

2011 Status Report
Demographic Monitoring and Survey for
Penstemon grahamii and *Penstemon scariosus* var. *albifluvis*
Uintah County, Utah

Prepared for:
Ron Bolander
Bureau of Land Management
Utah State Office
P.O. Box 45155
Salt Lake City, UT 84145-0155



Prepared by:
Rita Reisor, Conservation Director
Wendy Yates, Botanist
Red Butte Garden and Arboretum
300 Wakara Way
Salt Lake City, UT 84108

This report summarizes research results for two sensitive species, *Penstemon grahamii* (Graham's penstemon) and *Penstemon scariosus* var. *albifluvis* (White River penstemon). Work was conducted for the Bureau of Land Management (BLM) under the Cooperative Agreement L08AC14473. Research has been conducted by Red Butte Garden (RBG) for eight consecutive years, and the report includes summary monitoring data from all eight years with detailed methodology and results from the most recent year, and survey results from 2011 field surveys. A detailed description of the project establishment, previous methodology, and survey results can be found in the RBG Annual Status Reports 2004 – 2010.

Demographic research and survey was performed during the peak flowering season of both species, from May to June. Research includes four aspects of the project: 1) demographic monitoring at four previously established sites for *P. grahamii*; 2) demographic monitoring at three previously established sites for *P. scariosus* var. *albifluvis*; 3) Soil seed bank results from 2010 soil collection; and 4) potential habitat surveys for *P. grahamii* and *P. scariosus* var. *albifluvis*.

DEMOGRAPHIC MONITORING FOR *PENSTEMON GRAHAMII* (GRAHAM'S PENSTEMON)

Results

The *Penstemon grahamii* demographic study includes four sites: Buck Canyon, Blue Knoll, Blue Knoll East, and Sunday-School Canyon; all sites are located on BLM land. Buck Canyon and Blue Knoll sites were established in 2004, while Blue Knoll East and Sunday-School Canyon sites were established in 2010. Data collected included the plant condition (good, fair, or poor), age class, rosette diameter, number of flowering individuals, height of inflorescence, number of flowers per plant, number of fruiting individuals, number of fruit per plant, and herbivory. If there were more than one rosette per tag, diameters were summed for the total rosette diameter. Survivorship was calculated using the following formula:

$$\frac{\# \text{ alive 2011} - \# \text{ new tagged individuals}}{\# \text{ alive 2010}}$$

Buck Canyon

At Buck Canyon seven new individuals were tagged and added to the study plot. Survivorship at the Buck Canyon site was the highest observed for this site at 96.8 percent. Plant condition was found to be 95% good, 2.5% fair, and 2.5% poor. Herbivory was 26%, which was

a marked decrease from the 62% observed in 2010. This year 62.3% individuals produced flowers and 55.8% of those individuals produced fruit, which is the highest recorded to date for Buck Canyon. Among flowering individuals, the average number of flowers per plant was 20.6 and the average number of fruit per plant was found to be 18.5. Average plant rosette size was 6.2cm diameter and 8.6cm tall, with average inflorescence height of 8.8cm. Table 1 summarizes demography data collected from 2004 to 2011 of the Buck Canyon site.

Table 1. Summary of *P. grahamii* data over 8-year monitoring period at the Buck Canyon site.

Buck Canyon	2004	2005	2006	2007	2008	2009	2010	2011
Total # of individuals alive (includes new tags)	77	84	77	66	72	72	63	77
New individuals tagged	77	23	8	0	12	0	0	7
# of Individuals not relocated	n/a	1	5	8	9	6	9	9
# of individuals dead	n/a	8	13	16	4	3	0	0
Percent survivorship	n/a	79.2	82.1	85.7	90.9	95.8	87.5	96.8
Percent herbivory	35	4.7	31	13.6	11	54.2	61.5	26
% of individuals with flowers	27	4.7	0	15.2	30.5	43.1	42	62.3
% of Individuals with fruit	6.5	0	0	4.5	25	40.3	42	55.8
Average number of fruit per plant	2	0	0	2.7	5.3	8.8	7.1	18.5
Average Inflorescence Height (cm)	3.7	2.5	n/a	5.6	6	8.2	7.9	8.6
Average Rosette Diameter (cm)	n/a	4.6	3.8	4.3	4.1	5.6	5.7	6.2

Blue Knoll

At Blue Knoll 28 new individuals were tagged and added to the study plot. The Blue Knoll site recoded 95.1% survivorship, while in 2007 the survivorship rate was at its lowest recorded at 47.4%. Plant condition was found to be 95.6% good, 3.3% in fair and 1.1% poor. Herbivory was found to be 28.6%, which was similar to the Buck Canyon site. 46.2% individuals produced flowers and 38.5% of those developed fruit. Among flowering individuals, the average number of flowers per plant was 20.3 while the average number of fruit per plant was 17. Average plant rosette size was 5cm diameter and height with inflorescence was 8.8cm. Table 2 summarizes demography data from 2004 to 2011 of Blue Knoll site.

