-111.9275	38.1545833	*scariosus*
56	COM001	Near Spring Canyon, Sevier Co., UT, USA	-111.5487667	38.8608667	*comarrhenus*
57	SCA003	Geyser Peak, Sevier Co., UT, USA	-111.46215	38.5119500	*scariosus*
58	CMP001	Tony Grove, Cache Co., UT, USA	-111.6474	41.9040500	*compactus*
59	CYN001	Tony Grove, Cache Co., UT, USA	-111.6496667	41.9043167	*cyananthus*
60	GIB001	Browns Park, Daggett Co., UT, USA	-109.0498	40.8469833	*gibbensii*
61	STR001	Diamond Peak, Moffat Co., CO, USA	-108.8631333	40.9418333	*strictus*
62	STR002	Black Sulfur Creek area, Rio Blanco Co., CO, USA	-108.48805	39.7663833	*strictus*
63	SUB001	Top of Ferron Canyon, Sanpete Co., UT, USA	-111.375311	39.1368690	*subglaber*
64	SUB002	Near Francis, Summit Co., UT, USA	-111.1703333	40.5610500	*subglaber*

[a] The “STRUCTURE ID” is the number used to identify these samples in Figures 4 and 5.
[b]The “Sample ID” is used to identify these samples in Figure 6.

Figure 4. This map is of the region of the Uinta Basin of Utah and adjacent area of Colorado (it is the expanded area of the green pie charts found in Fig. 2). The individual colored pie charts are where the samples of *P. scariosus* var. *albifluvis* were made. These collections also represent the reported range of what has been described as *Penstemon scariosus* var. *albifluvis*. The colors of the pie charts represent the percent of genetic diversity which we found within only var. *albifluvis* in our study. Note that the green and red pie charts are essentially scattered across region. These preliminary data are suggesting that there are no real genetically unique populations of *P. scariosus* var. *albifluvis*. The key to each accession sample number is found in Table 1.

