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

2017 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 2018

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

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March 30, 2018

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1 PENSTEMON CONSERVATION TEAM ACTIVITIES

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

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

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

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

Information included in this annual report summarizes Penstemon Conservation Team activities from January 1 – December 31, 2017.

1.1 Mitigation Plan

There have been no updates to the Mitigation Plan (Penstemon Conservation Team 2015a) in 2017. To date, the Mitigation Plan sub-committee has reviewed only one stone collection project due to the lack of new development in 2016. No projects were proposed in 2017.

1.2 Weed Management Plan

No changes were made to the Weed Management Plan (Penstemon Conservation Team 2015b). In 2017, surveys were conducted near roads and two-tracks along approximately 15 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.

1.3 Livestock Grazing Management Plan

No changes or updates to the Livestock Grazing Management Plan (Penstemon Conservation Team 2015c) were made in 2016. Methods for assessing livestock grazing and weed impacts in beardtongue habitats were incorporated into demographic monitoring implemented in summer 2017. Monitoring to meet some of the objectives of the livestock grazing management plan is expected to continue in 2018.

1.4 Surface Disturbance Plan

In 2017, no changes were made to the plan (Penstemon Conservation Team 2015d), but the plan is being implemented.

1.5 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 final Strategy was finalized by the Team in January 2017, is included here as Appendix A, and is available on the SITLA website.

1.6 Demographic Monitoring Plan

A draft Penstemon Range-wide Demographic Monitoring Plan was implemented in 2017; both phase one (pollinator and demographic monitoring) and phase two (counts of fruits and seeds). BLM VFO botanists installed 25 plots for each *Penstemon* species in May and June 2017. The results of the 2017 monitoring effort are summarized in section 7.1.

1.7 Restoration Plan

The Restoration Plan Subcommittee developed an early draft Beardtongue Restoration Plan in late 2017. Review by the Penstemon Conservation Team and publication of a draft plan is expected in early 2018.

2 IMPLEMENTATION OF CONSERVATION AGREEMENT IN BEARDTONGUE HABITATS

2.1 BLM

In 2017, Vernal BLM did not authorize any disturbance/permits in 2017 within the Conservation Units for their area. No new mineral materials permits were granted in or near *Penstemon* conservation areas or habitat. A parcel of land called the "Z" parcel near Watson was transferred to SITLA in exchange for other lands elsewhere. This parcel did not include any known *Penstemon grahamii* or *P. albifluvis* habitat or conservation areas, but does contain Green River shale outcrops. These outcrops were surveyed by BLM botanists in 2017 and no *Penstemon* of either species were found.

The BLM White River Field Office authorized surface disturbing activities associated with oil and gas developments on approximately 4.7 acres in Conservation Areas in Rio Blanco County, Colorado. These activities occurred more than 300 feet from occupied beardtongue habitats. In addition, the WRFO noted some disturbance from dispersed hiking and hunting activities in Conservation Areas but the amount of disturbance that occurred is unknown.

The BLM Vernal and White River Field Offices maintain MS Excel workbooks tracking projects in and near *Penstemon grahamii* and *P. albifluvis* habitat. The 2017 workbooks with updated activities are provided in Appendix B.

2.2 SITLA

SITLA provided funding in support of the implementation of the Penstemon Conservation Agreement totaling $9,528 in 2017. No new leases were issued within Penstemon conservation Areas in 2017.

2.3 Uintah County

Uintah County actively participated as a Team member throughout 2017.

2.4 State of Utah

The State of Utah Department of Natural Resources ESMF program provided $70,000 in FY2017 (July 1, 2016 to June 30, 2017) that supported restoration and population monitoring and research under the Penstemon Conservation Action project.

2.5 Summary of Financial Contributions by Partnering Agency

The Penstemon Conservation Team met six times in 2017, including one conference call and five in-person meetings in Vernal, Utah. The in-kind contributions associated with these meetings and other Agreement-related activities are summarized in Table 1.

Table 1. 2017 Conservation Agreement Financial Contributions by Partner Agencies

Partner	Direct Funds	In-Kind (hours)
BLM - CO	$15,000	370
BLM - UT	0	600
DNR	$70,000	96
PLPCO	0	Unknown
Rio Blanco County	0	Unknown
SITLA	$9,528	130
Uintah County	0	55
UNHP and USU	Unknown	320
USFWS - CO	0	90
USFWS - UT	0	110
TOTAL	**$94,528**	**1,716**

A similar level of participation by the Agreement partner agencies is expected in 2018.

3 CONSERVATION AREA REVIEW

According to section 6.2 in the Agreement the Team must revisit conservation area boundaries every one to three years. In November of 2017 the Team began a general review of the existing conservation areas and boundaries while also considering new scientific information. New scientific information included in the examination of areas includes genetic research, survey data, population density analysis, population viability analysis, and connectivity analysis. This review is ongoing and will be completed in 2018. Any boundary modifications must meet the criteria established in section 6.2 of the Agreement.

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 is accessible to all conservation team members. Disturbance shapefiles will be 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 SWCA Environmental Consultants/Manzanita Botanical Consulting

The results of SWCA's ESMF Penstemon Conservation Action project (FY2017) were submitted to the Utah Division of Wildlife Resources Endangered Species Mitigation Fund on September 1, 2017. Any data collected by Manzanita Botanical Consulting has been submitted to the Penstemon Conservation Team for inclusion in this and future annual reports.

5 2017 FIELD SURVEY RESULTS

Surveys for Graham's and White River beardtongue were conducted by multiple agencies in 2017. These surveys focused on unsurveyed areas in and near the Book Cliffs White River beardtongue population, and on potential habitats in the Willow Creek and Sunday School Canyon areas. Survey results are summarized below and full reports are included in the Appendices.

5.1 BLM Vernal Field Office

In 2017, BLM Botanists and interns surveyed three areas of BLM administered lands within the Uinta Basin for *Penstemon grahamii* and *Penstemon albifluvis* (Figure 1). We conducted all surveys in accordance with the Penstemon Conservation Agreement and in areas identified as gaps in the distribution of these two species. We documented 183 new *P. grahamii* during surveys in the Sunday School Canyon area, and 3,043 new *P. albifluvis* in the Willow Creek, Sunday School Canyon, and Book Cliffs areas. We also documented *Cryptantha grahamii*. All three areas could continue to be surveyed in 2018 to fill in gaps in information, in particular to document additional *P. albifluvis* in the Sunday School Canyon area

where *P. grahamii* has already been found. Additional surveys conducted during range-wide monitoring plot establishment are not included in this report. See Appendix C for full report.

5.2 BLM White River Field Office

The BLM WRFO conducted surveys for Graham's and White River beardtongue in cooperation with the Colorado BLM State Office. Colorado survey activities for both *Penstemon grahamii* and *Penstemon albifluvis* were focused on BLM administered lands in conservation units 3-5. Additional surveys were completed in potential habitat of both species outside of the Evacuation Creek conservation area (Unit 3) near Park Canyon and Rabbit Mountain. We documented 100 – 200 *P. grahamii* individuals dispersed across several kilometers in Park Canyon outside of conservation unit 3. We located an additional 50 - 100 previously undocumented *P. albifluvis* individuals along Cottonwood Creek within conservation unit 4. Surveys completed along the southern margin of conservation unit five revealed very low *P. grahamii* density (ca. 5 individuals/acre). Additional surveys are slated for the spring of 2018 specifically to investigate areas of connectivity within conservation unit 4 in Colorado.

5.3 Utah State University

A plant survey conducted by Utah State University (USU) was completed in May and June of 2017 for the beardtongues. A large portion of the funding for these surveys was supplied by the Endangered Species Mitigation Fund (ESMF) office of the State of Utah. Sites to survey were chosen by a combination of discussions within the Penstemon Conservation Team and opportunistic, intuitive controlled surveys completed by Utah State University in the Uinta Basin. General areas surveyed include Sunday School Canyon in the Seep Ridge Unit, areas north and south of the Seep Ridge Unit, and west of the Sand Wash Unit. (See UNHP Survey Report). USU crews completed surveys for *Penstemon grahamii* and *P. albifluvis* over approximately 821 acres using an estimated 300 person hours. In that time, the crew found and counted 1,449 *Penstemon grahamii* plants and 2,151 *Penstemon albifluvis* plants. The survey report is provided in Appendix D.

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

No surveys were conducted as part of FY2017 activities.

6 2017 SEED COLLECTIONS

Seed collections were conducted by the BLM VFO in 2017. Seeds were also collected as part of the 2017 White River beardtongue reproductive success pilot study (Appendix E). Fruit development was very rapid due to dry conditions and high temperatures in June 2017, so most fruits had already dehisced, and many seeds were immature. Total seed counts are not currently available.

6.1 BLM

The BLM Vernal Field Office collected seed from thirteen locations in 2017 (Table 2). Fruit set for *Penstemon grahamii* was poor due to the dry spring, with mature, seed-bearing fruits available at only two sites. Fruit set for *P. albifluvis* was better, with seed collected from eleven sites, but there were some

sites where fruits had already opened and dispersed seeds before seed collecting took place. Seeds were sent to Red Butte Garden for long term storage.

Table 2. 2017 BLM Vernal Field Office Beardtongue Seed Collections

Nearest Demographic Monitoring Plot	Date	UTM Easting	UTM Northing	Number of Plants	Seeds Collected	Location Name
Penstemon albifluvis						
1018	7/12/2017	662920.9	4418661.2	300	52	Hells Hole Overlook
1070	7/13/2017	666326.4	4426182.8	300	50	
1079	7/13/2017	668043.2	4425174.7	100	16	
1076	7/13/2017	667714.9	4423847.8	150	50	
1050	7/12/2017	662039.7	4420186.6	50	30	Dragon Road East
1073-1075	7/13/2017	664974.0	4426439.0	250	50	
--	7/17/2017	629344.1	4395410.4	200	10	Sunday School Canyon
1071	7/17/2017	664956.3	4429982.8	200	50	
1072	7/17/2017	666269.6	4430544.4	26	26	
1016	7/18/2017	674719.6	4438805.3	70	8	
1065	7/19/2017	671487.7	4432835.4	200	62	
			Total	**1,846**	**404**	
Penstemon grahamii						
1002	7/13/2017	586358.4	4412464.2	10	3	Along Sand Wash Road
1021	7/19/2017	666181.8	4427149.9	10	3	
			Total	**20**	**6**	

BLM VFO seed collection sites are mapped in Figure 1.

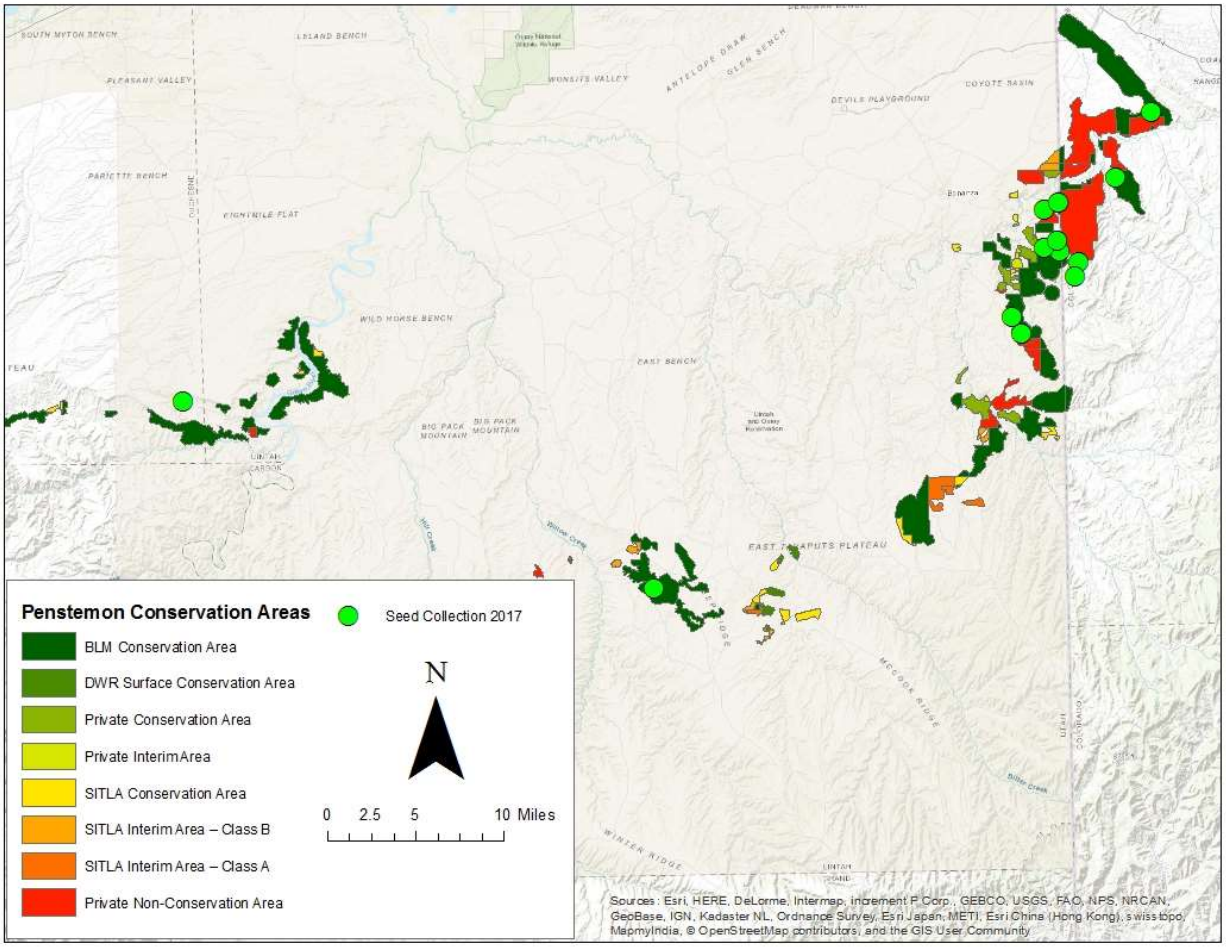

Figure 1. Beardtongue seed collection sites in 2017.

Seed collections are expected to be ongoing.

7 ONGOING RESEARCH

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

7.1 BLM

The BLM Vernal Field Office established and monitored 50 demographic plots in 2017. The study plots comprise a 1-meter quadrat centered around a randomly-selected beardtongue individual surround by a 100 square meter circular plot. Demographic, habitat, and disturbance data are collected within the 1-meter quadrat, with counts of beardtongue plants in the 100-meter circular plot. Collection of pollinator data was limited by cold and windy spring weather. Climate monitoring equipment (iButton temperature loggers) were not deployed in 2017 but will be deployed in the 2018 monitoring season. A report of the 2017 demographic monitoring results will be submitted to the Team in early 2018. Monitoring is expected to continue in 2018.

The BLM Colorado continued demographic monitoring of the Mormon Gap Graham's beardtongue (*Penstemon grahamii*) population in May 2017. The population has exhibited a downward trend over the course of the study (2005 – 2017). The population was nearly eradicated by a 2013 livestock trailing event at the study site in 2013, followed by a significant increase in the population in the 2014-2017 monitoring years. Despite this increasing trend, the population remains below historic levels. The monitoring report is provided in Appendix F.

Also in 2017 a monitoring study was established at a population of White River beardtongue (*Penstemon albifluvis*) in the southern portion of the Raven Ridge ACEC. The population occupies characteristic White River beardtongue habitat consisting of steep exposed Green River Formation with sparse pinon-juniper overstory. The population contained between 285 and 575 individuals. Power analysis will be completed following data collection in 2018.

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

The Penstemon Conservation Action project was initiated in early 2014 (FY2014) and was continued through June 2017 (FY2017). Conservation activities are summarized in Table 3.

Table 3. ESMF Penstemon Conservation Action Project FY2017 Research

Fiscal Year (Date Range)	Objectives	Proposed Activities	Outcomes
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. • Coordinate reproductive success study methods with Penstemon Conservation Team and subject experts.	• 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. • Implement a reproductive success pilot study.	• 254 and 2,105 seeds for Graham's and White River beardtongues, respectively, were collected late July and early August 2016. All seeds were delivered to the Red Butte Garden Conservation Program for curation. • Disturbance assessment was implemented as part of demographic monitoring. SWCA staff and subcontractors (Manzanita Botanical Consulting) assisted BLM with demographic monitoring in May and June 2017. Monitoring activities included documentation of habitat composition and surface disturbance parameters at 50 permanent monitoring sites. • Climate monitoring equipment (iButtons) to assess range-wide temperature and humidity variation in relation to habitat and disturbance was purchased as part of the FY2017 budget. The equipment will be installed by BLM at the long-term demographic monitoring sites. • Graham's beardtongue transplants at Red Leaf's Seep Ridge EPS site were revisited in early June 2017, with 80% survival. Most plants (76.5-79.2%) in the reclaimed soil treatments flowered, likely due to stress from high weed cover (40-47%). Only 10.5-15% of plants flowered in shale treatments flowered (weed cover was 2.5-3.5%). • The 13 Graham's transplants in the interim conservation area north of the Seep Ridge Block were not revisited in 2017.

Table 3. ESMF Penstemon Conservation Action Project FY2017 Research

Fiscal Year (Date Range)	Objectives	Proposed Activities	Outcomes
			• The White River beardtongue transplants were revisited in June 2017. The original 2014 transplant cohort continues to have high survival (54.3%) with 68.4% of plants flowering. No seedling recruitment has been detected to date. Survival of the four 2015 transplant cohorts is low (2.9-32.4%) due to impacts from native herbivores and marginal habitat suitability. • A reproductive success pilot study for White River beardtongue was implemented in June 2017. Flowers were marked on 228 beardtongue plants in nine study areas. The pilot study sites were revisited in July 2017 with support from SITLA and UNHP. The results were inconclusive due to low fruiting and rapid fruit development. Significant modifications to study methods are needed. Recommendations for revised methods (Appendix E) have been provided to the Penstemon Conservation Team.

ESMF Penstemon Conservation Action project funding will not continue beyond June 20, 2017. Ongoing activities initiated under the ESMF project will be continued with alternative funding sources.

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 Monitoring Plan

Demographic monitoring will continue in 2018, with expected installation of iButton climate loggers and additional study plots.

8.2 Livestock Grazing Management Plan

Habitat monitoring, as part of the demographic monitoring program, will be continued to inform current and future habitat conditions in beardtongue habitats. Recommend a sample size evaluation (based on various habitat parameters) to ensure that changes in livestock-related surface disturbance, weeds, and other habitat conditions can be detected with sufficient rigor to support the objectives of the Livestock Grazing Management, Demographic Monitoring, and Weed Management Plans.

8.3 Beardtongue Restoration Plan

Transplant success monitoring is expected to continue in order to determine 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.

8.4 Other Future Activities

Ongoing conservation-related research and activities are being conducted by the Agreement partner agencies. Expected 2018 activities include the following:

8.4.1 Reproductive Success Study

The results of the 2017 reproductive success pilot study were inconclusive due to rapid fruit development and loss of seed before study sites could be revisited. Intensive efforts during flowering were not efficient. Further, flowering and fruiting appeared to be highly variable across the range and may depend on local conditions that are not related to surface disturbance. We recommend continuation of the reproductive success study in 2018 with these revised methods: 1) Double the study sample with individuals clustered at varying distances from mapped surface disturbance to better capture spatial variation in flowering; 2) Focus efforts during flowering on hand-crossing only (do not mark insect-pollinated buds, flowers, or fruits); and 3) Focus field activities on monitoring fruit development and fruit collections. The reproductive success study methods are being revised and are expected to be reimplemented in 2018 or 2019.