Table 2. Summary of *P. grahamii* data over 8-year monitoring period at the Blue Knoll site.

Blue Knoll	2004	2005	2006	2007	2008	2009	2010	2011
Total # of Individuals Alive (includes new tags)	69	71	59	52	66	69	61	91
New Individuals Tagged	69	30	12	24	23	6	0	28
# of Individuals not relocated	n/a	3	12	31	26	21	7	4
# of Individuals Dead	n/a	25	18	24	15	6	2	1
Percent Survivorship	n/a	59.4	66.2	47.4	82.6	90.9	88.4	95.1
Percent Herbivory	50.7	18.3	40.6	11.5	19.6	68.1	59	28.6
% of Individuals with Flowers	44	18	0	15	30.7	24.6	50	46.2
% of Individuals with Fruit	4.3	5.7	0	9.6	27.3	23.2	37.8	38.5
Average Fruit per Plant	2.1	1.1	0	3.8	6.6	3.9	8.6	17
Average Inflorescence Height (cm)	6.1	2.3	n/a	7.9	6.8	7.7	8.2	8.8
Average Rosette Diameter (cm)	n/a	6.8	4.8	4.6	5	6.5	6.6	5

Blue Knoll East

At Blue Knoll 21 new individuals were added to the study in 2011. Eleven of the 21 new individuals are seedlings and the remaining 10 plants were adults. The ten adults were likely missed when the site was originally established in 2010. The survivorship for this site was found to be 100%. Data shows 85% of the plants in good condition, 8.8% of the individual in fair condition, and 6.2% of the individuals in poor condition. Herbivory was found to be 70.8% at this site. Average plant rosette size was 7.9cm diameter and height with inflorescence was 5.8cm. The average number of flowers per a plant was 8.6 while, the average number of fruits per a plant was 8.1. Table 3 summarizes demography data from 2010 to 2011 of Blue Knoll East site.

Table 3. Summary of *P. grahamii* data over 2-year monitoring period at the Blue Knoll East site.

Blue Knoll East	2010	2011
Total # of Individuals Alive (includes new tags)	100	113
New Individuals Tagged	n/a	21
# of Individuals not relocated	n/a	8
# of Individuals Dead	n/a	0
Percent Survivorship	n/a	100
Percent Herbivory	84	70.8
% of Individuals with Flowers	48	28.3
% of Individuals with Fruit	33	15
Average Fruit per Plant	14.2	8.1
Average Inflorescence Height (cm)	6.4	5.8
Average Rosette Diameter (cm)	7.5	7.9

Sunday School Canyon

The Sunday-School Canyon site had a total of 155 individuals tagged and monitored in 2010. In 2011, 24 new individuals were added to the study. One of the 24 new individuals was found to be a seedling and the remaining 23 plants were found to be adults. The 23 adults were likely missed when the site was originally established in 2010. The survivorship for this site was found to be 99.3%. Data shows 95% of the plants in good condition, 4.5% of the individual in fair condition, and 0.5% of the individuals in poor condition. Herbivory was recorded as 31.6% of the individuals at this site. Plants on average showed 7.8cm diameter and 10.7cm tall. The average number of flowers per a plant was found to be 20.3 while, the average number of fruits per a plant was found to be 7.7. Table 4 summarizes demography data from 2010 to 2011 of the Sunday School Canyon site.

Table 4. Summary of *P. grahamii* data over 2-year monitoring period at the Sunday School Canyon site.

Sunday School Canyon	2010	2011
Total # of Individuals Alive (includes new tags)	155	174
New Individuals Tagged	n/a	24
# of Individuals not relocated	n/a	4
# of Individuals Dead	n/a	1
Percent Survivorship	n/a	99.3
Percent Herbivory	39	31.6
% of Individuals with Flowers	30.3	54
% of Individuals with Fruit	27.7	49.4
Average Fruit per Plant	5.5	7.7
Average Inflorescence Height (cm)	6.3	10.7
Average Rosette Diameter (cm)	7.7	7.8

Combined Sites

During 2011 the number of living individuals from all four sites was 455; 215 (47%) of these being flowering individuals. The site with the most flowering individuals was Sunday School Canyon (43%) while; the site with the lowest number of flowering adults was Blue Knoll East (14.9%). Herbivory was also reported highest at Blue Knoll East (70.8%) and lowest at Buck Canyon (26%). Table 6 is a comparative summary of data collected from all four *P. grahamii* sites in 2011.

Table 6: Summary of four study sites for *P.grahamii* in 2011.