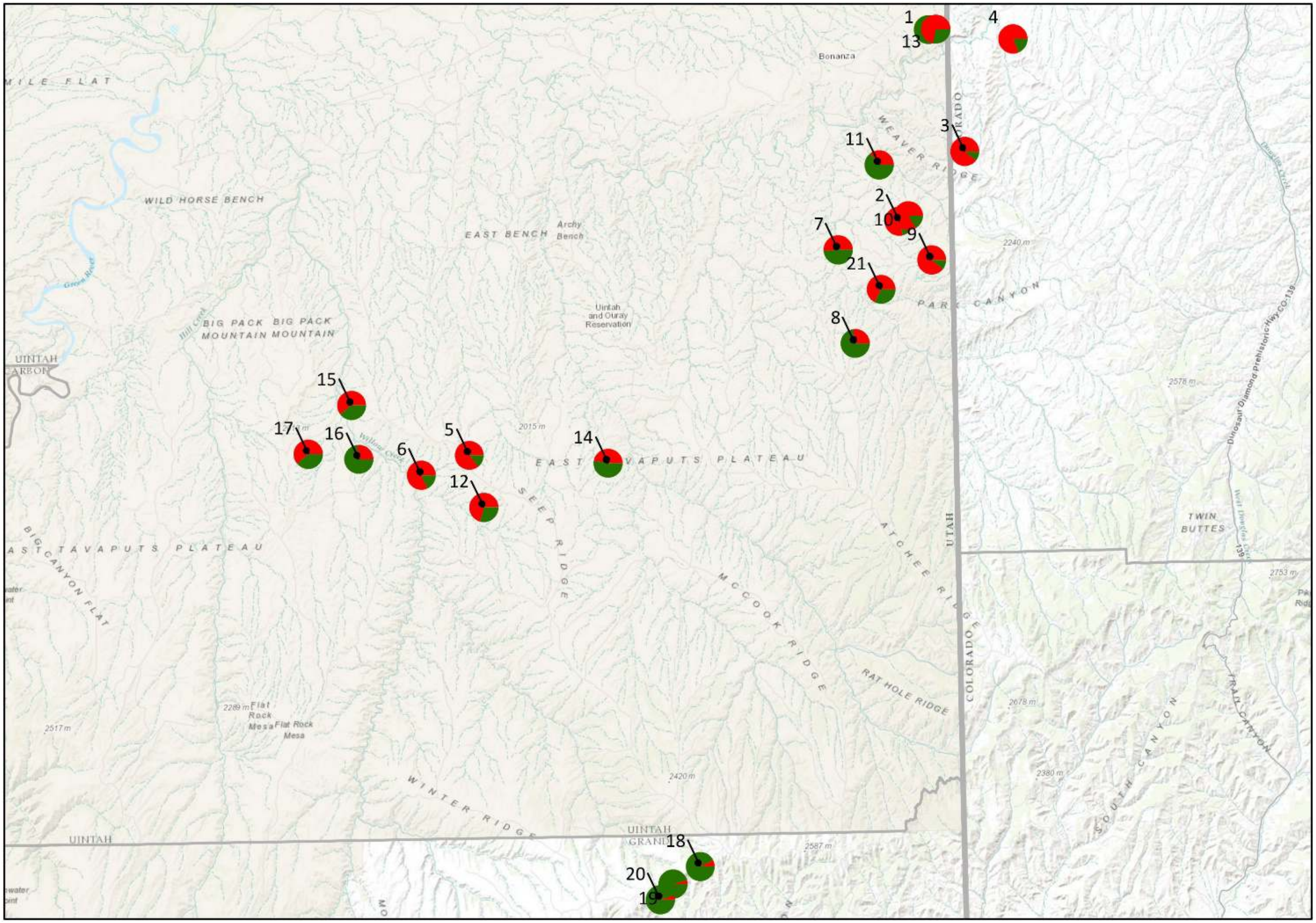
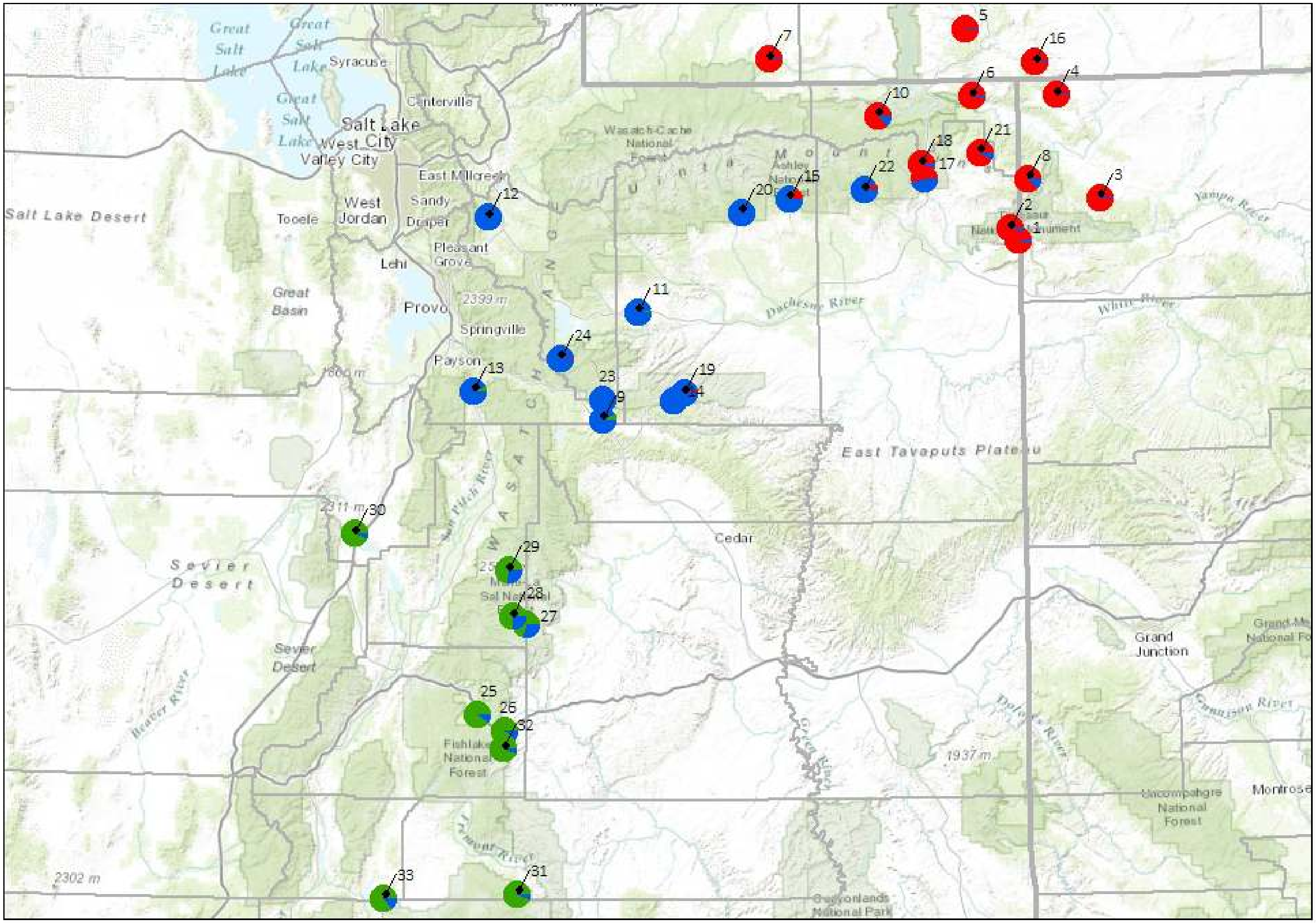