8.4.2 Climate Monitoring

Range-wide climate monitoring should be implemented by installing iButtons in early 2018.

8.4.3 Seed Collections

Seed collections will continue in 2018 as climate-linked flowering and fruiting permits.

9 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

White River Penstemon and Graham's Penstemon Seed Management Strategy

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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

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
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May 2017

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

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May 30, 2017

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Figure C-2. Map of existing Graham's beardtongue seed collection locations. ... C-**Error! Bookmark not defined.**

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INTRODUCTION AND PURPOSE

The purpose of this Seed Management Strategy (hereafter, Strategy) is to guide the development and implementation of an ex situ seed bank conservation strategy for Graham's and White River beardtongues in accordance with the requirements outlined in the Penstemon Conservation Agreement (hereafter, Agreement) (PCT 2014). The objectives of this Strategy are to 1) describe the importance of an ex situ seed bank for conservation, 2) identify the key principles for developing a seed bank, 3) develop a strategic approach for future collections, and 4) provide the logistical details required for implementation of this plan.

This Strategy fulfills the commitment to develop a seed bank, as described in Table 4 action 16 of the Agreement, and provides standardized procedures for the development and implementation of seed collection and seed storage for Graham's and White River beardtongues.

Adaptive Management

Adaptive management is a strategic approach for meeting management challenges under changing conditions and available information. Implementing adaptive management will be the responsibility of the Penstemon Conservation Team (PCT 2014, section 6.5). The Penstemon Conservation Team will review and use new information gathered from seed collection reports, seed germination tests, restoration studies, and other applicable research in order to revise this seed storage and collection plan as needed. Sources of new information may be studies directly funded through the Agreement or from outside research relevant to the ecology of the species.

Objective 1: Establish Ex situ Seed Banking

'*Ex situ*' refers to actions that take place off site, such as research conducted in a laboratory rather than in the wild. '*In situ*' actions are those that take place in the wild where a species occurs naturally, such as monitoring conducted in the field. Since *ex situ* seed banking is one of the most economical and efficient methods for preserving the genetic diversity of rare species, it is an ideal tool for the Conservation Team to employ.

The ultimate goal of *ex situ* collection and storage of seeds or other plant materials is to make those materials available for the long-term survival and resiliency of populations in the wild. A major benefit of ex situ conservation is the preservation of plant material for research efforts and restoration purposes, without a need to remove plants from wild populations. *Ex situ* plant materials can also be a useful tool to provide public awareness for a species.

Ex situ (off site) conservation of plant genetic material can be achieved through several different methods, such as, seed banks, gene banks, in-vitro storage methods, pollen banks, and DNA genetic banks. Botanical gardens are the most conventional method of ex situ conservation, all of which house specimens (vegetative propagules, tissues, and seed) for reintroduction into nature. Plants may also be preserved in part through seedbanks or germplasm banks. Seed banking is typically the most economical and efficient approach when it comes to ex situ conservation methods.

Most long-term seedbanks have a cryogenic laboratory facility in which the seeds can be preserved for up to a century or more without losing their viability. For plants that cannot be preserved in seedbanks,

germplasm may be conserved as in-vitro storage, where cuttings of plants are kept under strict conditions in glass tubes and vessels.

An important component of seed banking is having two types of seed storage, "black box," and "working" collections. A black box collection can be thought of as an archived genetic collection. The goal is to provide long term seed storage at a specialized facility to help preserve plant genetics in perpetuity. This collection is typically left untouched unless there is a catastrophic event requiring the use of these seed due to the loss of reproductive material from the wild or loss of a working collection.

In contrast, a "working" collection stores seeds that will be used within a shorter time frame for restoration, research, and in situ conservation needs. Seed collected for the working collection will be cleaned, stored, and used later in reclamation seed mixes and/or used for propagation for plant materials. Seeds from the working collection can be used toward habitat restoration and as mitigation for impacts from development activities. Prior to planned development activities, seeds should be collected and placed in both the black box and working collections for genetic conservation and future reclamation activities at the same site.

Seed banking is the preferred ex situ method that the Penstemon Conservation Team will implement to preserve Graham's and White River beardtongue genetics. When developing these seed collections, it is the Team's objective to collect seed from across the entire range of each species, including from each designated conservation area, and repeat these collections over time.

Objective 2: Achieve the Principles of Seed Banking

The following basic principles of ex-situ seed banking are incorporated into the Strategy.

- Collection Purpose – As previously described the two types of collections, black box and working collections, serve different but related purposes (see Objective 1). As part of our seed collection protocol, we will determine the number of individuals, populations, and seeds that need to be collected from wild populations. The final use of the seeds will be determined prior to conducting a wild seed collection.

- Genetic Diversity – Genetic diversity is the key to maintaining a healthy population in the wild. A seed bank, whose purpose is to support wild populations through augmentation and reintroduction, should also represent the diversity of the species in order to ensure successful reintroductions. Genetic diversity of a collection is achieved by collecting seed from many individuals across both place and time (Menges et al. 2004, Walters 2004). Each sub-population has the potential to have unique genetic traits. Therefore, we will target seed collections across the species range, including the edge of the species range where genes favoring adaptability may be more frequent. We will also identify populations across the species range for repeat collections in order to capture the genetic variability across the range and between years.

- Redundancy – Redundancy of seed collections will be accomplished by collecting seed from the same populations over time. Redundancy is also important when considering the storage of the seeds. In order to avoid a loss of valuable seeds, time, effort, and funding the seed collections will not be stored all at the same location. This will offer protection against an emergency event such as loss of power, fire, disease, or other natural disaster. Seeds will be deposited at more than one storage facility to ensure there is no over reliance in one facility, and the collections are protected by implementing the principle of redundancy.

- Resiliency – Resiliency of a seed collection describes the longevity and viability of the seeds after they are placed into storage. The resiliency of the seeds after being taken out of storage depends on many influencing factors, such as the environmental conditions at collection, treatment during handling, storage temperature, relative humidity in storage, seed water content, and the characteristics of the individual taxon (Walters 2004). The resiliency of the seeds will decline as storage time increases, and this varies widely based on the particular species (Walters 2004). In order to determine the seed collections longevity, i.e., how long seeds can be stored before declining beyond a critical threshold, we will determine the health and viability of the seed when they are initially collected. This baseline viability will be used to determine when a collection needs to be replenished.

Objective 3: Develop and Implement a Strategy for Future Collections

EVALUATION OF EXISTING EX SITU SEED BANK MATERIALS

Over the past fifteen years seed of both *Penstemon* species was collected by Red Butte Garden and Arboretum (RBG) at the University of Utah, and placed in long-term conservation storage at the National Center for Genetic Resources Preservation (NCGRP) or kept on-site at RBG to be used as a secondary black box collection and working collection. Storing seeds at more than one location provided redundancy for the seed collections. Seeds stored at the NCGRP are primarily intended for emergency use and NCGRP is considered to be the "black-box" storage facility. All seeds were collected and handled according to protocols established by the Center for Plant Conservation (CPC) and International Union for the Conservation of Nature (IUCN) Guidelines for the Management of Ex-situ Populations.

A complete summary of the seed currently held in storage at RBG and NCGRP for each species is listed in Tables 1 and 2 of Appendix A. A map of current collection locations by species is shown below Appendix C, Figures 1 and 2. A total of 12,174 wild seeds of Graham's beardtongue from 12 general locations have been collected and placed in storage at the RBG and NCGRP facilities. Additionally, 7,936 seeds have been produced from first generation (F1) greenhouse plants. A total of 18,931 wild collected seeds of White River beardtongue from six general locations have been collected and are currently in storage.

The majority of existing seeds in storage were collected near established long-term population monitoring sites, and therefore represent a narrow portion of the populations and genetic diversity for both species. The range and genetic diversity of both species is not thoroughly represented in existing collections.

FUTURE SEED COLLECTION STRATEGY

A planned, strategic approach to collection of seeds and storage locations is necessary to achieve the principles of genetic diversity, redundancy, and resiliency necessary for a robust ex situ seed bank. Additionally, enough seed must be collected to develop a robust "black-box" conservation collection as well as a working collection for restoration research and applied restoration projects.

To achieve an ex-situ seed collection that represents the genetic diversity of the species across the landscape we will collect seeds from as many locations as possible across the extent of the species' range. Seed collections will not be limited to designated conservation areas; however, the conservation areas will be used to assist with identifying areas where collection will occur.

Seed collections may be targeted or opportunistic. Target collections will be strategically planned to insure genetic robustness of the ex-situ collections. Opportunistic collections may be from target or non-target areas and should be conducted when possible. For example, if species' surveys overlap with natural

seed dispersal, seed may be collected during the survey window to maximize efficiency of time and funding, while also increasing the robustness of the seed bank. Additionally, repeated opportunistic collections, such as collections made near monitoring plots adds to the robustness of the overall collection by providing good genetic representation across time.

Who will collect – The targeted collections will be conducted by federal agencies or approved qualified botanists (USFWS 2011) acting as third-party contractors. Prior to conducting any seed collection, the third party must be authorized for access by the land owner or land management agency.

Timing of collections – Within four years the Team aims to have all five beardtongue units, for both species, represented in black box and working collections. See the Collection Timeline – 4 Year Plan section below for a detailed schedule. Annual weather patterns and reproduction activity of populations can affect the ability to collect seeds and may change the collection time line. The Team will adapt this Plan as necessary to account for variability in seasonal reproduction.

Frequency of collections – Viability data from other *Penstemon* species being held in long-term cold storage indicate that seeds maintain a stable viability rate for up to 20 to 30 years before sharp declines in viability occur (personal communication, Christine Walters, NCGRP, 5/15/2016). Therefore, a conservative approach to replenishing a black-box ex situ seed bank for *Penstemon* species is to recollect from the same populations at a maximum of interval every 20 years. More frequent collections may be required to support other uses for seeds, such as reintroduction, where used seeds will require replacement.

How much to collect – The amount of seed needed varies widely based on the intended use for the seeds and the health of the populations. Detailed discussion and worksheets for evaluating the size of a collection can be found in Appendix 1 of Guerrant et al. 2004. In summary, to achieve maximum genetic diversity and have 95% of alleles represented in a collection, we will apply the following general principles;

- For populations that have more than 50 individuals, we will collect seed from at least 50 individuals in order to capture 95% of the alleles.
- For a species with over 50 populations, a minimum of 50 populations should be collected from.
- For populations with 50 or fewer individuals, we will collect seed from each reproductive individual if possible. For a species with 50 or fewer populations, we will collect seed from all populations if possible.

To avoid negatively impacting a population, no more than 10% of the available seed should be collected in one year. More frequent, smaller collections have a less negative impact on sensitive populations than infrequent intense collections.

COLLECTION TIMELINE – 4 YEAR PLAN

This collection timeline will be updated before the field season in the 5th year (before March 2021). The specific collection locations within the target areas will be determined by the field crew leaders. Some flexibility in collection location must be built into the strategy in order to adapt to localized climatic conditions, safety and accessibility, and sub-population health. Seed collection locations within units should prioritize areas where seed was not previously collected.

Year 1

The following areas will be targeted in the first year:

Unit 1 – Sand Wash Unit – Graham's Beardtongue

- Both BLM and SITLA conservation areas will be targeted for collection.
- Up to 10 locations will be collected.
- Collections will range across the unit from east to west.
- The western most sub-population along Wrinkles road will be targeted.
- Special attention will be given to collect from disjunct conservation areas within the unit.

Unit 5 – Raven Ridge Unit – Graham's Beardtongue and White River Beardtongue

- Up to 5 locations will be targeted for each species.
- Both BLM and SITLA Interim B areas will be targeted for collection.
- Northern and western most locations of White River and Graham's beardtongue will be targeted.
- Special attention will be given to collect from disjunct conservation areas within the unit.

Year 2

The following areas will be targeted in the second year:

Unit 4 – White River Unit – Graham's Beardtongue and White River Beardtongue

- Up to 10 locations will be targeted for White River beardtongue.
- Up to 10 locations will be targeted for Graham's beardtongue.
- Collections will be from private conservation areas, private interim areas, SITLA interim, and BLM areas.

Book Cliffs White River Beardtongue Population

- At least one, and up to 3, collections will be made from the book cliffs location discovered in 2014. Number and location of collections will be determined by updated survey and population data.

Year 3

The following areas will be targeted in the third year:

Unit 3 – Evacuation Creek Unit – Graham's Beardtongue and White River Beardtongue

- Up to 10 locations will be targeted for each species.
- Collections will be from private conservation areas, private interim areas, SITLA interim, and BLM areas.

Year 4

The following areas will be targeted in the fourth year:

Unit 2 – Seep Ridge Unit – Graham's Beardtongue and White River Beardtongue

- Up to 5 locations will be targeted for Graham's beardtongue.
- Up to 10 locations will be targeted for White River beardtongue.
- Collections will be from SITLA conservation area, SILTA interim areas, DWR and BLM will be targeted.
- Areas on the eastern portion of the unit and disjunct areas will be prioritized since other areas within the unit are already represented in the seed bank.

Collection Protocols

Seed will be collected, cleaned, and stored according to the guidelines established by the CPC and NCGRP, which are described in detail in Guerrant et al 2004 and Wieland 1993 (Appendix B). As established in the CPC guidelines, no more than 10% of the available seed on a given day will be collected. If the field crew leader determines that removing 10% of the seed will be harmful to the health of the population, fewer seeds will be collected so that the existence of the population is not compromised (Guerrant et al 2004, Appendix 1). Maternal lines will be kept separate during collections, as described in the CPC protocols, in order to carry a population's genetic diversity through to final restoration applications. A seed collection data form (Appendix D) will be filled out for each seed collection and maintained for long-term record keeping. One copy of the data form will be submitted with the seeds for storage (along with additional forms required by the storage facility) and a second copy will be maintained at the BLM, Vernal Field Office.

Seed Viability Testing

Ideally seed collections should be tested to determine baseline viability prior to placement in long-term storage. Baseline viability is used to assess the long-term viability of seeds in storage and replenishment rates. Viability is also necessary to determine how much seed needs to be collected and to plan for reintroduction efforts. Viability testing will be conducted as soon as possible after collection or within 12 months of collection.

Once in long-term storage it is helpful to test a small sample of seeds in order to determine the rate of attrition while in storage and plan replenishment collections. Periodic testing will be conducted after 5 and 10 years post collection, followed by testing at 10 year intervals to determine if attrition is occurring.

Viability testing of collections will be conducted as funding allows.

Seed Cleaning and Storage

Long-term conservation black-box collections will be submitted to Red Butte Garden, where seeds will be cleaned, accessioned, and stored. Seeds going to NCGRP must be submitted by a CPC partner institution, such as Red Butte Garden. Therefore, Red Butte Garden will submit a portion of the seeds for storage at NCGRP and these will be maintained as part of the CPC National Rare Plant Collection. Viability tests will be conducted by either NCGRP or Red Butte Garden upon request of the donating agency.

The Team's records for collection data, storage location, and viability will be stored in a database managed by the BLM, Vernal Field Office. A copy of the seed collection data form will be submitted to the BLM annually in order to maintain records in one location.

Working collections will be cleaned and housed at one of the following facilities depending on available capacity, length of storage, and intended seed use.

1. Red Butte Garden and Arboretum
   C/O Conservation Department
   300 Wakara Way
   Salt Lake City, UT 84108

   Contact Person:
   Bruce Pavlik, Conservation Director
   (801) 585-5853
   bruce.pavlik@redbutte.utah.edu

2. Great Basin Research Center
   494 West 100 South
   Ephraim, UT 84626

   Contact Person:
   Kevin Gunnell
   (435) 283-4441 ext. 2024
   www.greatbasinnpp.org/udwr

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Guerrant E.O., P.L. Fiedler, K. Havens, and M. Maunder. 2004. Appendix 1 Revised genetic sampling guidelines for conservation collections of rare and endangered plants. In Guerrant, E.O., K. Havens, and M. Maunder (Eds.). *Ex situ Plant Conservation: Supporting Species Survival in the Wild*. Washington, D.C.: Island Press.

Menges, E. S., E. O. Guerrant, and S. Hamzè. 2004. Effects of seed collection on the extinction risk of perennial plants. In Guerrant, E.O., K. Havens, and M. Maunder (Eds.). *Ex situ Plant Conservation: Supporting Species Survival in the Wild*. Washington, D.C.: Island Press.

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.

Red Butte Garden and Arboretum. 2013. Red Butte Garden Rare Plant Seed Collection Protocol. Red Butte Garden Conservation Department, Salt Lake City, UT.

U.S. Fish and Wildlife Service (USFWS). 2011. Utah Field Office Guidelines for Conducting and Reporting Botanical Inventories and Monitoring of Federally Listed, Proposed and Candidate Plants. Utah Ecological Services Field Office: U.S. Fish and Wildlife Service.

Wieland, G. 1993. Guidelines for the Management of Orthodox Seeds. St. Louis, MO: Center for Plant Conservation.