	Sunday School	Blue Knoll East	Buck Canyon	Blue Knoll
Number of plants alive	174	113	77	91
Flowering plant	93	32	48	42
Non flowering plants	81	81	29	49
Percent good condition	95	85	95	95.6
Percent Herbivory	31.6	70.8	26	28.6
Average diameter cm	7.8	7.9	6.2	5
Average height cm	10.7	5.8	8.6	8.8
Average flowers per plant	20.3	8.6	20.6	20.3
Average fruits per plant	7.7	8.1	18.5	17

Survivorship trends at all sites have been increasing across most of the study years and sites, with a notable exception in 2007 at Blue Knoll (Figure 1).

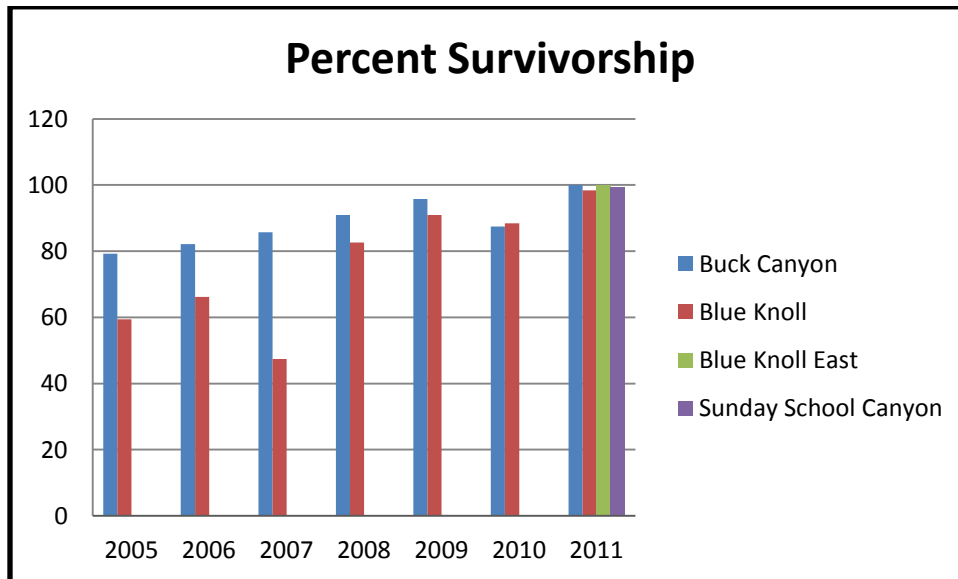


Figure 1. Survivorship trends of *P. grahamii* at Buck Canyon, Blue Knoll, Blue Knoll East, and Sunday School Canyon populations.

Plant movement between size classes was measured from 2010 to 2011. New recruits were not included in the size class movement analysis since two years of data is required. Rosette diameters were classified into four basal rosette size classes ranging from 0.5-12cm in diameter. Combined data from the four sites shows that 14.6% of the individuals declined in plant size class from 2010 to 2011. 29.6% increased size class and 55.8% remained in the same size class. The details of movement between size classes for all four sites are presented in Table 5.

Table 5. The total number of *P. grahamii* individuals moving between size classes from 2010 to 2011 as measured by diameter of basal rosette(s) at all study sites. Size classes: small = 0-2.5cm, medium = 3.0 - 4.5cm, large = 5.0-6.5cm, xlarge=7.0cm+

size class	Buck Canyon	Blue Knoll	Blue Knoll East	Sunday School Canyon
small to small	2	0	1	2
small to medium	1	1	0	1
small to large	1	1	0	3
small to xlarge	1	1	1	0
medium to small	0	1	0	2
medium to medium	4	3	1	7
medium to large	10	3	5	5
medium to xlarge	2	2	6	6
large to small	0	1	0	1
large to medium	3	3	5	7
large to large	6	8	8	8
large to xlarge	9	10	16	20
xlarge to small	0	0	0	0
xlarge to medium	3	2	2	3
xlarge to large	3	3	5	11
xlarge to xlarge	15	19	41	77
Total increases	24 (40%)	18 (31.1%)	28 (30.8%)	37 (24.2)
Total decreases	9 (15%)	10 (17.2%)	12 (13.2%)	22 (14.4)
Total no change	27 (45%)	30 (51.7%)	51 (56%)	94 (61.4)

Observations

P. grahamii Demographic Monitoring

The 2011 flowering seasons was late and short due to a late and cool, wet spring season. It is difficult to quantify how the annual weather fluctuations influence the plant responses. Herbivory was not at its lowest observed, but was lower than recent years, which was likely influenced by the cooler weather. The presence of the Tiger Moth caterpillar, which had been a

significant grazer of *P. grahamii*, was greatly reduced this year and the rate of herbivory also dropped. Blue Knoll, which had been hit hard by herbivory in past years rebounded this year with average plant size, flowering and fruiting being comparable to the other sites. It is likely that this is a result of both reduced herbivory and favorable climatic conditions.