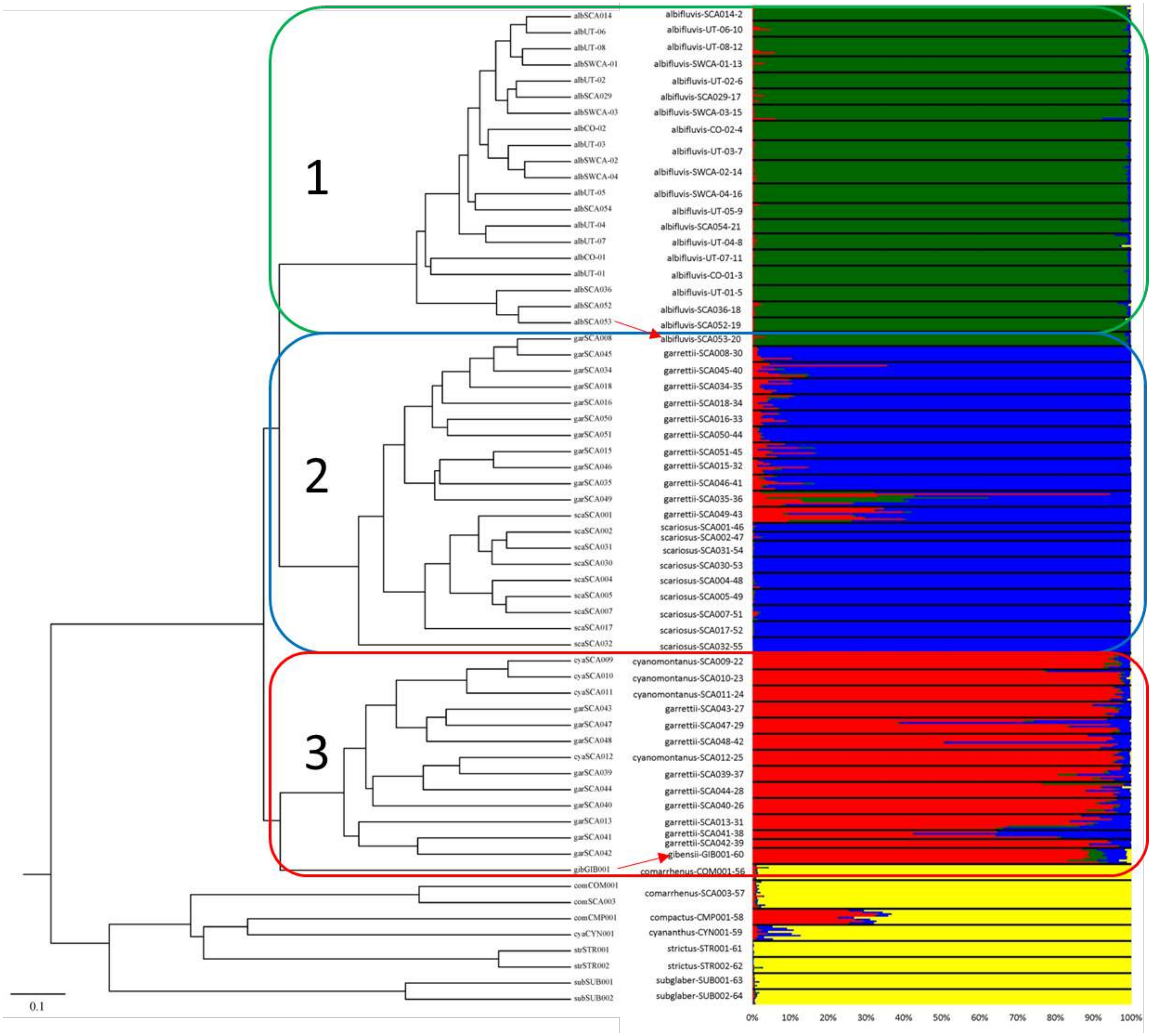