APPENDIX A

Tables

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Table A-1. White River Beardtongue Seed Currently in Ex situ Storage

RBG Seed Accession Number	Collection Date	Location Name	Location Lat/Long NAD 83	# Individuals	# Seed Collected	Storage Location		Germination %	Germination Date
						RBG	NCGRP		
NA	1992?	Unknown, collected by Denver BG		NA	701	NA	701	88	1992
S-6	8/3/2001	White River	N 39.974975° W109.167569°	25	2000	2000	0	NA	
S-164	6/30/2005	White River	N 39.974975° W109.167569°	14	1170	100	1000	NA	
S-214	6/30/2005	White River	N 39.974975° W109.167569°	13	411	411	0	NA	
S-241	6/25/2006	White River	N 39.974975° W109.167569°	9	70	9	61	NA	
S-247	6/25/2006	White River	N 39.974975° W109.167569°	NA	678	361	317	NA	
S-274	7/6/2007	Bitter Creek	N 39.737309 W109.353458	NA	1161	541	503	26% and 88%	2013 and 2015
S-368	7/9/2009	White River	N 39.974975° W109.167569°	NA	1678	1490	0	98%	2015
S-369	7/10/2009	Watson site	N 39.878986° W109.155692°	NA	1093	993	0	88%	2015
S-407	7/10/2010	White River	N 39.974975° W109.167569°	14	1277	0	1277	41%	2011
S-501	7/18/2013	Watson Site	N 39.878986° W109.155692°	39	316	256	0	87%	2015
S-502	7/19/2013	White River	N 39.974975° W109.167569°	60	2410	804	1206	90%	2015
In process	7/8/2015	White River	N 39.974975° W109.167569°	31	3028	3028	0	NA	

Table A-1. White River Beardtongue Seed Currently in Ex situ Storage

RBG Seed Accession Number	Collection Date	Location Name	Location Lat/Long NAD 83	# Individuals	# Seed Collected	Storage Location		Germination %	Germination Date
						RBG	NCGRP		
In process	7/2/2015	Watson	N 39.878986° W109.155692°	8	114	114	0	NA	
In process	7/2/2015	Hells Canyon	N 39.897730° W109.087712°	17	1351	1351	0	NA	
In process	7/7/2016	BLM [RSR1]	TBD	8	1,896	1,896	0	NA	
In process	8/4/2016	Agency Draw	N 39.732400° W109.590700°	2	209	209	0	NA	
TOTAL					18,931	13,563	6,364		

Table A-2. Graham's Beardtongue Seed Currently in Ex situ Storage

Seed Accession Number	Collection Date	Location Name	Location Lat/Long NAD 83	# Individuals	# Seed Collected	Storage Location		Germination %	Germination Date
						RBG	NCGRP		
S-37	7/1/2004	Buck Canyon	N 39.737546° W109.502966°	2	10	10	0	NA	
S-275	7/6/2007	UNK	N 39.713786° W109.616498°	NA	~268	108	122	30%	2011
S-276	6/26/2007	UNK	N 39.725079° W109.339211°	NA	80	0	70	NA	
S-324	7/22/2008	Blue Knoll East	N 39.730186° W109.466520°	NA	227	206	0	NA	
S-325	7/22/2008	Blue Knoll	N 39.726626° W109.502046°	NA	350	330	0	NA	
S-326	7/22/2008	Buck Canyon	N 39.737546° W109.502966°	NA	418	418	0	NA	
S-354	7/22/2009	Colorado Border site, Park Canyon	N39.841155° W109.049945°	bulk	270	270	0	NA	
S-355	7/22/2009	Park Canyon	N 39.834756° W109.107818°	bulk	2231	2097	0	40%	
S-364	7/15/2009	Park Canyon	N 39.834756° W109.107818°	bulk	331	<331	0	41%	
S-365	7/16/2009	Blue Knoll East	N 39.730186° W109.466520°	NA	289	289	0	NA	
S-366	7/16/2009	Blue Knoll	N 39.726626° W109.502046°	NA	264	0	264	NA	
S-367	7/16/2009	Buck Canyon	N 39.737546° W109.502966°	NA	748	348	400	NA	
S-414	6/1/2010	Blue Knoll	N 39.726626° W109.502046°	NA	19	0	0	0%	12/2/2011

Table A-2. Graham's Beardtongue Seed Currently in Ex situ Storage

Seed Accession Number	Collection Date	Location Name	Location Lat/Long NAD 83	# Individuals	# Seed Collected	Storage Location		Germination %	Germination Date
						RBG	NCGRP		
S-415	6/1/2010	Blue Knoll East	N 39.730186° W109.466520°	NA	10	0	0	0%	12/2/2011
S-416	6/1/2010	Buck Canyon	N 39.737546° W109.502966°	NA	121	0	0	0%	12/2/2011
S-417	6/1/2010	Sunday School Canyon	N 39.663728° W109.435887°	NA	11	0	0	9%	12/2/2011
S-494	7/11/2013	Greenhouse F1 Parent P-324	N/A	1	900	400	450	29%; 16%; 25%; 0%	11/10/2014; 3/5/2015; 11/10/14; 12/8/2014
S-495	7/11/2013	Greenhouse F1 Parent P-317	N/A	1	2,570	1,172	1,285	29%; 16%; 25%; 0%	11/10/2014; 3/5/2015; 11/10/14; 12/8/2014
S-496	7/11/2013	Greenhouse F1 Parent P-316	N/A	1	1500	750	750	NA	
S-497	7/11/2013	Greenhouse F1 Parent P-315	N/A	1	1150	575	575	NA	
S-498	7/11/2013	Greenhouse F1 Parent P-314	N/A	1	356	150	156	29%; 16%; 25%; 0%	11/10/2014; 3/5/2015; 11/10/14; 12/8/2014
S-499	7/11/2013	Greenhouse F1 Parent P-322	N/A	1	307	104	154	29%; 16%; 25%; 0%	11/10/2014; 3/5/2015; 11/10/14; 12/8/2014
S-500	7/11/2013	Greenhouse F1 Parent P-319	N/A	1	575	352	123	NA	
S-520	7/22/2013	Sunday School Canyon	N 39.663728° W109.435887°	15	1106	1006	0	NA	

Table A-2. Graham's Beardtongue Seed Currently in Ex situ Storage

Seed Accession Number	Collection Date	Location Name	Location Lat/Long NAD 83	# Individuals	# Seed Collected	Storage Location		Germination %	Germination Date
						RBG	NCGRP		
S-526	7/22/2013	Blue Knoll site	N 39.726626° W109.502046°	6	238	238	0	NA	
S-527	7/22/2013	Blue Knoll East	N 39.730186° W109.466520°	9	632	632	0	NA	
S-528	7/22/2013	Buck Canyon	N 39.737546° W109.502966°	13	1073	973	0	NA	
S-582	7/22/2014	Blue Knoll East	N 39.730186° W109.466520°	18	1860	1760	0	NA	
S-583	7/22/2014	East of Blue Knoll East Site	N 39.732311 W 109.463065	11	599	599	0	NA	
S-584	7/21/2014	Buck Canyon	N 39.737546° W109.502966°	15	651	551	0	NA	
S-585	7/21/2014	Sunday School Canyon	N 39.663728° W109.435887°	7	171	171	0	NA	
In process	6/17/2016	Seep Ridge	TBD	1	6	6	0	NA	
In process	6/21/2016	Wrinkles Road	N 39.843965 W 110.142345	2	44	44	0	NA	
In process	6/22/2016	Buck Canyon	TBD	1	35	35	0	NA	
In process	7/6/2016	Seep Ridge	TBD	7	104	104	0	NA	
In process	8/4/2016	Seep Ridge	TBD[RSR2]	1	8	8	0	NA	
TOTAL					19,201	13,706	4,349	NA	

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APPENDIX B

Beardtongue Rare Plant Seed Collection Protocol

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BEARDTONGUE RARE PLANT SEED COLLECTION PROTOCOL

(Revised from Red Butte Garden Rare Plant Seed Collection Protocol 2013)

Based on Center for Plant Conservation methods described in "Ex situ Plant Conservation: supporting species in the wild" Editor Guerrant et al. 2004.

Field Collection Materials

1. Paper coin envelopes or cloth bags.
2. Scotch tape
3. Dry cooler to place bags/envelopes once seed is collected
4. GPS or Map to record location of seed collection
5. Tweezers
6. Magnifying loupe
7. Camera

Field Collection Methods

1. Seed will be assessed for maturity prior to collection. Only mature seeds will be collected.
2. Seeds may be collected at the time of natural dispersal either directly from the plants or from the ground immediately beneath the plant.
3. Only collect from healthy populations without presence of disease.
4. Confirm the species of plant you are collecting with an expert.
5. Take photographs the plant and habitat. Include pictures of the following: habitat, population, the whole plant, floral characteristics, vegetative characteristics, and seeds. Photograph any unusual observations as well, such as fungus, herbivory, habitat destruction, etc. if it is not typical for the species.
6. Fill out a seed collection data form (for the institute that the seed is being sent to) while in the field. Each site or population should get a new field data form.
7. Collect seeds along maternal lines in a separate envelope for each parent plant.
8. Label each envelope with the scientific name of the plant, date collected, approximate number of seeds in the envelope, and population name (Element Occurrence #, common place name, or GPS coordinates).
9. Seal envelopes using scotch tape to seal ALL seam at the top and bottom of the envelope. (Glue on the envelopes will not stick in hot dry conditions and leaves gaps for seeds to escape.)
10. **DO NOT ever use plastic bags for collection or storage** of the seeds as they need to remain dry, cool, and ventilated to remain viable.

Amount of Seed to Collect

1. Populations fewer than 50 individuals: Collect seed from all plants, 10% of available seed per plant.
2. Populations of 50+ individual plants: Collect seed from 50 plants if possible and 10% of available seed per plant.
3. Limit collections to no more than 10% of the seed available at the time of the visit.
4. Do not collect all of the seeds produced by one individual.

*As time and resources allow, collect from as many available populations as feasible, up to 50 populations. With small populations of fewer than 50 plants, it is critical to collect from many populations.

Guidelines for Selecting Populations

1. Keep in mind, we want to collect ecologically significant variation. That means collecting material from distinct individuals, at different times and from different habitats (Husband and Campbell 2004).
2. Do not select only the "best" looking plants for collection. A broad genetic representation is desired for the seed bank.
3. When there are many populations to select from, target the largest populations. Not only can transplant success be higher from propagules of larger populations (Helenurm 1998), but there is more variation, and a lower risk of extinction to the population from the seed collection.
4. **Do not** collect if it is your best judgment that any seed collection will be detrimental to the survival of that population.

Field Storage and Transport

Option 1: Keep seeds in a cooler. The seeds should still remain dry in the cooler so place cold packs or ice in a separate plastic container in the cooler.

Option 2: Keep seeds in a paper or cloth bag in the shade of a vehicle or tree. Keep seeds a parked vehicle with ALL windows open.

- Keep seeds cool and dry.
- **Do not** allow seeds to remain in a closed vehicle in the sun or on a warm day. A closed car can easily reach temperatures of 130+ F in the summer and even 30 minutes in a hot car can reduce seed viability.
- Seeds **cannot** be transported inside of a trunk of a vehicle unless in a cooler.
- While transporting seeds keep the above recommendations in mind. If taking a long rest stop while traveling the seeds must be kept in a cool location such as a cooler, motel room, or a back pack carried with you.

Shipment

1. Send seeds to the designated storage facility as soon as possible after collection.
2. Seeds being sent to NCGRP must be sent to Red Butte Garden first for accession. Mail seeds shipped overnight to the address listed below or hand deliver.
3. Ship to: Red Butte Garden and Arboretum
   Attn: Bruce Pavlik
   Conservation Department
   300 Wakara Way
   Salt Lake City, UT 84108

Questions or concerns should be directed to Bruce Pavlik at bruce.pavlik@redbutte.utah.edu (801) 585-5853.

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APPENDIX C

Seed Collection Maps

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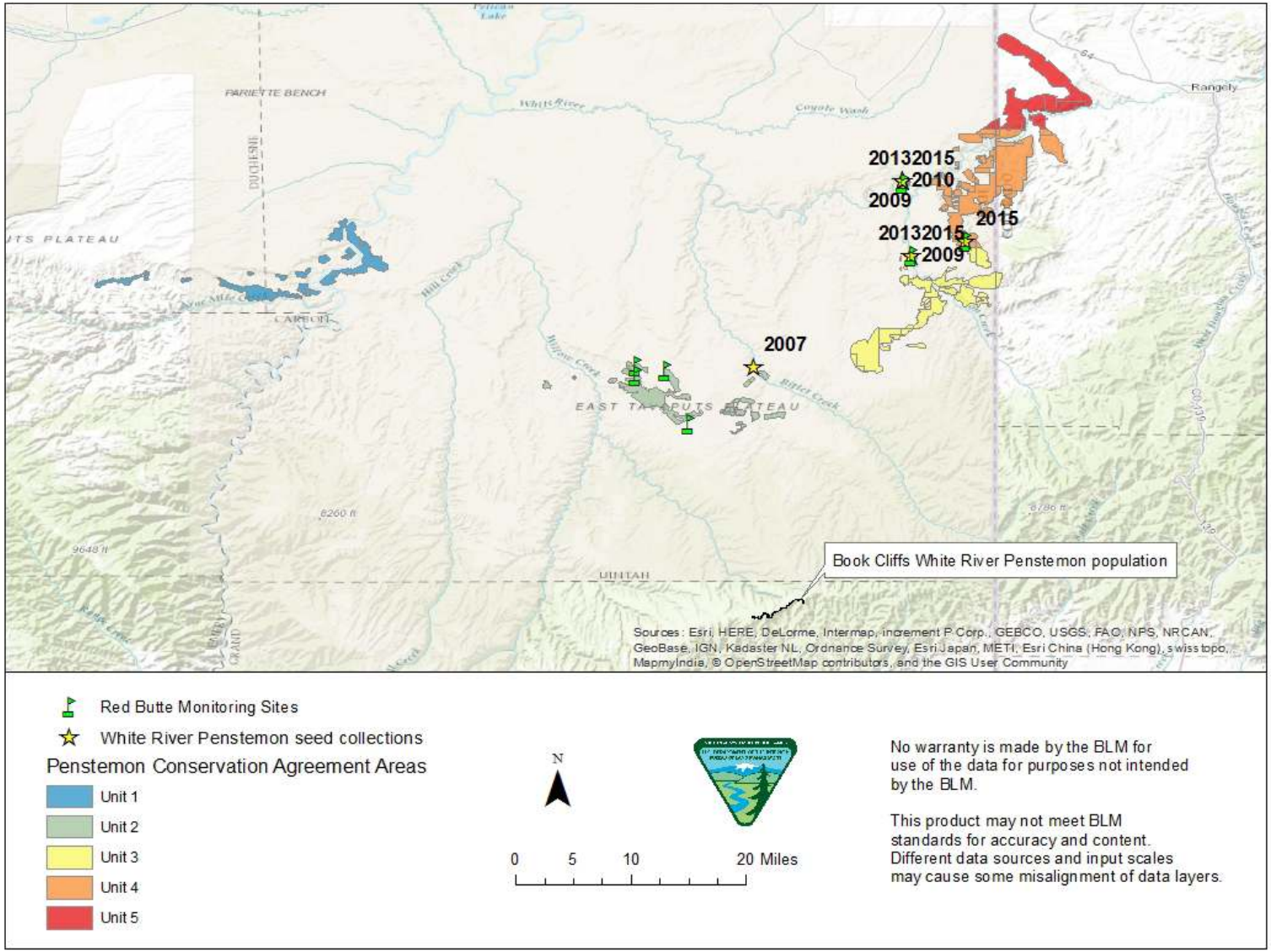

Figure C-1. Map of existing White River beardtongue seed collection locations.

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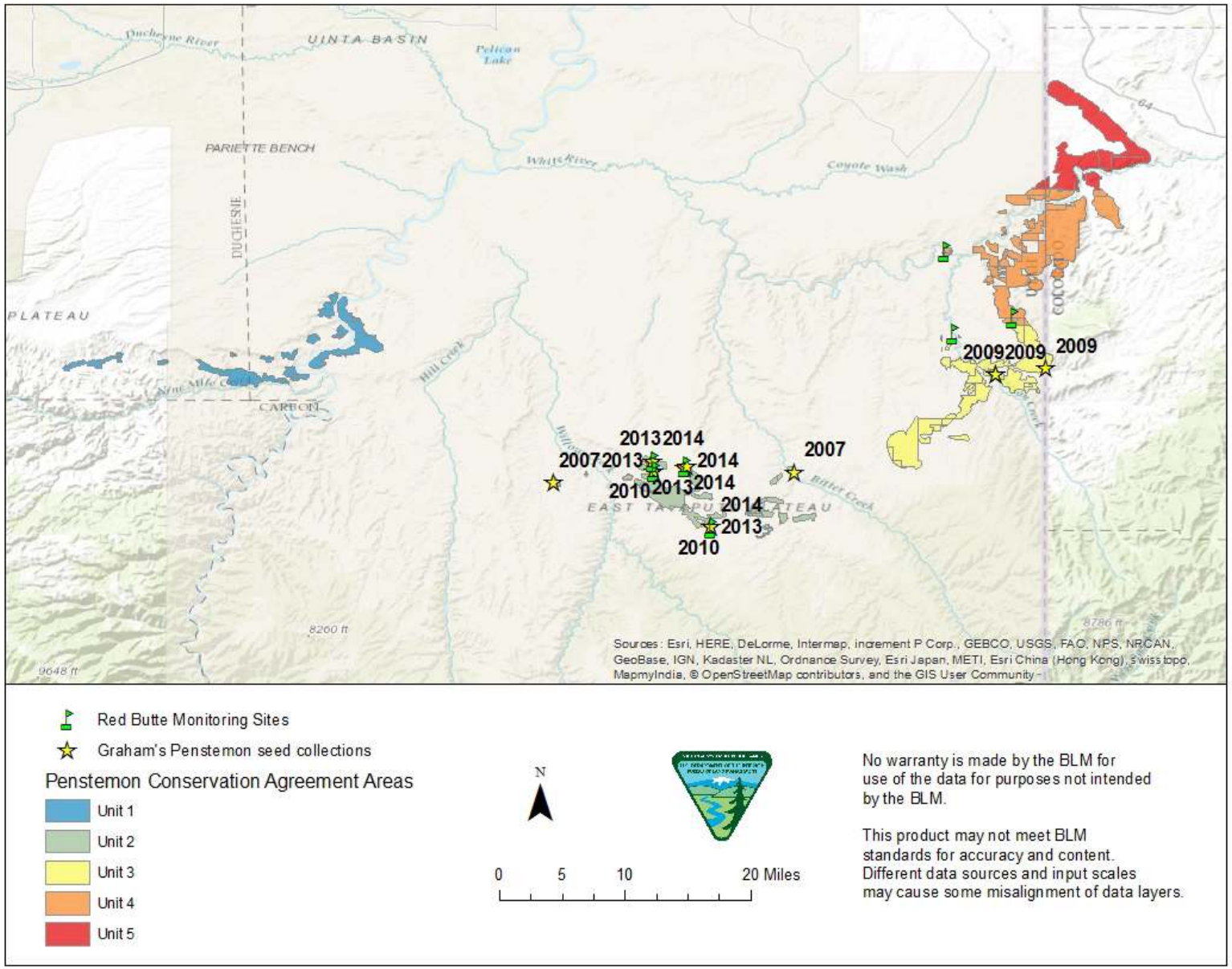

Figure C-2. Map of existing Graham's beardtongue seed collection locations.