The raw data shows the annual fluctuations experienced by each population and the slightly different responses of the population based on site location. Given the annual fluctuations, the overlying trends remain similar between the four monitoring sites. As shown in Figure 1, survivorship trends follow similar patterns of increases and decreases annually, and are likely influenced by the same factors. Though all sites seem to be affected by the same factors, Blue Knoll appears to be having greater negative and positive responses depending on the type of variable introduced. The Blue Knoll population in general appears to struggle more in years where herbivory has been exceptionally high, as shown by the low flowering and fruiting response and smaller plant stature. It is worth investigating further what makes this site more susceptible to fluctuations in the environment than other populations in order to predict those populations which may be more “at risk” to be harmed by human activity.

DEMOGRAPHIC MONITORING FOR *PENSTEMON SCARIOSUS* VAR. *ALBIFLUVIS* (WHITE RIVER PENSTEMON)

Results

Three study areas of *Penstemon scariosus* var. *albifluvis* were visited during their peak flowering season, at which time demographic data were recorded. The first study site, White River, was visited on June 30. This site is located near highway 45 along the White River on BLM land. The second site, Watson, was visited June 15 and is located near Evacuation Creek on private property. The third site, Hells Canyon, was visited on June 15 and is located east of highway 45 on BLM land

Data collected included the condition of each plant, age class, diameter, height, flowers per stem, fruits per stem, number of stems per plant, herbivory, and fruits per capsule. A metal detector is used to relocate existing marked individuals and any lost tags. Due to the unstable substrate and steep slopes, tags may become moved or lost due to natural shifting of the soil or animal activity.

Observation of the monitoring sites for *Penstemon scariosus* var. *albifluvis* showed the populations to be in healthy, good condition. We observed light to moderate animal/insect disturbances such as grazing and trampling. Our data show 98.7% of individuals tagged at the White River site were in good condition, 0.7% in fair condition, and 0.7% found in poor condition. This year 93% of individuals found at the Watson site were reported in good condition, this was an increase from the previous year with only 63 %. The percent of plants found in fair condition was 6.4% and 0.6 % in poor condition. The Hells Canyon site appears to be comparable to the two other sites showing little disturbance. Our data show 92% of tagged individuals in good condition, 1.6% in fair condition, and 6.4% in poor condition.

This year herbivory was moderately low at the White River and Hells Canyon monitoring plots, while the Watson site was relatively higher. The White River site it was recorded at 1.3%, The Watson site herbivory was found to be 84.9% and 34.7% at the Hells Canyon site. For the past two years plant development has been delayed due to cooler temperatures, this may cause herbivory to be reduced compared to previous years. It is unknown why herbivory at the Watson site was higher compared 2010. The site is located by water and insects in these areas were observed in large quantities. The Watson site also shows an indication of heavy grazing by animals. Specific animals eating the plants have not been observed, and it is possible that rabbits and small rodents are responsible in addition to larger ungulates.

White River Site

Due to the large population size at the White River site our monitoring plot encompasses more individual plants than are possible to include in the demographic monitoring study. For the entire plot in 2011 there were 805 individuals, creating a population structure of 236 flowering adults, 193 non-flowering adults, and 376 seedlings.

Our sample population of *Penstemon scariosus* var. *albifluvis* was composed of 151 living and tagged individuals within the plot; creating a population structure of 86 flowering adults, 47 non-flowering adults, and 18 seedlings (new recruitments). In June of 2010 163 living individuals were identified; of these we relocated 133 during our visit in June 2011. Overall survivorship from 2010 to 2011 was 73%. The average number of flowering and fruiting plants was 57% with an average of 136 flowers per plant, and average 13 fruits per plant. Data showed

that 100% flowering plants produce fruit. Randomly selected capsules show an average of 18 seeds per capsule. The eight year demographic summary is shown in Table 7.

Over the eight years since the study was initiated 44 of the original 135 individuals tagged were relocated in 2011. Those forty-four (32.6%) continue to thrive while the remaining 91 (67.4%) individuals are dead or tags have been lost.

The number of individuals not relocated has increased over the past five years and plant tags have been lost due to the unstable substrate, soil movement, and animal activity. Loose tags are often found down slope near the river, while others were not found and may have been removed by animals, buried, or fallen into the river. Due to this high loss of tags we have decided to alter our approach in the future. We will discontinue tagging of any new individual plants; however, tags on previously marked individuals will continue to be maintained. In order to retain collection of the life history information crucial to this study, the individuals which are currently tagged will also be marked with a GPS and mapped with the goal of being able to positively relocate them should the tags become lost in the future. This problem of lost tags has not been significant at the other *Penstemon scariosus* var. *albifluvis* sites and tagging of all individuals at those sites will continue.