1
13
4
Bonanza
MILE FLAT
3
11
WEAVER RIDGE
2
10
9
7
21
8
WILD HORSE BENCH
EAST BENCH
Archy Bench
Uintah and Ouray Reservation
2240 m
PARK CANYON
BIG PACK MOUNTAIN
BIG PACK MOUNTAIN
UINTAH
15
17
16
6
5
12
14
2015 m
EAST TAVAPUTS PLATEAU
SEEP RIDGE
BIG CANYON FLAT
2578 m
TWIN BUTTES
UTAH
COLORADO
ATCHEE RIDGE
MCCOOK RIDGE
RAT HOLE RIDGE
2753 m
2289 m
Flat Rock Mesa
Flat Rock Mesa
2517 m
2678 m
2380 m
SOUTH CANYON
2420 m
WINTER RIDGE
UINTAH
GRAND
18
20
19
2587 m

Figure 5. Essentially this map is the same as Fig. 2, except it is missing the *P. scariosus* var. *albifluvis* sample accessions. This map focuses on the genetic diversity found in the accessions collected of the traditionally described as *P. scariosus* var. *cyanomontanus*, var. *garrettii* and var. *scariosus*. These collections also represent the reported range of these varieties of *Penstemon scariosus*. The colors of the pie charts represent the percent of genetic diversity which we found within and between these taxa. Note that the color distribution of these pie charts do represent more closely the traditional geographic regions of the varieties of *P. scariosus* which are reported by Holmgren (1984) and Neese and Atwood (2008). The key to each accession sample number is found in Table 1.



Great Salt Lake
Syracuse
Centerville
Salt Lake City
West Valley City
East Millcreek
West Jordan
Sandy
Draper
Tooele
Salt Lake Desert
Lehi
Pleasant Grove
Provo
Springville
Payson
Great Basin
Wasatch-Cache National Forest
Uinta Mountains
Ashley National Forest
Duchesne River
White River
Yampa River
East Tavaputs Plateau
Cedar
Sevier Desert
Manti-La Sal National Forest
Fishlake National Forest
Beaver River
Fremont River
Green River
Canyonlands National Park
Grand Junction
Gunnison River
Dolores River
Uncompahgre National Forest
Montrose
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33
2399 m
2311 m
2302 m
1937 m