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Appendix D

Rare Plant Seed Collection Form

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RARE PLANT SEED COLLECTION FORM

(Adapted from Red Butte Garden Collection form)

CPC Accession # _____

Date: _____ **Collector:** _____ **Other Accession #** _____

Family: _____ **Genus:** _____ **Species:** _____ **Variety:** _____

State: _____ **County:** _____ **Elevation (m):** _____

Reason Collected: _____

GPS/UTM Datum (NAD 83) N: _____ **E:** _____

Map name & type: _____ **Land Owner:** _____

Location Description: (Directions and Site)

_____

_____

_____

Seeds Collected from (Circle): *Plants Ground Both* **Seeds Collected (Circle):** *Bulk or Maternal Lines* **Collected at (circle)**: *natural dispersal immature Post-dispersal*

No. of Plants Found: _____ **No. of Plants Sampled:** _____ **Flower Date**: _____

 # seeds collected _____ **Area Sampled (m^2):** _____ **Plant Height (cm/m):** _____

Plant Habit (circle): *tree shrub forb grass succulent*

Habitat and Associated Species:

_____

_____

_____

Habitat Information (Circle):

Light:	Open	¼ Shade	½ Shade	¾ Shade	Full Shade
Slope:	0-5	6-10	11-40	41-60	>60
Exposure:	North	South	East	West	

Soil Type: _____ **Soil Color:** _____

Population Threats: _____

Land Use: _____

Additional Comments: _____

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Appendix B

2017 BLM VFO and WRFO Project Tracking for *Penstemon grahamii* and *P. albifluvis*

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Table B-1. BLM Vernal Field Office Penstemon Conservation Area Disturbance Tracking

Year	Project Title	NEPA number	Stage of NEPA/ Consultation	Disturbance in Penstemon Conservation Areas?	Conservation Areas Affected	Disturbance Type	Amount of Disturbance
2017	Enefit EIS	DOI-BLM-UT-G010-2014-0007-EIS	Final Draft, BA preparation for consultation	Yes	Unit 4	pipelines, powerlines, other utilities	
2017	Augusi Ridge	DOI-BLM-UT-G010-2018-EA	Initial NEPA writing phase	No	NA	NA	NA. Area outside of (but near to) known Penstemon habitat
2017	December 2017 Lease Sale	DOI-BLM-UT-G010-2017-0028-EA	Complete	No, but some parcels intersected Conservation Areas	Unit 1	Potential for O+G development, lessee would have valid existing right	None associated with leasing
2017	Theos	DOI-BLM-UT-G010-2015-0121-EA	Complete	Yes	Unit 4	Grazing impacts from cattle	Dispersed direct and indirect impacts from grazing over ~7000 acres of BLM, State and private land; difficult to quantify.
2017	Uintah County Buck Canyon Gravel Pit EA	DOI-BLM-UT-G010-2017-0016-EA	Draft stage	No	Unit 2 (and proposed new areas)	Gravel pit in wash	Indirect/direct impacts from dust, loss of native plant communities
2017	Rock Solid Stone Collection EA	DOI-BLM-UT-G010-2017-0064-EA	Draft stage	No	Unit 2 (and proposed new areas)	Surface disturbance, stone removal	Indirect/direct impacts from dust, erosion, stone removal, ATV tracks
2017	Book Cliffs Guzzlers Project EA	DOI-BLM-UT-G010-2017-0064-EA	Final Draft	Yes*	Unit 4	minimal surface disturbance	*None in or near habitat

Table B-1. BLM Vernal Field Office Penstemon Conservation Area Disturbance Tracking

Year	Project Title	NEPA number	Stage of NEPA/ Consultation	Disturbance in Penstemon Conservation Areas?	Conservation Areas Affected	Disturbance Type	Amount of Disturbance
						with guzzler construction, light cross country ATV use where needed	
NA	TBD	DOI-BLM-UT-G010-2018-xxxx-EA	Draft stage	No	Unit 2 (and proposed new areas)	Gravel pit in wash	indirect/direct impacts from dust, loss of native plant communities

Table B-2. BLM White River Field Office Penstemon Conservation Area Disturbance Tracking

Company/Applicant Name	NEPA Number	Project Name	Disturbed in Penstemon Conservation Area?	Amount of Disturbance (acres)	Species Affected	Disturbance Type
Robert Bayless LLC	Extention on previous NEPA DOI-BLM-CO-N05-2014-71CX	Bayless 23-7H2 well, extisting well pad	Yes	0	White River beardtongue	Gas well drilling
Robert Bayless LLC	DOI-BLM-CO-N05-2017-0021-EA	Application for Permit to Drill (APD) 15-1H	Yes	4.7	White River beardtongue, more than 300 feet away from occupied	Well pad expansion and well drilling
Glendon Barrett	DOI-BLM-CO-N05-2016-0109-DNA	Littleton Stake Trek SRP	Yes	0	Graham's beardtongue, 350m away	Hiking in the area, but 350 meters away from plants
	Various documents	Hunting SRPs	Yes	Unknown amount	White and Graham's	Hunting, disturbance unknown at this time

Appendix C

BLM VFO Conservation Agreement Surveys for Penstemon grahamii and Penstemon albifluvis in Duchesne and Uintah Counties, Utah

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

2017 Field Season Report

Prepared by:

BLM-VFO

Introduction

In 2017, BLM Botanists and interns surveyed three areas of BLM administered lands within the Uinta Basin for *Penstemon grahamii* and *Penstemon albifluvis* (Figure 1). We conducted all surveys in accordance with the Penstemon Conservation Agreement and in areas identified as gaps in the distribution of these two species. We documented 183 new *P. grahamii* during surveys in the Sunday School Canyon area, and 3,043 new *P. albifluvis* in the Willow Creek, Sunday School Canyon, and Book Cliffs areas. We also documented *Cryptantha grahamii*. All three areas could continue to be surveyed in 2018 to fill in gaps in information, in particular to document additional *P. albifluvis* in the Sunday School Canyon area where *P. grahamii* has already been found. Additional surveys conducted during range-wide monitoring plot establishment are not included in this report.

Methods

Prior to field surveys, GIS analyses identified distribution gaps to focus survey efforts. Field crews walked these areas in a meander-style survey with handheld GPS devices and marked locations of *Penstemon grahamii* and *Penstemon albifluvis*, or other special status plants. Both individual plants and clusters of plants were marked. We recorded negative point data where target species were not found. These data were uploaded into the Vernal Field Office TES geodatabase and were provided to the Utah Natural Heritage Program.

Results

About 7,850 acres were surveyed in 2017 from three identified survey areas, from north to south: Willow Creek (560 acres, Figure 2), Sunday School Canyon (6,320 acres; Figure 3), and Book Cliffs (970 acres; Figure 4), though the entirety of these areas were not surveyed and gaps in point data could continue to be surveyed in future years.

We found 183 new *Penstemon grahamii* in Sunday School Canyon (Figure 2) and 3,043 new *Penstemon albifluvis* across all three survey areas. We documented 133 new *Cryptantha grahamii*.

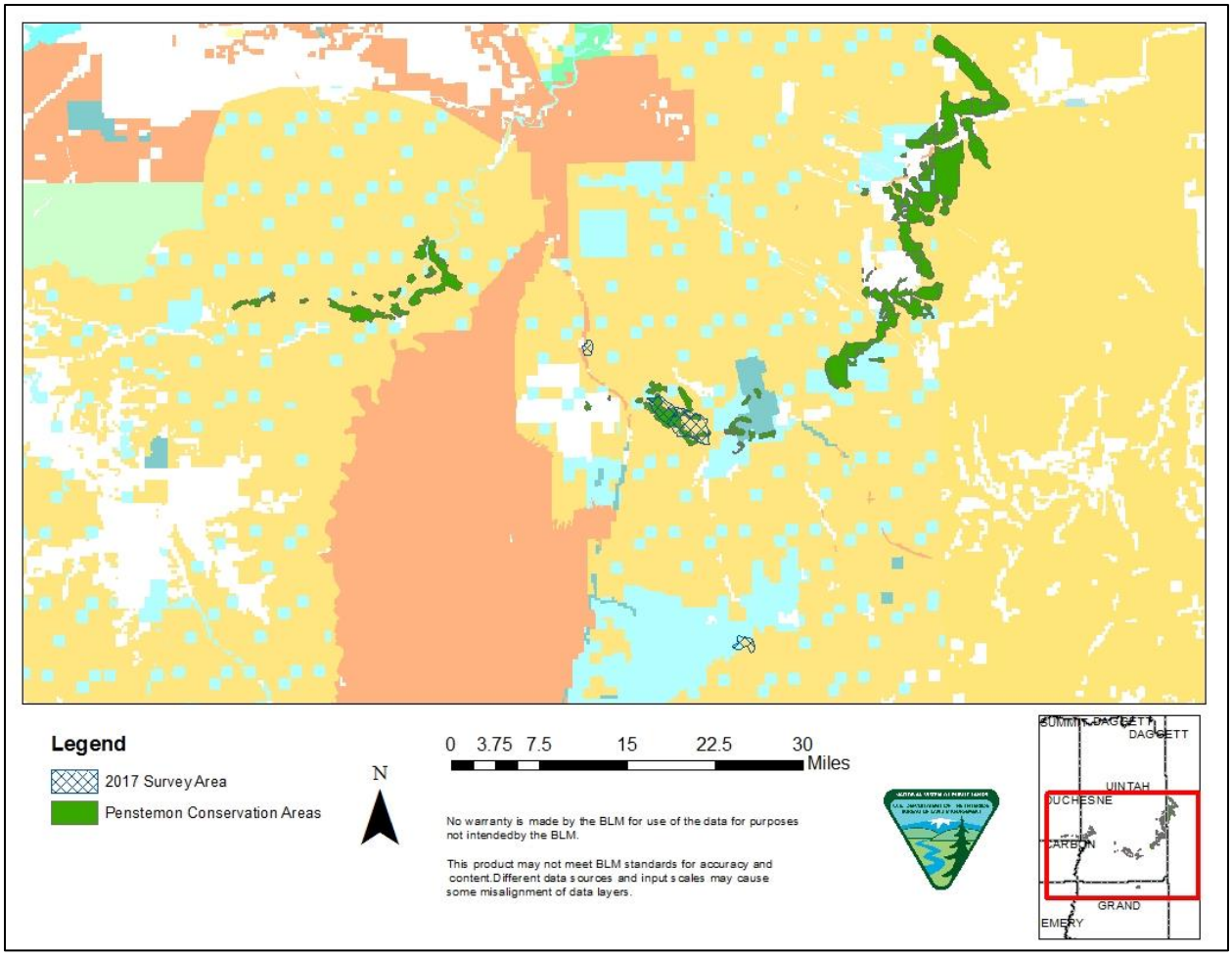

Figure 1. Overview map of the 2017 survey areas and Penstemon Conservation Agreement Areas.

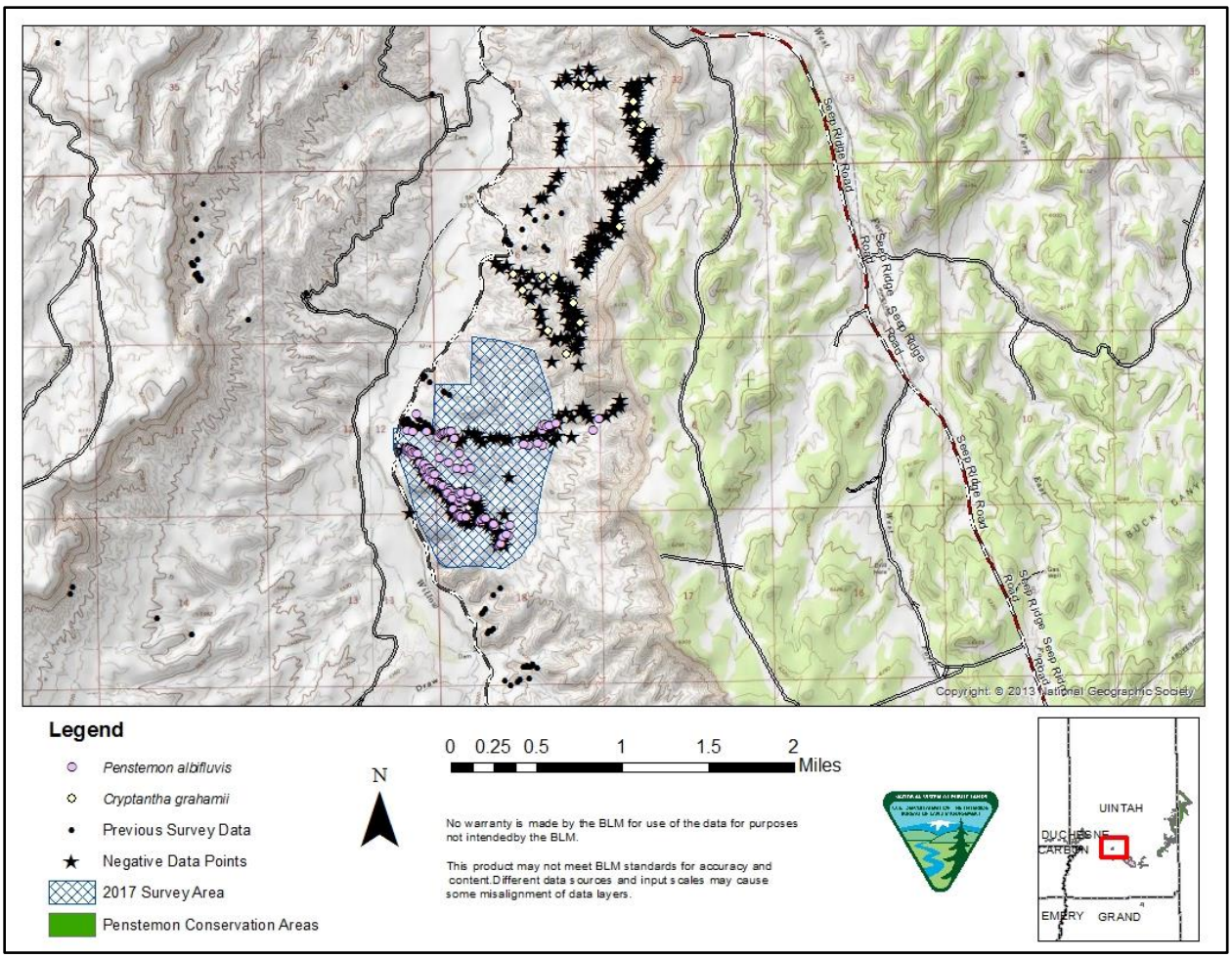

Figure 2. Map of the Willow Creek survey area. Colored dots indicate plants found, and black dots indicate previously existing data. Stars represent negative data, typically (but not always) in suitable habitat.

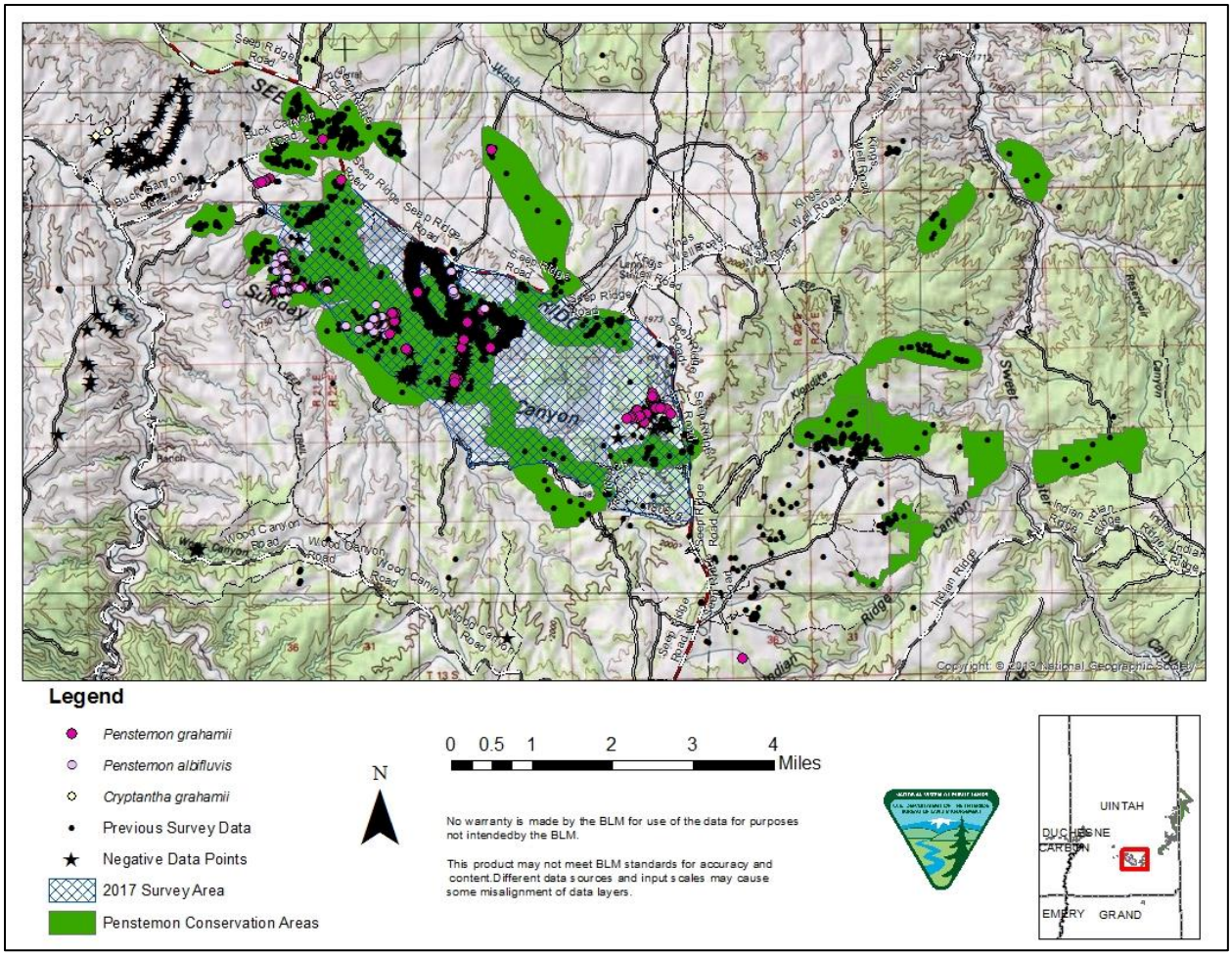

Figure 3. Map of the Sunday School Canyon survey area. Colored dots indicate plants found, and black dots indicate previously existing data. Stars represent negative data, typically (but not always) in suitable habitat.

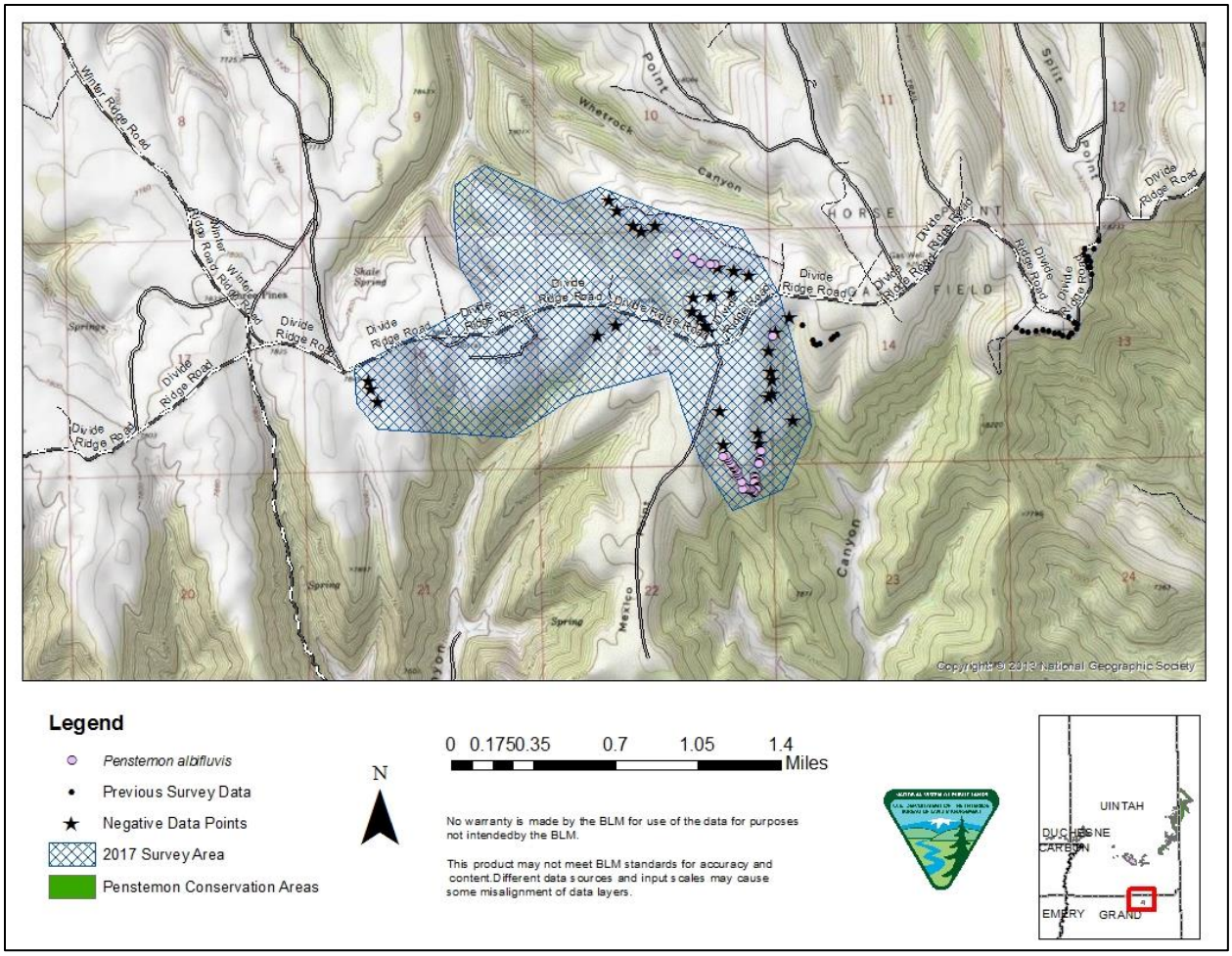

Figure 4. Map of Book Cliffs survey area. Colored dots indicate plants found, and black dots indicate previously existing data. Stars represent negative data, typically (but not always) in suitable habitat.