As a result of lost tags it has been challenging to gather accurate information on seedling survivorship. To resolve this issue a new seedling plot has been added to the study which is located outside of and near the larger demographic plot and will allow accurate seedling survivorship data to be collected. In order to measure seedling data we designated a permanent 1m² plot outside of the larger monitoring plot, centered on a high concentration of seedlings found in 2011 (Figure 2). Plot corners were permanently marked with nails, tags, and GPS coordinates, and individuals were mapped using a grid within the plot frame. The smaller plot and mapping technique will allow both the total number of seedlings and survival to be accurately recorded. Fifty nine seedling plants were located within the seedling plot and base diameter and plant condition data was collected. The average diameter for the individuals in this plot was found to be 1cm and all plants were found in good condition. The UTM coordinate for this plot is NAD 1983 12N 656526 E 4426449 N (Figure 2).

Table 7. Summary of *P. scariosus* var. *albifluvis* demographic data over 8-year monitoring period at White River population.

White River Site	2004	2005	2006	2007	2008	2009	2010	2011
Total # of Individuals Alive (includes new tags)	135	111	116	91	86	231	163	151
New Individuals Tagged	135	0	10	0	0	152	21	18
# of Individuals not relocated	n/a	11	8	24	26	34	65	23
# of Individuals Dead	n/a	13	9	10	2	2	26	14
Percent Survivorship	n/a	82.2	95.6	78.4	94.5	91.8	61.5	73
Percent Herbivory	37	32.4	48.2	38.4	18.6	42.4	2.5	1.3
% of Individuals with Flowers	42	87.3	81.8	96.7	96.5	93.7	42	57
% of Individuals with Fruit	17	75.6	69	57	95.3	93.7	42	57
Average Fruit per Inflorescence	0.8	9.5	n/a	6.5	11.3	14.6	13.9	17.6
Average Inflorescence Height (cm)	18.1	25.2	20.0	28.3	31.6	28.3	27.3	31.2
Average Woody Caudex Diameter (cm)	4.0	4.0	4.2	4.7	7.5	7.5	6.1	4.2



Figure 2. Seedling plot at White River site.

Watson Site

The Watson population was established with 180 individuals in 2004; 58 (32%) of these plants have survived from 2004 to 2011. 20 (11%) individuals were counted as dead and the remaining 102 (56.7%) plants have been recorded as missing. The missing individuals at this site may be influenced by the heavy grazing observed at the Watson site. It is likely that tags were lost during the three year period which research was not conducted at this site, and tags were not stabilized. The survival rate from 2010 to 2011 is 90% and 50 new individuals were added in 2011. Of the eight seedlings tagged in 2010, five (62.5%) were relocated in 2011, two (25%) were recorded dead and the remaining one (12.5%) was not found. In 2011, 57% individuals flowered and 54% produced fruit. Both of these results are lower percentages than were observed in 2008 and 2009. Table 8 summarizes demography data from 2004 to 2011 of Watson site.

The White River location continues to produce more flowers and fruits compared to the Watson site. The cause of this is unknown, however, the Watson location may be dealing with more environmental impacts related to energy development, which may decrease the possibility for pollinators to pollinate and increase the opportunity for herbivory.

Table 8. Summary of *P. scariosus* var. *albifluvis* demographic monitoring data from 2004 to 2011 at Watson population.

Watson Site	2004	2008	2009	2010	2011
Total # of Individuals Alive (includes new tags)	180	91	157	130	172
New Individuals Tagged	180	33	74	8	46
# of Individuals not relocated	n/a	104	112	46	52
# of Individuals Dead	n/a	18	2	7	8
Percent Survivorship	n/a	32.2	91.2	78	90
Percent Herbivory	n/a	72.5	91	35.9	84.9
% of Individuals with Flowers	25	71	82	35	57
% of Individuals with Fruit	18.8	68	75	33.4	54
Average Fruit per inflorescence	n/a	6.6	6.5	7.1	13.8
Average Inflorescence Height (cm)	10.5	19	20.6	21.3	22.3
Average Woody Caudex Diameter (cm)	3.2	6	5.7	6.1	4.3

Hells Canyon

The Hells Canyon site was established on June 24, 2010. A total of 124 individuals were tagged and data was recorded in 2011. The 2011 population is comprised of 24 (19.3%) flowering adults and 100 (80%) non-flowering individuals, and 68 seedlings (new recruits). The

low flowering plant rate is caused by the number of seedlings added in 2011. Survivorship was 50.5% in 2011, with 43 (39%) individuals dead and the remaining 12 (10.8%) plants were recorded as tags missing. Data shows 92% of the plants in good condition, and herbivory was 34.7%. The average diameter was 2.5 cm and average height was 13.9 cm. The average number of flowers per plant was found to be 30 while, the average number of fruits per flowering plant was 26. Table 9 summarizes demography data from 2010 to 2011 at the Hells Canyon site.

Table 9. Summary of *P. scariosus* var. *albifluvis* demographic monitoring data from 2010 and 2011 at Hells Canyon population.