Figure 5.
The key to each *Penstemon scariosus* accession sample represented in this dendrogram is found in Table 1. There are three "boxed" sections of this dendrogram. Box 1 (the green box) represent all, and only, the accessions collected of var. *albifluvis* (see Fig. 2, and 4). Box 2 (the blue box) represents the samples of *P. scariosus* from the southern portion of the range (see Fig. 2, and 4) of this species with includes all of traditionally classified as var. *scariosus* and the southern portion of those classified as var. *garrettii*. Finally, Box 3 (the red box) includes the north eastern accessions (see Fig. 2, and 4) of the traditionally classified var. *garrettii*, all of var. *cyanomontanus* and it includes our one sample of *P. gibbensii*.


1
2
3
0.1
albSCA014
albUT-06
albUT-08
albSWCA-01
albUT-02
albSCA029
albSWCA-03
albCO-02
albUT-03
albSWCA-02
albSWCA-04
albUT-05
albSCA054
albUT-04
albUT-07
albCO-01
albUT-01
albSCA036
albSCA052
albSCA053
garSCA008
garSCA045
garSCA034
garSCA018
garSCA016
garSCA050
garSCA051
garSCA015
garSCA046
garSCA035
garSCA049
scaSCA001
scaSCA002
scaSCA031
scaSCA030
scaSCA004
scaSCA005
scaSCA007
scaSCA017
scaSCA032
cyaSCA009
cyaSCA010
cyaSCA011
garSCA043
garSCA047
garSCA048
cyaSCA012
garSCA039
garSCA044
garSCA040
garSCA013
garSCA041
garSCA042
gibGIB001
comCOM001
comSCA003
comCMP001
cyaCYN001
strSTR001
strSTR002
subSUB001
subSUB002
albifluvis-SCA014-2
albifluvis-UT-06-10
albifluvis-UT-08-12
albifluvis-SWCA-01-13
albifluvis-UT-02-6
albifluvis-SCA029-17
albifluvis-SWCA-03-15
albifluvis-CO-02-4
albifluvis-UT-03-7
albifluvis-SWCA-02-14
albifluvis-SWCA-04-16
albifluvis-UT-05-9
albifluvis-SCA054-21
albifluvis-UT-04-8
albifluvis-UT-07-11
albifluvis-CO-01-3
albifluvis-UT-01-5
albifluvis-SCA036-18
albifluvis-SCA052-19
albifluvis-SCA053-20
garrettii-SCA008-30
garrettii-SCA045-40
garrettii-SCA034-35
garrettii-SCA018-34
garrettii-SCA016-33
garrettii-SCA050-44
garrettii-SCA051-45
garrettii-SCA015-32
garrettii-SCA046-41
garrettii-SCA035-36
garrettii-SCA049-43
scariosus-SCA001-46
scariosus-SCA002-47
scariosus-SCA031-54
scariosus-SCA030-53
scariosus-SCA004-48
scariosus-SCA005-49
scariosus-SCA007-51
scariosus-SCA017-52
scariosus-SCA032-55
cyanomontanus-SCA009-22
cyanomontanus-SCA010-23
cyanomontanus-SCA011-24
garrettii-SCA043-27
garrettii-SCA047-29
garrettii-SCA048-42
cyanomontanus-SCA012-25
garrettii-SCA039-37
garrettii-SCA044-28
garrettii-SCA040-26
garrettii-SCA013-31
garrettii-SCA041-38
garrettii-SCA042-39
gibensii-GIB001-60
comarrhenus-COM001-56
comarrhenus-SCA003-57
compactus-CMP001-58
cyananthus-CYN001-59
strictus-STR001-61
strictus-STR002-62
subglaber-SUB001-63
subglaber-SUB002-64
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

B. Work Schedule

Completed.

C. Budget Information

Already reported.

D. Planned Activity for Next Reporting Period

No further reporting periods planned. We are working on expanding how we are look at the samples collected and placing them into perspective with additional samples we collected in 2016. Our objective is to prepare one or more peer reviewed publications on the data reported here in combination with the additional data we have collected.