Appendix D

USU Uinta Basin Penstemon Survey Report May- June 2017

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Uinta Basin Penstemon Survey (May- June 2017)

Prepared for:

Penstemon Conservation Team

Uinta County, Utah

Rio Blanco County, Colorado

Utah State Trust Lands Administration

US Fish and Wildlife Service

State of Utah

Bureau of Land Management – Vernal Field Office and White River Field Office

Prepared By:

State of Utah DNR

Utah State University – Wildland Resources Dept

Contents

Executive Summary 3
Introduction 3
Methods 3
Results 5
Discussion 5
Appendix – Survey Maps 6

Executive Summary

A plant survey conducted by Utah State University (USU) was completed in May and June of 2017 for the 2 rare Uinta Basin penstemons –Graham's penstemon (*Penstemon grahamii*) and White River penstemon (*P. albifluvis)*. Sites to survey were chosen by a combination of discussions within the Penstemon Conservation Team and opportunistic, intuitive controlled surveys completed by Utah State University in the Uinta Basin. General areas surveyed include Sunday School Canyon in the Seep Ridge Unit, areas north and south of the Seep Ridge Unit, and west of the Sand Wash Unit. (See Figure 1 and Appendix). USU crews completed surveys for *Pentsemon grahamii* and *P. albifluvis* over approximately 821 acres using an estimated 300 person hours. In that time, the crew found and counted 1,449 *Penstemon grahamii* plants and 2,151 *Penstemon albifluvis* plants.

Introduction

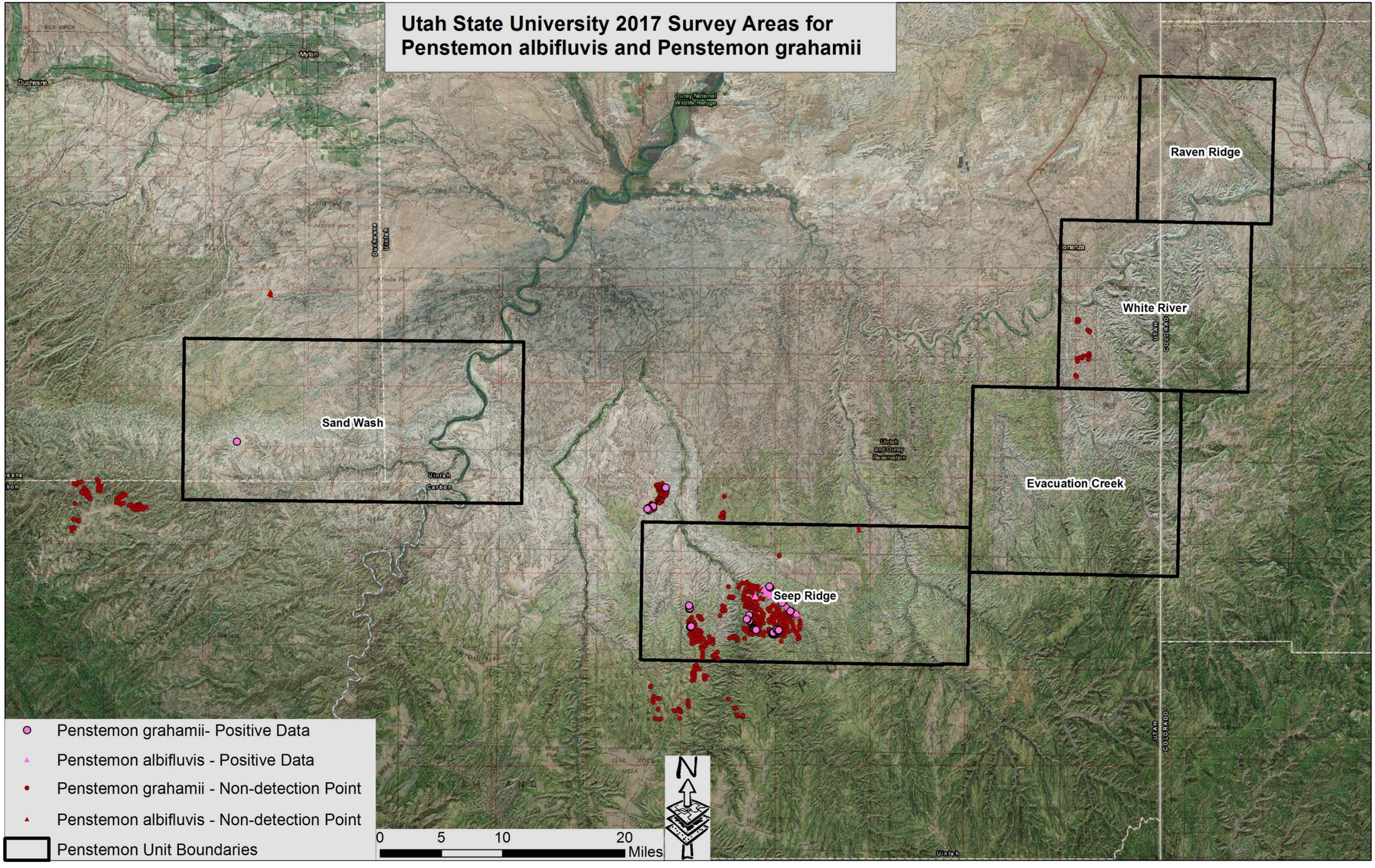
As a representative on the Penstemon Conservation Team, the State of Utah via the Department of Natural Resources Rare Plant Conservation Coordinator has been participating in meetings since November of 2016. Active participation by all members of the Team has provided ongoing input to the various conservation and management plans and actions set forth in the original Penstemon Conservation Agreement signed in 2014. The results of this survey is part of the Penstemon Conservation Team's efforts to fill information gaps on penstemon distribution and abundance.

Methods

Discussions in Penstemon Conservation Team meetings concerning data needs generated several priority areas for needed information regarding plant distribution and abundance. Potential survey polygons were then digitized and uploaded on survey crew tablets for field surveys. Once the digitzed polygons were reached, the survey crew traversed the polygons to search for and map any rare plants encountered. Crews often surveyed additional areas of exposed Green River shale formation outside the digitized polygons if suitable habitat were present. If no rare plants were detected, surveyors put a 'non-detection' point on the survey tablets every 250 meters along the travel / walking route (horizontal accuracy usually +/- 3 meters). If rare plants were found, the crew counted the number of reproductive and non-reproductive plants within a 15 meter radius of the point – the default radius on the tablets. If 15 meters was not a reasonable area in which to count the number of plants, the crew used professional judgment to decrease (and in rare situations increase) the radius in which to count plants and enter into the tablets. Other information entered into the tablets (largely drop-down menu driven) included date, surveyor name, surveyor affiliation, photo, other potential rare target species found, associated species, weeds found, potential threats and additional notes.

The number of acres surveyed were calculated by buffering the survey route by 15 meters on each side, then calculating acres. This could be an under-representation of the total number of acres surveyed as often surveyors will diverge from a given survey path to assess suitable habitat, but would not necessarily be registered on the GPS unit.

Figure 1. Overview of areas surveyed by USU for rare Penstemon in 2017.



Results

The most fruitful survey efforts were in the Sunday School Canyon area where 1,161 Graham's penstemon and 2,151 White River penstemon were found and counted. Table 1 shows the results of the other areas surveyed in 2017. Three additional *P. grahamii* plants were found and counted within the Sand Wash Unit on an opportunistic survey effort.

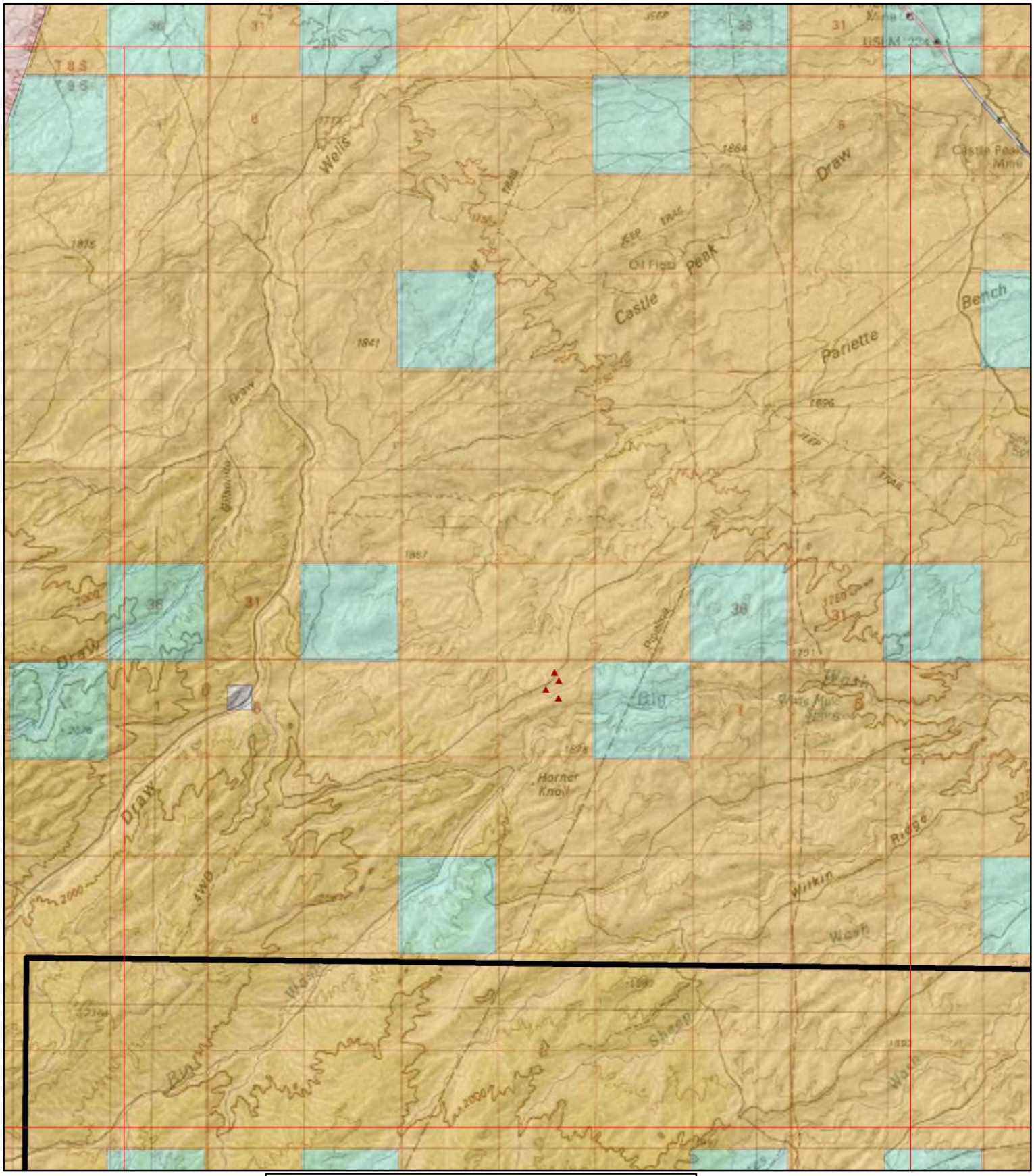
Table 1. 2017 Utah State University Uinta Basin *Penstemon* survey results

Place Name	Unit Name	Approx. acres surveyed	# P. grahamii plants	# P. albifluvis plants
Hwy 45 and Hell's Hole Road	White River	34	0	0
E of Big Pack Mtn, W of Willow Creek	North of Seep Ridge	75	90	0
S of Sunday School Canyon	Seep Ridge	386	1,161	2,151
W of Sunday School Canyon, E of Agency Draw	Seep Ridge	138	195	0
E of Agency Draw, W. of Willow Creek	South of Seep Ridge	110	0	0
W of Sand Wash - S. of 9 mile Ck	West of Sand Wash	78	0	0
TOTALS		**821**	**1446**	**2151**

Discussion

Prior to these surveys, the Sunday School Canyon area was suspected to be particularly suitable habitat. The numbers of both penstemon species in this area confirmed this notion. The areas around Agency Draw and the East side of Big Pack Mountain also yielded additional occupied suitable habitat for Graham's penstemon. The Penstemon Conservation Team continues to discuss other data gaps for research needs as well as penstemon distribution and abundance with the intent to better protect and manage these plants into the future.

Appendix – Survey Maps



Penstemon Unit Boundaries

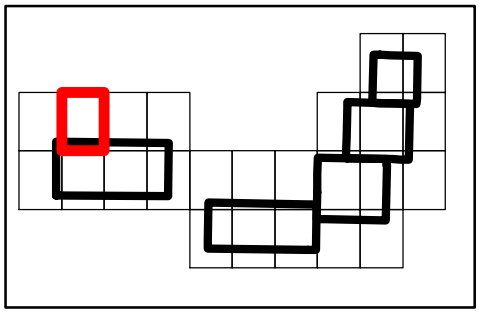
LandOwnership

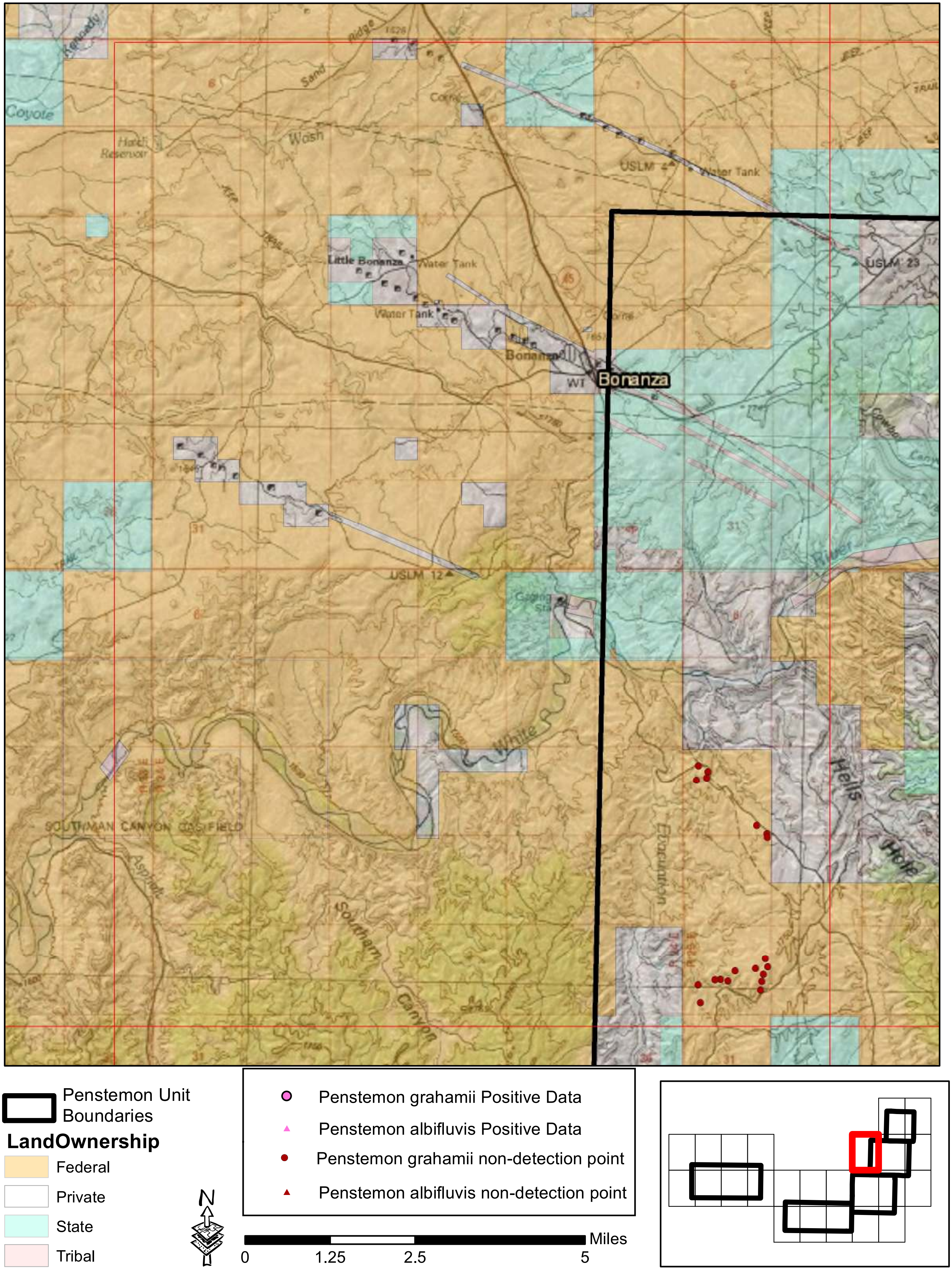
- Federal
- Private
- State
- Tribal

N

- Penstemon grahamii Positive Data
- Penstemon albifluvis Positive Data
- Penstemon grahamii non-detection point
- Penstemon albifluvis non-detection point