Hells Canyon	2010	2011
Total # of Individuals Alive (includes new tags)	111	124
New Individuals Tagged	n/a	68
# of Individuals not relocated	n/a	12
# of Individuals Dead	n/a	43
Percent Survivorship	n/a	50.5
Percent Herbivory	22.5	34.7
% of Individuals with Flowers	69.4	24
% of Individuals with Fruit	69.4	24
Average Fruit per inflorescence	5.4	8.6
Average Inflorescence Height (cm)	15.4	13.9
Average Woody Caudex Diameter (cm)	6.2	2.5

Combined Sites

Growth rates, measured by the diameter of the woody caudex, were monitored and results include 218 plants in the demographic study from 2010 - 2011 from the White River site and Watson sites combined. Twenty six percent increased in size class, only 8% decreased to a smaller size class, and 65% remained in the same size class (Table 10). The majority of plants range in size from 3.0-6.5cm diameter of woody caudex.

Table 10. Movement between basal size classes from 2005 to 2011 comparing *P.scariosus* populations as measured by diameter of woody caudex. Size classes: small = 0-2.5cm, medium = 3.0 -4.5cm, large = 5.0-6.5cm, xlarge=7.0cm+

size class	White River	Watson	Hells Canyon
small to small	0	0	0
small to medium	4	1	0
small to large	2	1	0
small to xlarge	0	1	0
medium to small	1	1	0
medium to medium	0	3	0
medium to large	4	3	0
medium to xlarge	13	2	1
large to small	0	1	2
large to medium	0	3	0
large to large	3	8	1
large to xlarge	14	10	2
xlarge to small	0	0	1
xlarge to medium	0	2	0
xlarge to large	0	3	3
xlarge to xlarge	63	19	47
Total increases	37 (35.6%)	18 (31.1%)	3 (5.2%)
Total decreases	1 (1%)	10 (17.2%)	6 (10.5%)
Total no change	66 (63.4%)	30 (51.7%)	47 (82.4%)

SOIL SEED BANK STUDY

Soil samples were collected from four research sites during June 2010. Study sites sampled were Buck Canyon, Blue Knoll, Blue Knoll East, and Sunday School Canyon. Soil samples were sieved and hand sorted during October 2010 through January 2011. The community type of all three study sites is pinyon-juniper and the soil is oil shale from the Green River formation.

In 2009 we conducted a soil seed bank study using methodology based on the methods developed by Susan Meyer during her soil seed bank research (Dr. Susan Meyer personal communication, May 2009) and a random sampling strategy. Due to the sparse dispersal of plants and clumping nature, the study yielded very low seed production and possibly unreliable results. Therefore we conducted a second soil seed bank study in 2010, modifying these methods to fit *P. grahamii* habitat and spatial arrangement. In order to determine if the soil seed bank is influenced by the clumped nature of the plants, we collected an additional 120 soil samples in 2010 using a “targeted sampling strategy”. We randomly selected 30 individuals

from each of the four sites and collected soil directly next to each plant. All soil samples were collected at a depth of 4cm and a diameter of 12cm by placing a tin can and pressing the open end of the can into the soil, while placing a masonry trowel over the open end to remove the soil. The soil obtained was placed in sealed paper bags for drying and storage.

Soil samples were hand sorted, separating *P. grahamii* seeds from the soil. To ensure the correct identification of the seeds within the soil, known *P. grahamii* seeds collected by Red Butte Garden were carefully observed in the soil and through the cleaning process. Seeds are black, 3-4mm in length and have a distinct twist. These characteristics facilitated identification and extraction from soil samples. The process for evaluating the soil used was as follows: 1) sift through coarse strainer, 2) sift through 4mm strainer; 3) examine remaining soil, rock, and organic matter by hand, 4) seeds were verified by a second staff person.

Seeds collected from the soil seed bank study were tested for viability via standard Petri dish germination testing, followed by tetrazolium test. Embryos were marked with 1% tetrazolium solution and seeds which turn pink or red tested positive and were considered viable.

A total of 161 seeds were recovered from the 120 soil samples. The total soil volume collected and used in the study was 27,120 cubic centimeters (27.12 liters). This is equivalent to an average of 0.7 seeds per soil sample. 121 of the seeds were from the Buck Canyon site, 19 seeds were from the Blue Knoll site, 11 seeds were from the Blue Knoll East Site, and 10 seeds were from the Sunday School Canyon site. Only 1 seed germinated and was counted viable during the germination test. The other 160 seeds were tested in a tetrazolium solution. Results show 104 (65%) of the seeds were found to be viable while the remaining 57 (35%) seeds were not counted viable. It is likely that enough time was not allowed for the seeds to undergo proper cold and moist stratification to break dormancy requirements prior to the germination test and therefore yielded low results from the germination test.

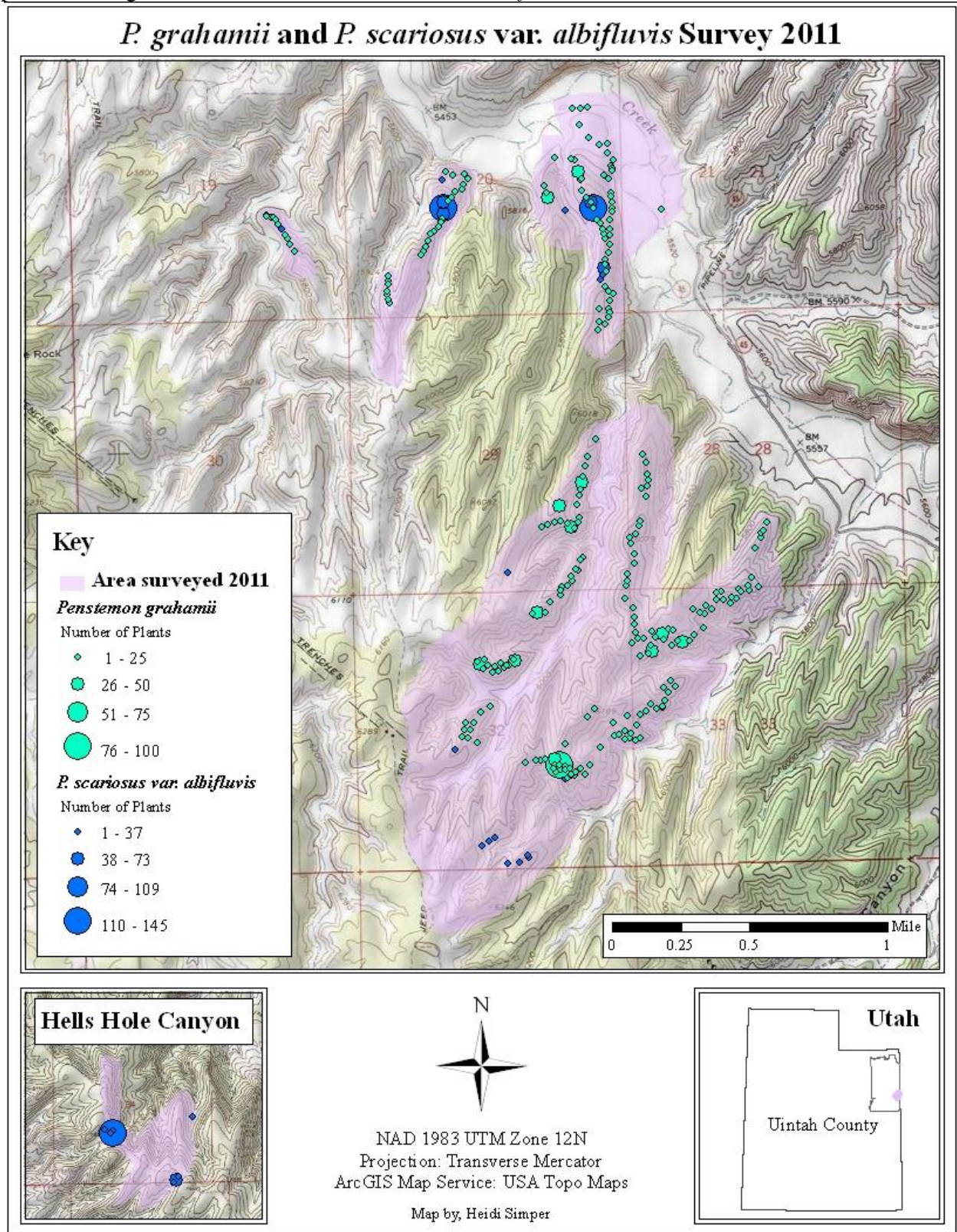
SURVEY FOR *PENSTEMON GRAHAMII* AND *PENSTEMON SCARIOUSUS* var. *ALBIFLUVIS*

Survey locations and maps were provided by the Utah State Heritage Program, BLM, and U. S. Fish Wildlife Service. Survey focused on *P. grahamii*, and *P. scariosus* var. *albifluvis*. The majority of the survey took place on private and state lands only a small area was located on BLM land during 2011. Surveys were conducted in order to clearly identify the range of these two species. Researchers stood approximately 10 -20ft. apart and walked in parallel lines with a

hand held GPS device which was used to mark both positive and negative data points. Positive points indicate that the target plant was found, and negative points indicate that the target plant was not found within the appropriate habitat at this time. A negative point was taken after approximately 50 feet was surveyed without finding the target species.