0 1.25 2.5 5 Miles




Coyote
Sand
Wash
Corral
USLM 4
Water Tank
Little Bonanza
Water Tank
Bonanza
WT
Bonanza
USLM 23
USLM 12
White
River
Hells
Hole
Evacuation
SOUTHMAN CANYON GAS FIELD
Southam
Canyon
Penstemon Unit Boundaries
LandOwnership
Federal
Private
State
Tribal
N
Penstemon grahamii Positive Data
Penstemon albifluvis Positive Data
Penstemon grahamii non-detection point
Penstemon albifluvis non-detection point
Miles
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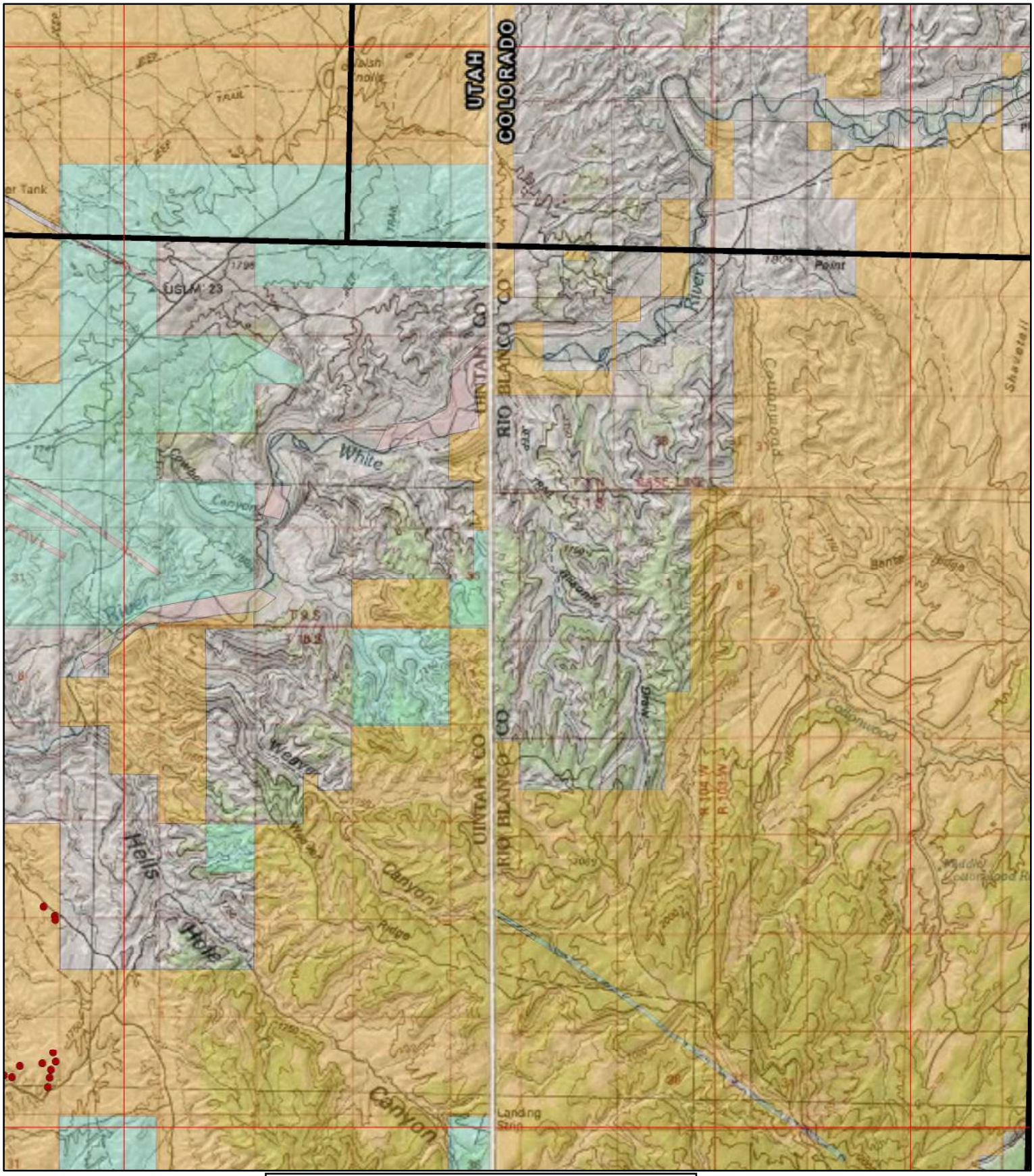


Penstemon Unit Boundaries

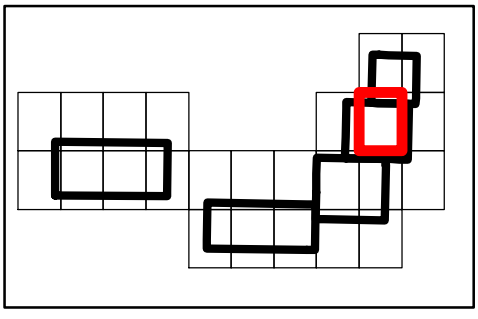
LandOwnership

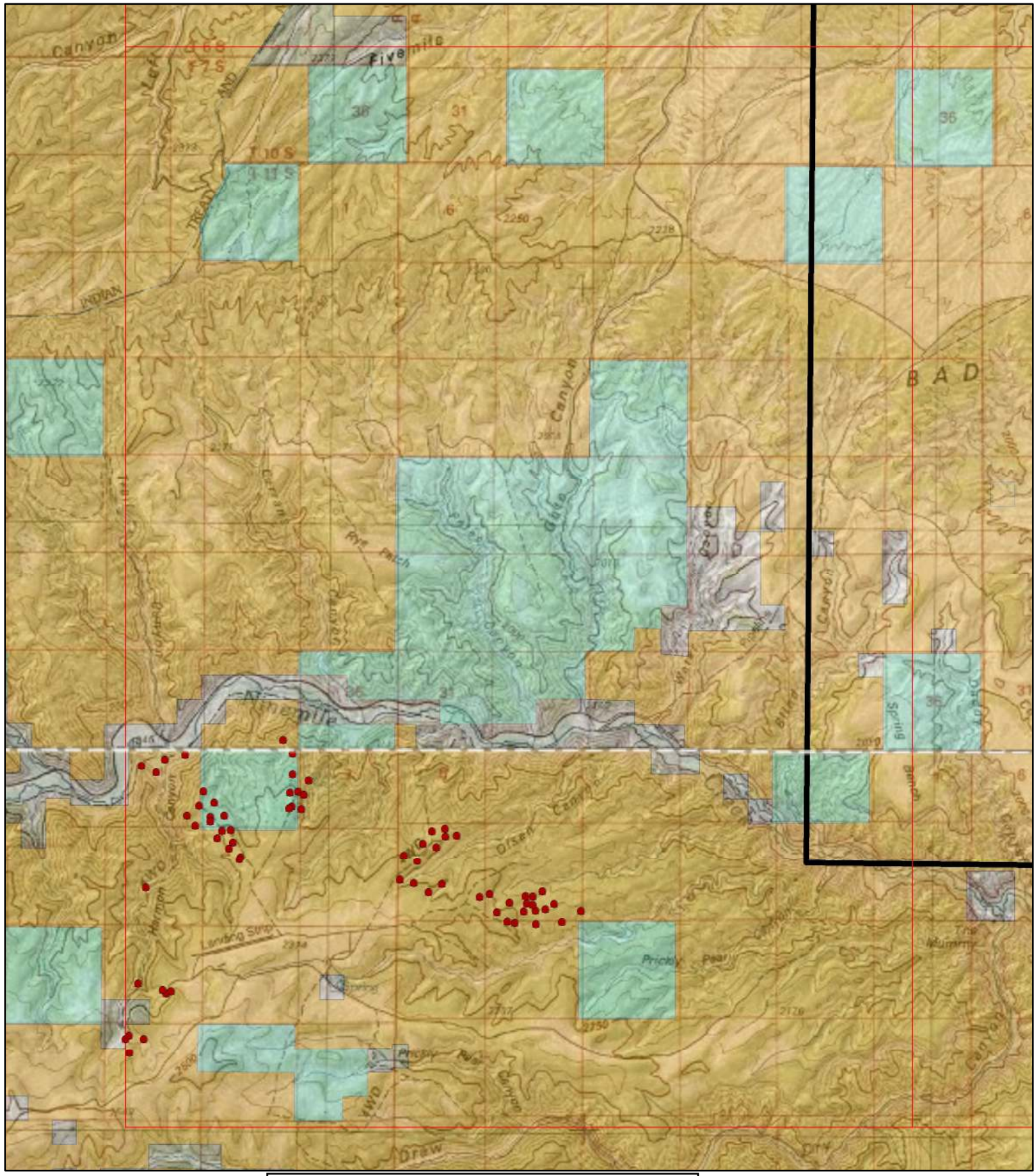
- Federal
- Private
- State
- Tribal

- Penstemon grahamii Positive Data
- Penstemon albifluvis Positive Data
- Penstemon grahamii non-detection point
- Penstemon albifluvis non-detection point

N

0 1.25 2.5 5 Miles




Penstemon Unit Boundaries
LandOwnership
Federal
Private
State
Tribal
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Penstemon grahamii Positive Data
Penstemon albifluvis Positive Data
Penstemon grahamii non-detection point
Penstemon albifluvis non-detection point
Miles
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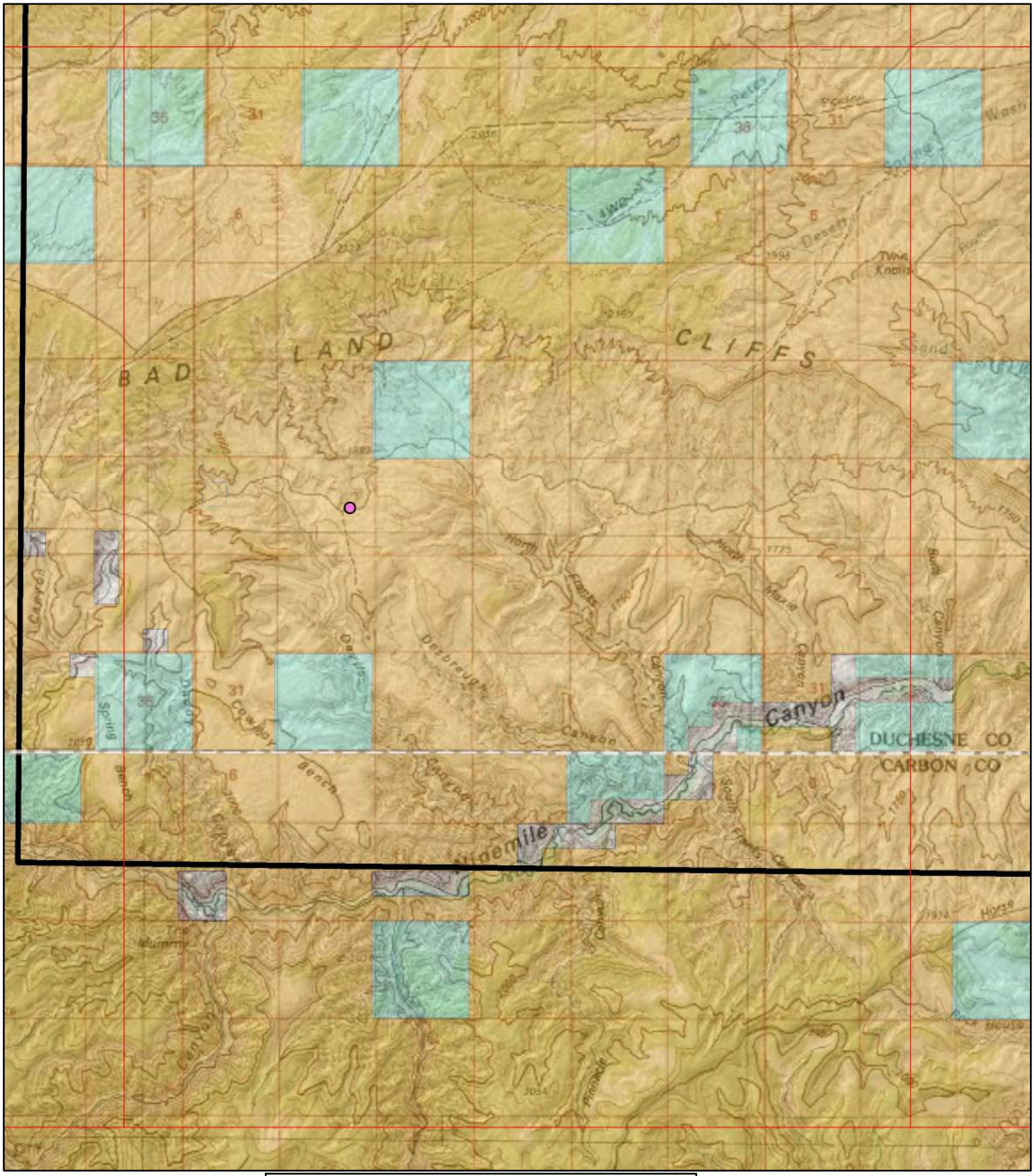
BAD LAND CLIFFS
DUCHESNE CO
CARBON CO
Canyon
Penstemon Unit Boundaries
LandOwnership
Federal
Private
State
Tribal
Penstemon grahamii Positive Data
Penstemon albifluvis Positive Data
Penstemon grahamii non-detection point
Penstemon albifluvis non-detection point
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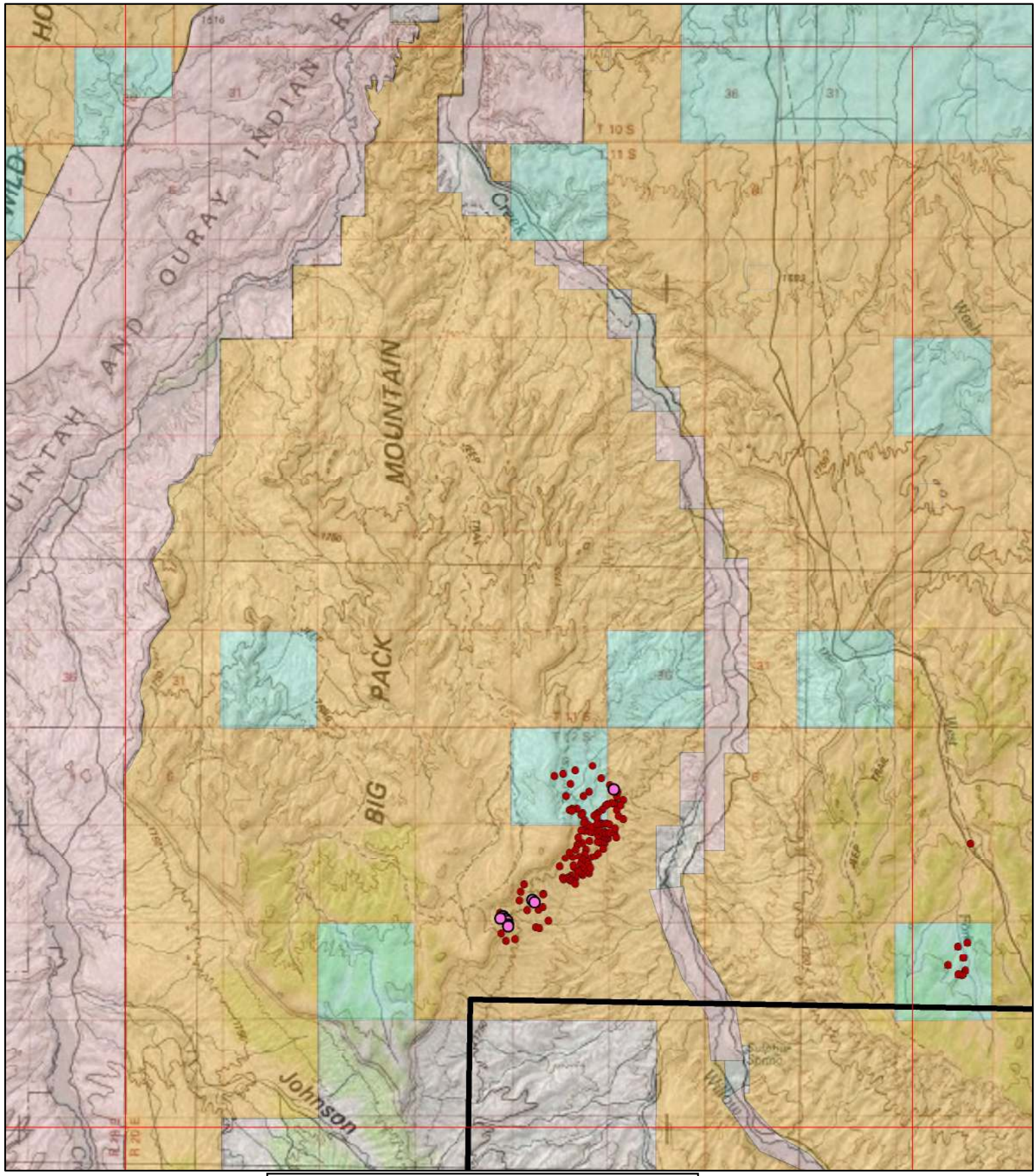
Miles



Penstemon Unit Boundaries

LandOwnership

- Federal
- Private
- State
- Tribal

- Penstemon grahamii Positive Data
- Penstemon albifluvis Positive Data
- Penstemon grahamii non-detection point
- Penstemon albifluvis non-detection point

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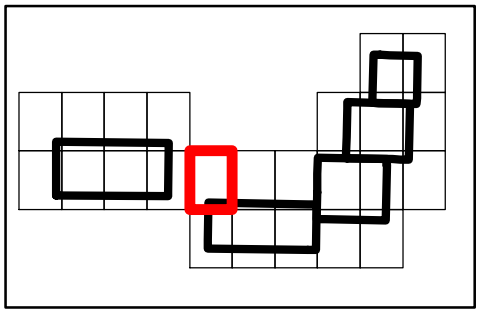

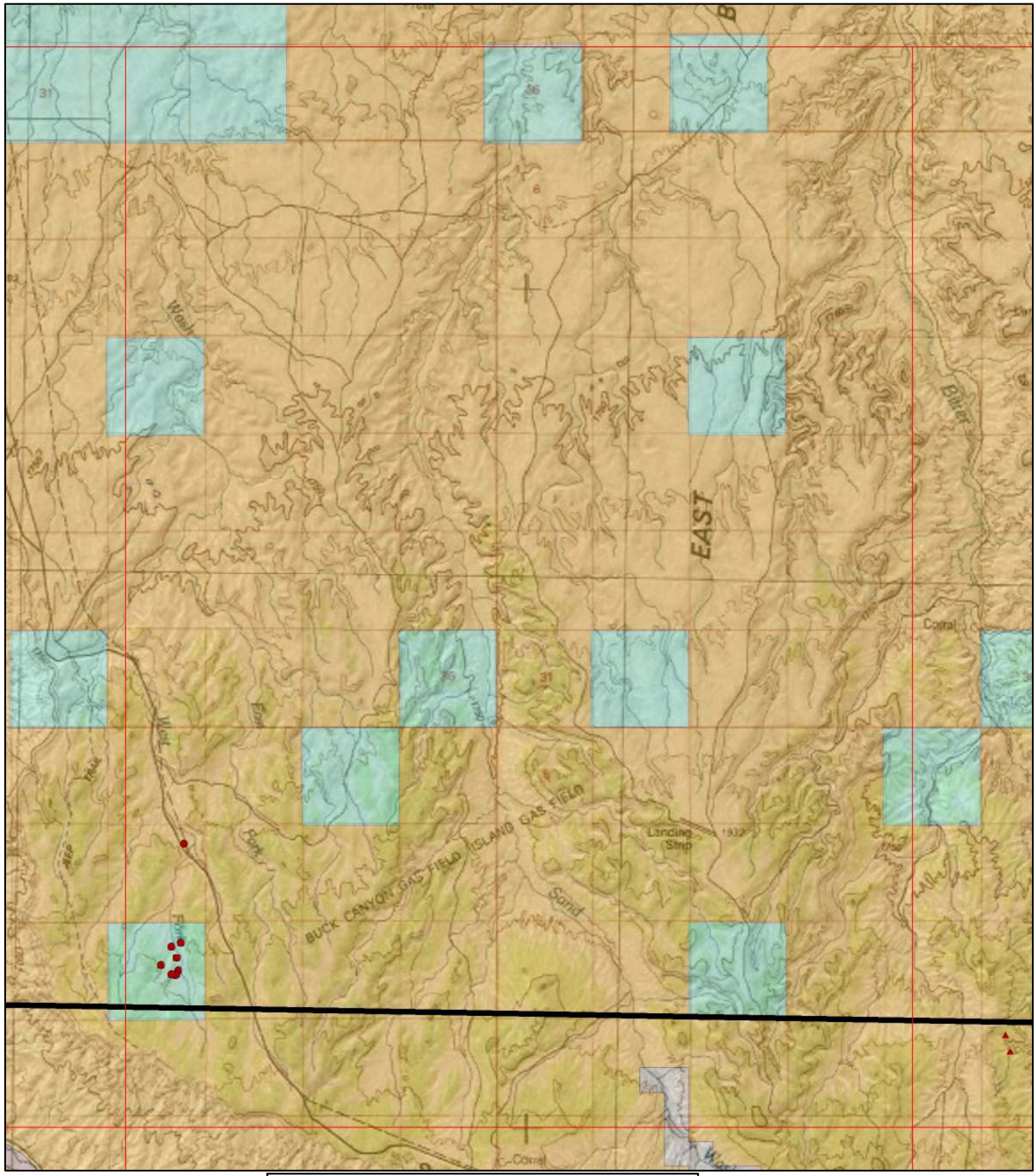
EAST
BUCK CANYON GAS FIELD
ISLAND GAS FIELD
Landing Strip
Corral
Sand
Penstemon Unit Boundaries
LandOwnership
Federal
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Tribal
Penstemon grahamii Positive Data
Penstemon albifluvis Positive Data
Penstemon grahamii non-detection point
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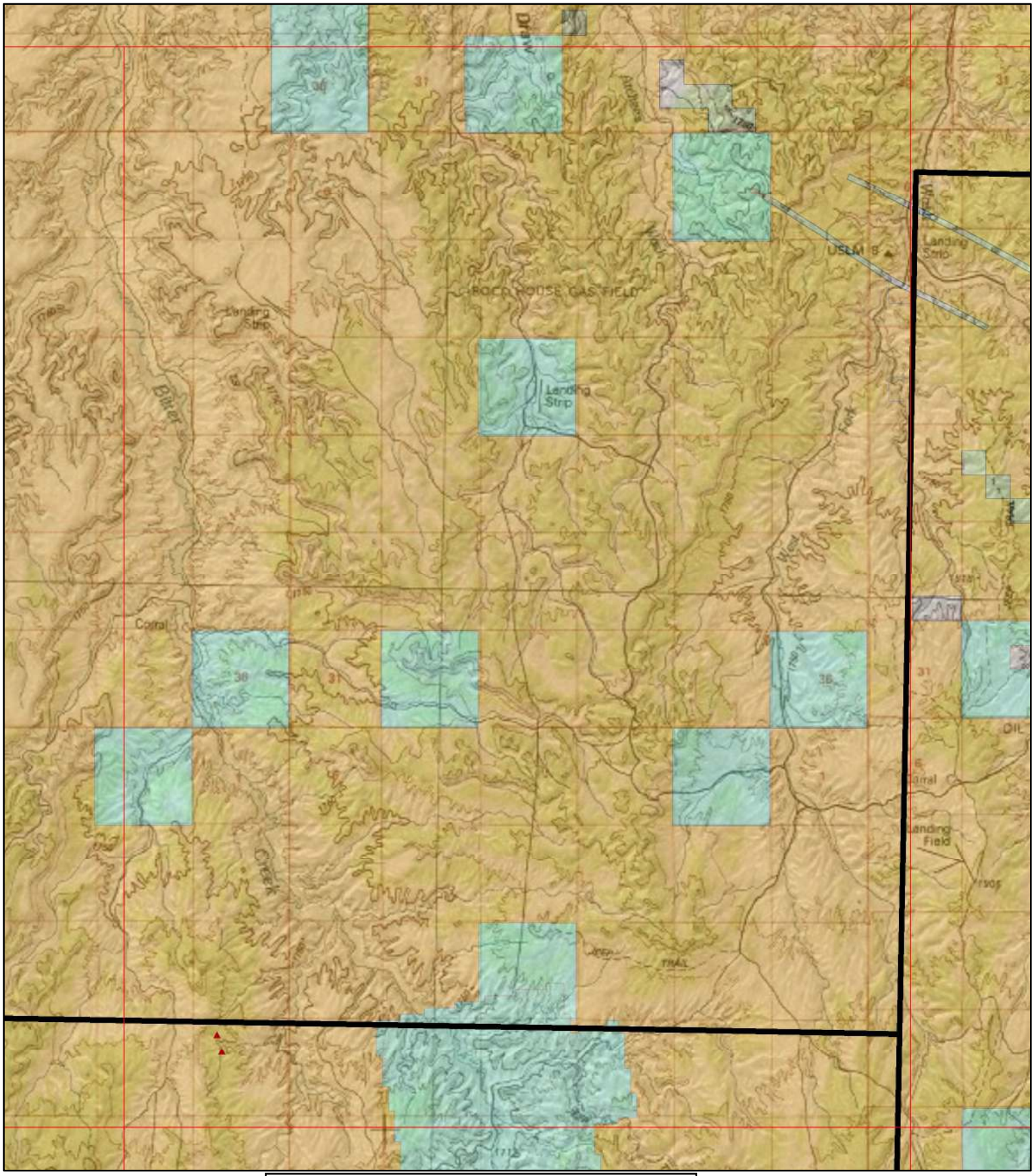
ROCK HOUSE GAS FIELD
Landing Strip
Landing Strip
Landing Strip
Landing Field
Corral
Bitter
Creek
Fork
TRAIL
Penstemon Unit Boundaries
LandOwnership
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Private
State
Tribal
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Penstemon albifluvis Positive Data
Penstemon grahamii non-detection point
Penstemon albifluvis non-detection point
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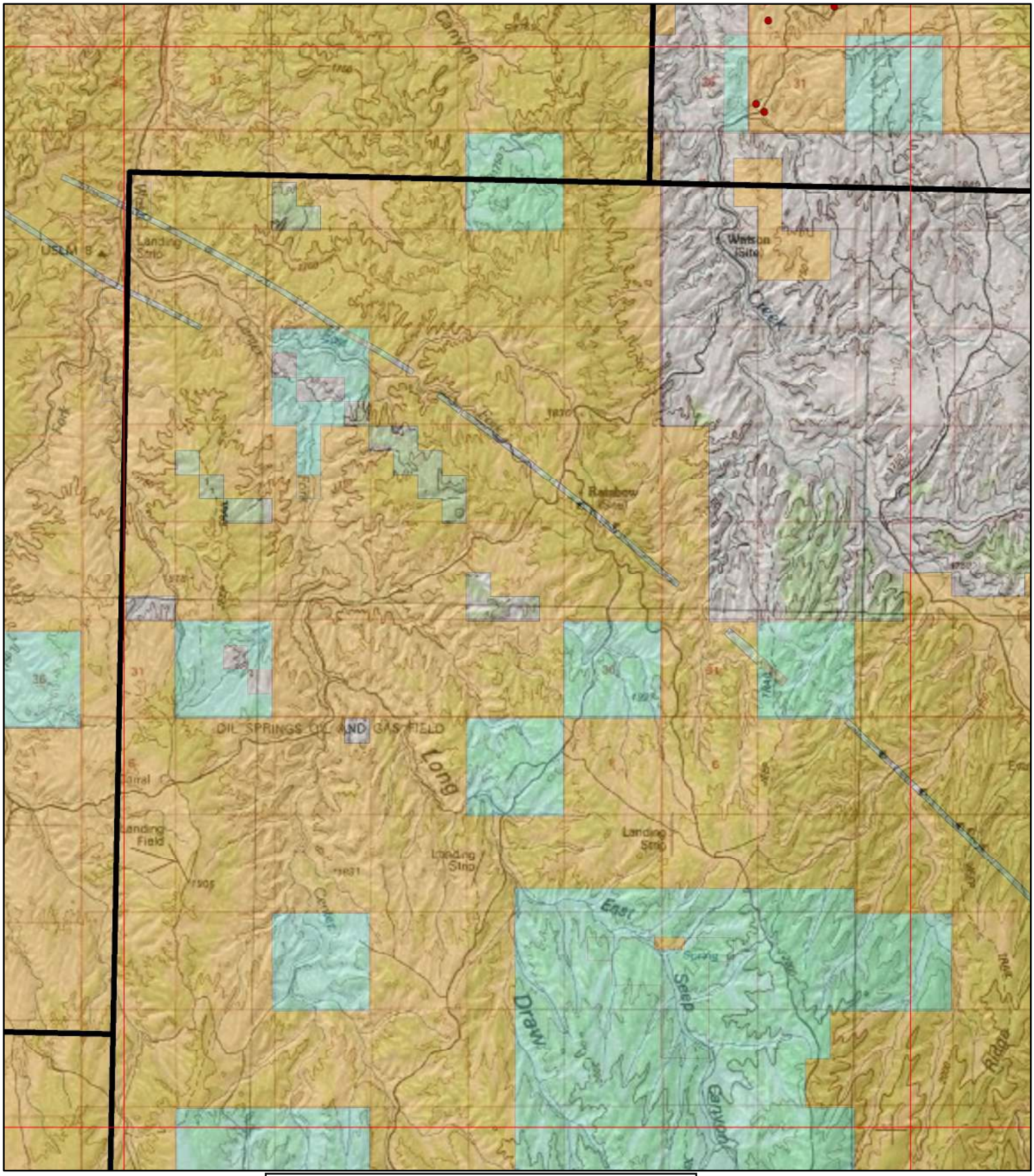
Penstemon Unit Boundaries
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Tribal
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Penstemon albifluvis Positive Data
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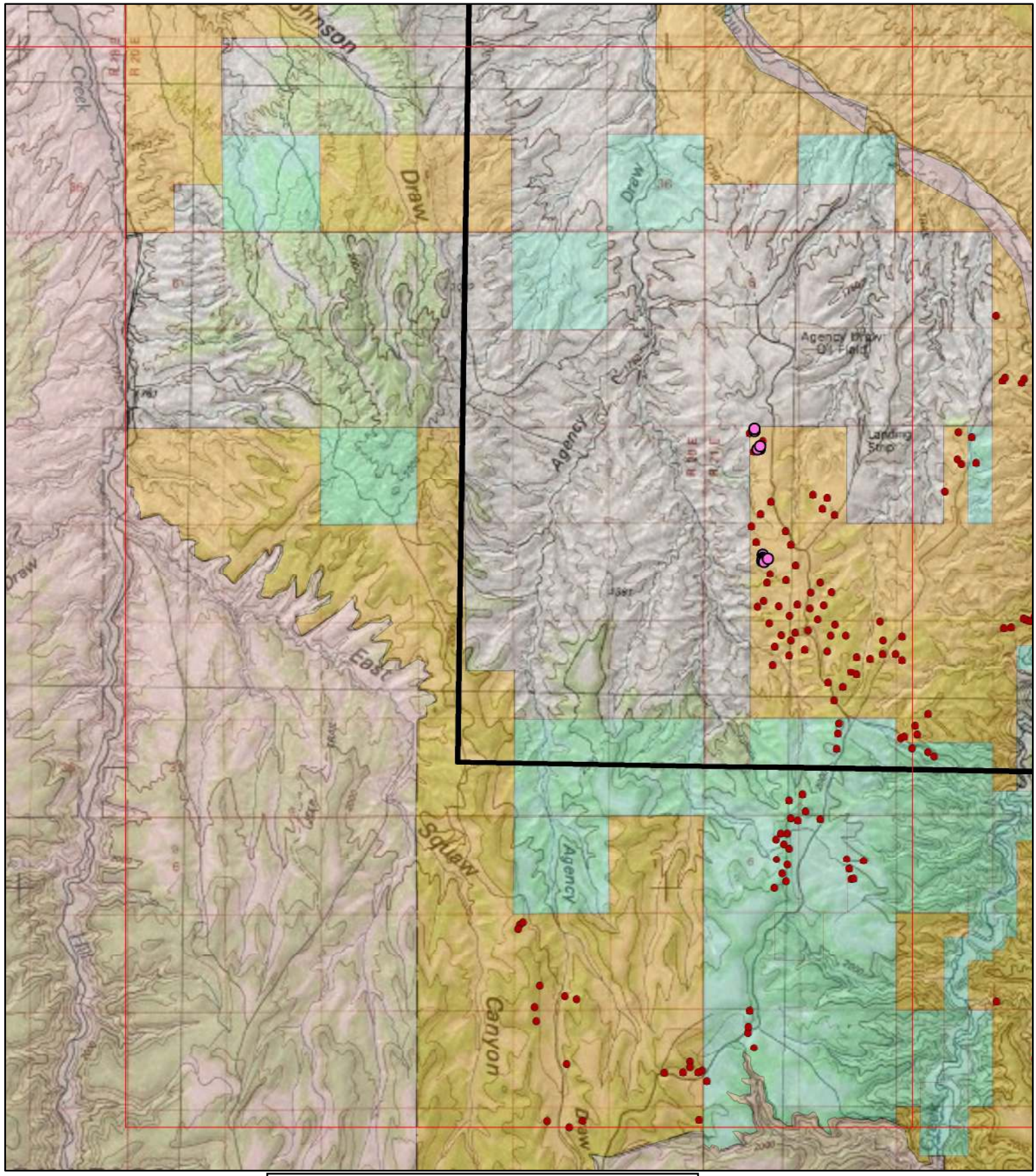
Penstemon Unit Boundaries
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Penstemon albifluvis Positive Data
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Penstemon albifluvis non-detection point
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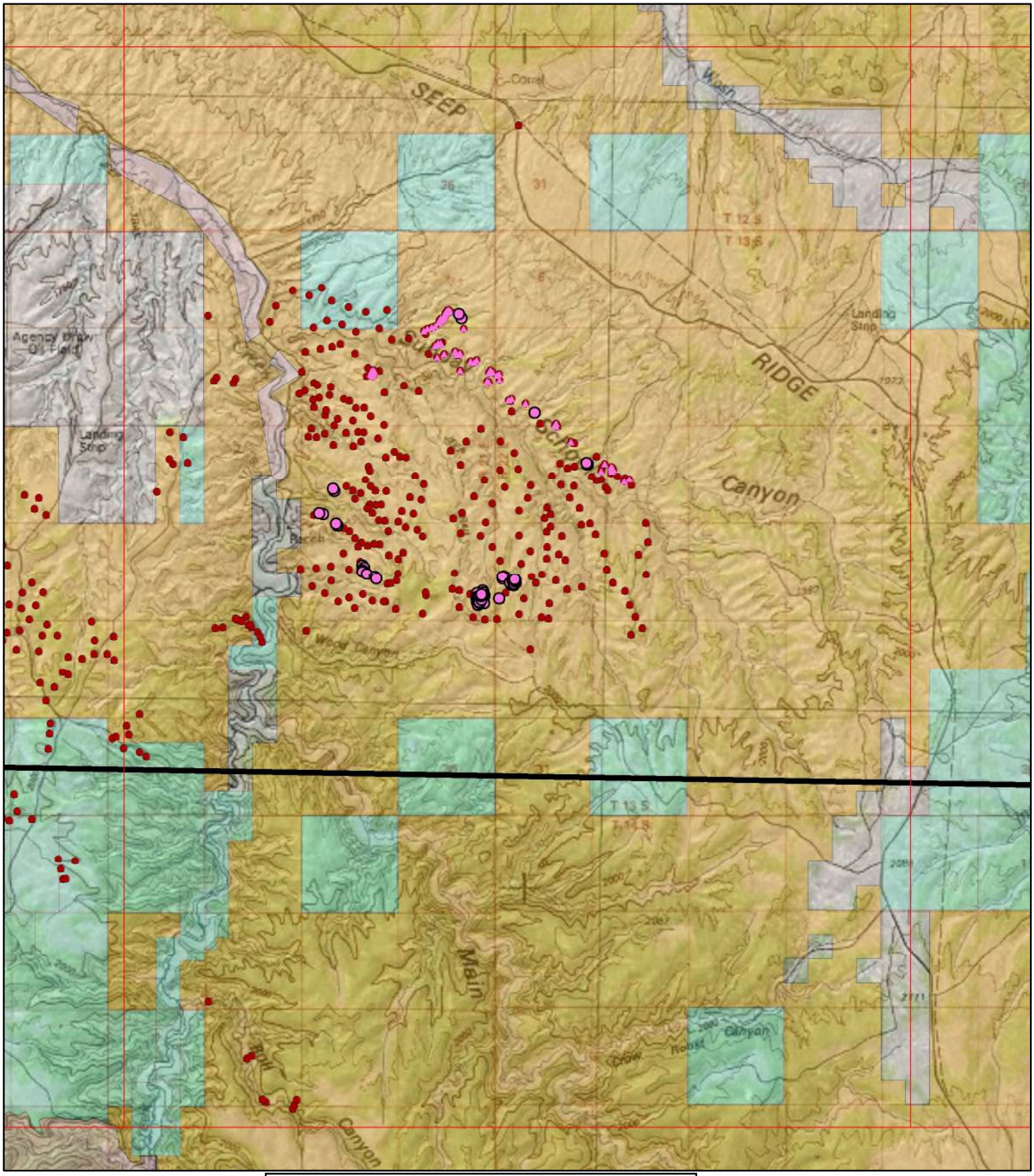

Penstemon Unit Boundaries

LandOwnership

- Federal
- Private
- State
- Tribal

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- Penstemon albifluvis Positive Data
- Penstemon grahamii non-detection point
- Penstemon albifluvis non-detection point

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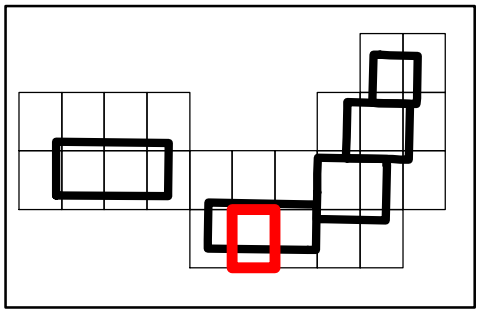

Appendix E

White River Beardtongue (*Penstemon albifluvis*) Reproductive Success 2017 Pilot Study Report

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White River Beardtongue (*Penstemon albifluvis*) Reproductive Success 2017 Pilot Study Report

Hornbeck, J.H. 2018. White River Beardtongue (*Penstemon albifluvis*) Reproductive Success 2017 Pilot Study Report. Manzanita Botanical Consulting, Salt Lake City, Utah.

Introduction

The objective of this pilot study was to quantify the effects of surface disturbance on the reproductive success of the rare shale-endemic plant species, Graham's beardtongue (*Penstemon grahamii*) and White River beardtongue (*Penstemon albifluvis* [syn. *P. scariosus* var. *albifluvis*]). Because 2017 was a poor flowering year for Graham's beardtongue, we focused pilot efforts on White River beardtongue with the intention of refining the methods and duplicating the study for both species in future years. The study objectives and methods were developed collaboratively between the Penstemon Conservation Team (2014), J. Hope Hornbeck (Manzanita Botanical Consulting), Vince Tepedino (USDA Agricultural Research Service), and Trent Toler (High Desert Ecological).

In March 2017, Mindy Wheeler, Utah Rare Plants Conservation Coordinator, met with Utah federal agency botanists (Rita Reisor, Jena Lewinsohn, Jessi Brunson) and Manzanita Botanical (J. Hope Hornbeck). The purpose of the call was to identify approaches for evaluating the effects of disturbance on pollinator movements and *Penstemon* reproductive success. This information is considered a priority need by USFWS due to challenges to the sufficiency of a 300-foot disturbance buffer around threatened, endangered, and sensitive plant species in the Uinta Basin. The primary question being addressed is: Is pollinator activity, abundance, or diversity limited by surface disturbance? In this pilot effort, we address this question for White River beardtongue using the average number of seeds per fruit as a surrogate measure of pollinator visitation. Our working hypothesis is that the average number of seeds per fruit will decrease with increasing proximity to surface disturbance.

In May 2017, the Penstemon Conservation Team discussed the implementation of a reproductive success pilot study using FY2017 Utah Endangered Species Mitigation Fund (ESMF) funding through June 2017. This pilot project also meets, in part, seed collection objectives for July-August 2017.

Methods

Following the March conference call, Mindy Wheeler contacted Trent Toler, an ecologist and entomologist who has worked with Vince Tepedino on other beardtongue reproductive biology projects (Tepedino et al. 2007). Mr. Toler contacted Dr. Tepedino, and provided recommendations for the study design and reproductive success monitoring methods to Mindy Wheeler and J. Hope Hornbeck. J. Hope Hornbeck and Trent Toler finalized the 2017 study targets and methods in May 2017. Spatial analyses of beardtongue locations relative to the Penstemon Conservation Area (CA) disturbance layer developed by the Penstemon Conservation Team in 2015 were completed by SWCA GIS specialists as part of the ESMF FY2017 project.

Study Site and Plant Selection

In June 2017, we selected nine study sites and 228 individual *P. albifluvis* plants in Uintah County, Utah. We selected sites to represent three levels of distance from the CA disturbance layer (primarily native surface and two-track roads): less than 100-meters, between 100 and 300-meters, and greater than 300 meters. Study populations varied from dense concentrations of flowering plants to sparsely-distributed plants on ridgelines or in drainages (the typical distribution pattern). Individuals were marked with a numbered aluminum tag nailed approximately 6-10 inches from the base of the plant, and buds, flowers, and developing fruits were marked with colored thread. The geographic locations of all marked plants were recorded with a GPS unit with sub-meter accuracy.

Fruit Collection and Seed Counts

We returned to the study sites in early July 2017 to collect mature fruits from all marked *P. albifluvis* plants. Fruits were collected in paper coin envelopes marked with the species, tag number, date, and collector. Fruits will be transported in a dry cooler for seed counts off-site. All collected seed will be submitted to the Red Butte Garden Conservation Program for curation. Seed collection and management protocols followed the 2017 Penstemon Seed Management Strategy (Penstemon Conservation Team 2017). We collected habitat composition and location information at each study site. These data will be submitted with the seed collections.

Data Analyses

Reproductive success was quantified as average seeds per fruit for each individual White River beardtongue plant. Statistical analyses comprised linear regressions and ANOVA to quantify relationships between reproductive success and: 1) minimum distance to the CA disturbance layer, and 2) total area of disturbance within 100-meter, 300-meter, and 1,000-meter buffers.

Results

The results of the 2017 reproductive success pilot study were inconclusive due to rapid fruit development and loss of seed before study sites could be revisited. Only 34 of the fruits collected contained mature seeds, and average seeds per fruit was highly variable (range 0.5 to 25) and the data did not follow a normal distribution. There were no significant interactions between seeds per fruit and disturbance metrics.

Discussion and Recommendations

Intensive efforts during flowering were not efficient. Further, flowering and fruiting appeared to be highly variable across the range and may depend on local conditions that are not related to surface disturbance. We recommend continuation of the reproductive success study in 2018 with these revised methods: 1) Double the study sample with individuals clustered at varying distances from mapped surface disturbance to better capture spatial variation in flowering; 2) Focus efforts during flowering on hand-crossing only (do not mark insect-pollinated buds, flowers, or fruits); and 3) Focus field activities on monitoring fruit development and fruit collections. In addition, opportunistic collection of intact fruits (with mapped locations) would further enhance the study sample.

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Appendix F

BLM White River Field Office 2017 Graham's Beardtongue Demographic Monitoring Report

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Demographic Monitoring of Graham's Penstemon (*Penstemon grahamii*) in the Raven Ridge ACEC - 2017 Summary and Status Report

Penstemon grahamii in flower. Photo: Phil Krening

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Summary

Monitoring of Graham's Penstemon (*Penstemon grahamii*) was completed in May of 2017. This marked the ninth year of data collection over the twelve-year duration of the current monitoring study at the Mormon Gap study site. The population has exhibited a downward trend nearing statistical significance over the course of the study (2005 – 2017). Following a livestock trailing event that had substantial impact on the site in 2013, taking the population nearly to zero, we have observed a significant increase in the population over the past four monitoring years. Despite a trend suggesting recovery, the population remains below historic levels.

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 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.

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* occurrences on Raven Ridge. Plants were tagged and census counts were taken of each plot 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) - hereafter referred to as the Raven Ridge / Mormon Gap population - from the original study that concluded in 1990. The 2005 BLM study consisted of the original 20m x 35m (700m²) 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 Monitoring Objectives:

Management Objective: Maintain stable or increasing population density of *Penstemon grahamii* at the Raven Ridge / Mormon Gap population for a 20-year period (2005 – 2025).

Sampling Objective: We aim to be 90% confident that *Penstemon grahamii* density estimates are ± 20% of the true value.

3.2 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, 2014). 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.

3.3 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. When 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.

3.4 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 $\leq 20\%$.

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 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 that 5% of a population has been sampled you must apply the FPC to the results of the significance test (Elzinga et al., 1998).

All statistical transformations were completed using Microsoft Excel.

4. Results –

4.1 Trend monitoring –

Due to methodological differences, our ability to make direct comparisons between the original monitoring study (1986 – 1990) and the more recent data (2005 – 2017) is limited.

Based on the best available data, the Raven Ridge / Mormon Gap population of *P. grahamii* 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 was attributed to a large number of sheep trailing through the population. Evidence of the disturbance was documented upon visitation to the site for monitoring in 2014.

Following the near extirpation of the population in 2013 we have documented a significant increase $t(14) = 3.32$, $p < 0.05$ in plant density at the site between 2014 and 2017. Despite signs of recovery, the population remains below historic levels.

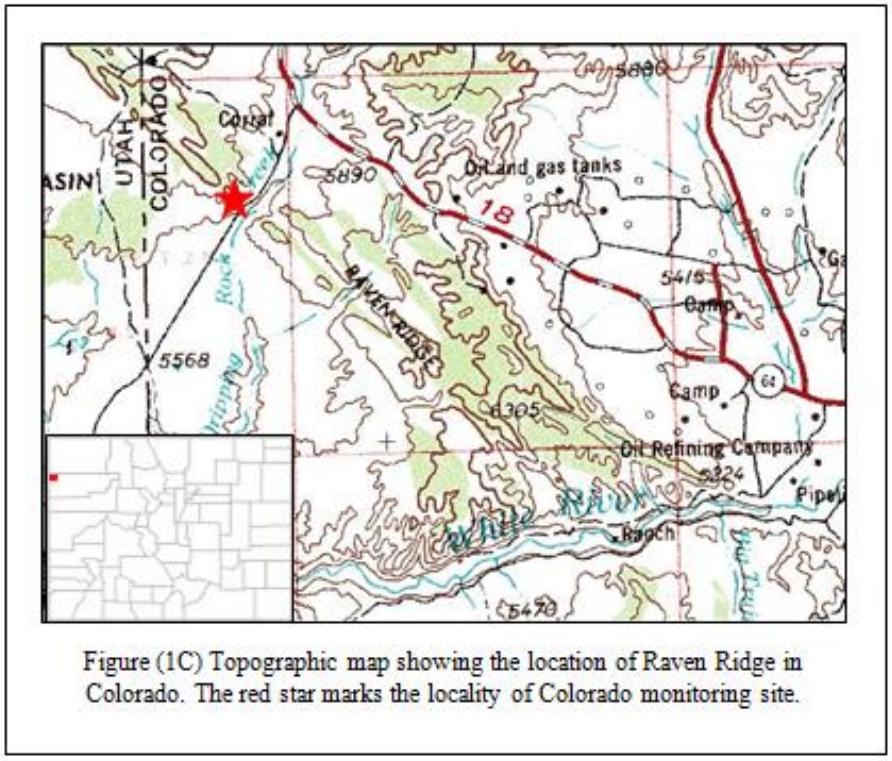

Figure (1C) Topographic map showing the location of Raven Ridge in Colorado. The red star marks the locality of Colorado monitoring site.

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

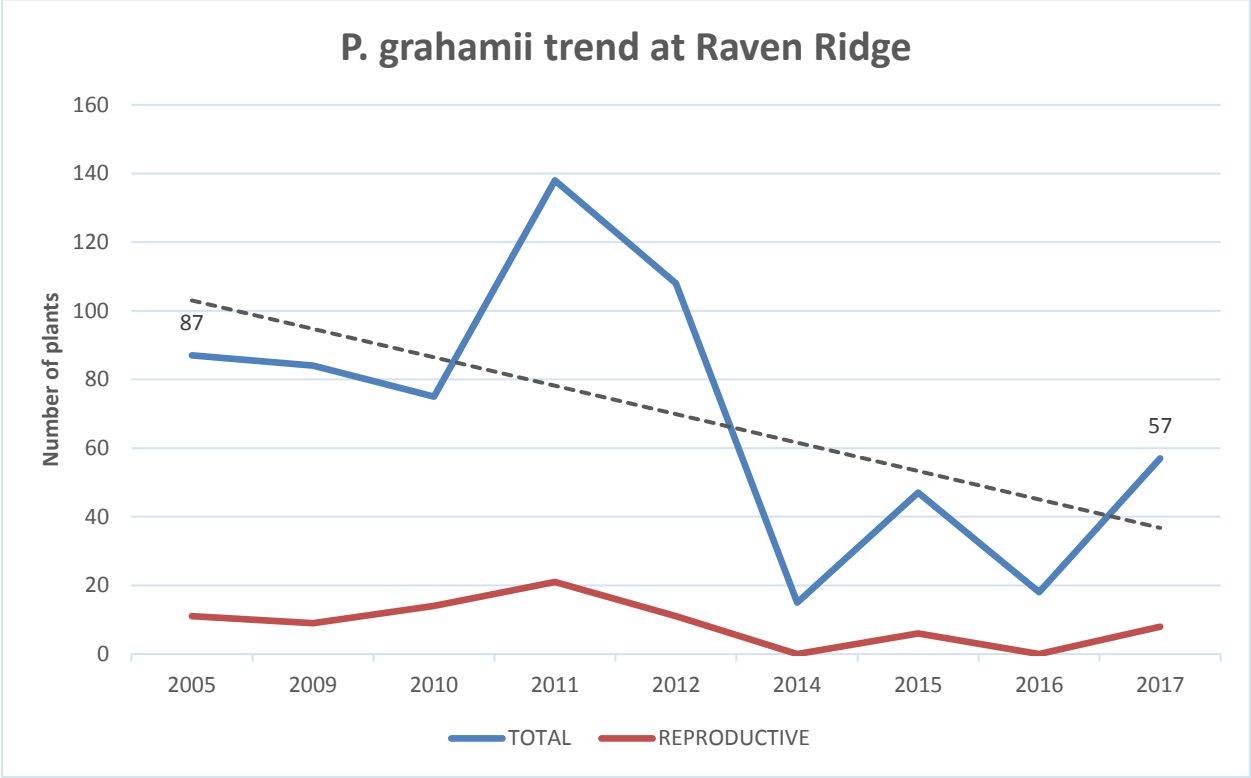

Figure 2. Penstemon grahamii trend at Raven Ridge / Mormon Gap 2005 - 2017

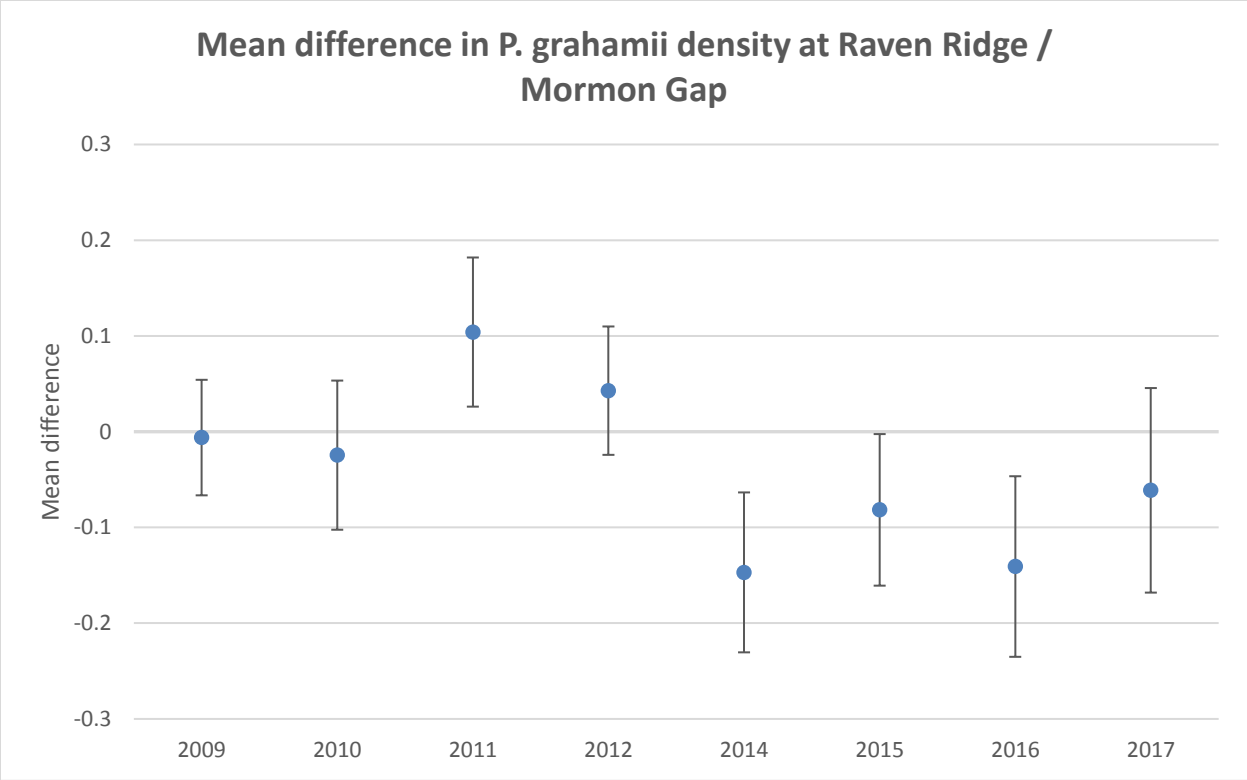

Figure 3. Change in mean Penstemon grahamii density at Raven Ridge / Mormon Gap 2005 - 2017

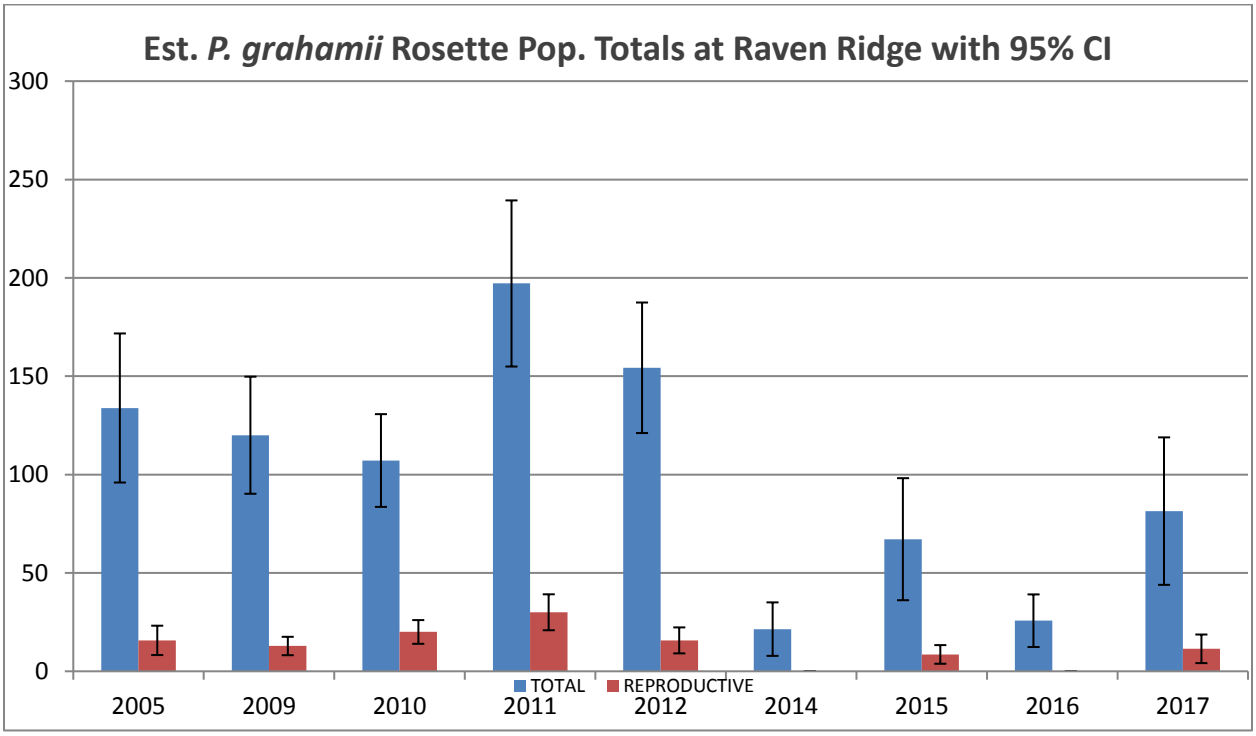

Figure 3. Estimated Penstemon grahamii population totals at Raven Ridge / Mormon Gap 2005 - 2017

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