All GPS data was collected in standard UTM coordinates using datum NAD 1983 and converted to latitude and longitude for mapping purposes. When a plant of interest was found, the area was surveyed in detail and the data recorded. *P. grahamii* plants were recorded as either flowering or non-flowering rosettes. The survey for *P. grahamii* recorded a total of 1,684 flowering individuals, 736 non-flowering rosettes, and 322 individuals were not determined to be flowering or non flowering, resulting in a total of 2,742 individuals recorded in 2011. The surveys for *P. albifluvis* var. *scariosus* recorded 1,217 individuals. Appendix A includes maps of the area surveyed. Appendix B is a list of locations of the two target plants as well as negative data collected. Appendix C includes pictures of the 2011 survey and monitoring project.

Appendix A. Area surveyed in 2011 is highlighted in pink with positive points of *P. grahamii* presented in green markers and *P. scariosus* var. *albifluvis* as blue dots.



Appendix B: Latitude longitude data points for *Penstemon grahamii*, *Penstemon scariosus* var *albifluvis*, and negative data from 2011 survey.

Feature	Latitude	Longitude	Elevation	Plant Type or neg. data	PEGR Flw/Pnts	PEGR Non-Flw/Pnts	Total PEGR	PESC
1	39.81661667	-109.1399667	1908	PEGR	3		3	
2	39.8167	-109.1392167	1900	PEGR	6	2	8	
3	39.81673333	-109.1389	1895	PEGR	10	10	20	
4	39.81673333	-109.1386	1889	PEGR	10	4	14	
5	39.81673333	-109.1379667	1888	PEGR	12	17	29	
6	39.81641667	-109.1379667	1885	PEGR	11	7	18	
7	39.81628333	-109.13805	1880	PEGR PESC	1		1	9
8	39.81605	-109.1379	1878	PEGR PESC	16	3	19	3
9	39.81618333	-109.1375333	1884	PEGR	20	4	24	
10	39.8162	-109.13725	1887	PEGR	7	3	10	
11	39.81598333	-109.1371	1886	PESC				26
12	39.81566667	-109.1372333	1887	PESC				4
13	39.81585	-109.13665	1886	PEGR	14	2	16	
14	39.81593333	-109.1363	1888	NEG				
15	39.81621667	-109.1361667	1890	NEG				
16	39.81641667	-109.1376167	1892	PEGR	3	8	11	
17	39.81636667	-109.1372167	1893	PEGR	10	9	19	
18	39.81623333	-109.1369167	1890	PEGR	8		8	
19	39.8159	-109.13685	1894	PEGR	3	5	8	
20	39.81625	-109.1362167	1889	PEGR	3	1	4	
21	39.81641667	-109.1359833	1881	NEG				
22	39.81658333	-109.1358	1875	NEG				
23	39.81683333	-109.1356333	1873	NEG				
24	39.81701667	-109.1355	1863	NEG				
25	39.81726667	-109.1351667	1860	NEG				
26	39.81748333	-109.1348833	1851	NEG				

Feature	Latitude	Longitude	Elevation	Plant Type or neg. data	PEGR Flw/Pnts	PEGR Non-Flw/Pnts	Total PEGR	PESC
27	39.8176	-109.1346	1847	NEG				
28	39.81778333	-109.1344333	1840	NEG				
29	39.81791667	-109.1344	1840	NEG				
30	39.818	-109.1341667	1840	NEG				
31	39.81813333	-109.1341333	1840	NEG				
32	39.8179	-109.1338667	1842	PEGR	19	3	22	
33	39.81798333	-109.1335667	1843	PEGR	8		8	
34	39.81775	-109.1331667	1844	PEGR	6	1	7	
35	39.8178	-109.1328333	1845	PEGR	15	3	18	
36	39.81766667	-109.1324167	1846	PEGR	6	7	13	
37	39.81775	-109.1320833	1846	PEGR	10	7	17	
38	39.81841667	-109.13235	1839	PEGR	2		2	
39	39.81876667	-109.1324167	1839	NEG				
40	39.81896667	-109.1320833	1840	PEGR	15	5	20	
41	39.8192	-109.1316833	1839	PEGR	5	4	9	
42	39.81926667	-109.13095	1842	PEGR	12	2	14	
43	39.81935	-109.1305667	1840	PEGR	10	1	11	
44	39.82036667	-109.1304167	1844	PEGR	4	5	9	
45	39.82068333	-109.13005	1839	NEG				
46	39.82076667	-109.1299	1840	PEGR	1		1	
47	39.82075	-109.1292667	1832	NEG				
48	39.82043333	-109.1296667	1837	PEGR	6	3	9	
49	39.82011667	-109.1301	1835	PEGR	4		4	
50	39.8197	-109.1303333	1839	PEGR	8	3	11	
51	39.81941667	-109.1305	1841	PEGR	3	3	6	
52	39.81956667	-109.1310167	1853	NEG				

Feature	Latitude	Longitude	Elevation	Plant Type or neg. data	PEGR Flw/Pnts	PEGR Non-Flw/Pnts	Total PEGR	PESC
53	39.81951667	-109.1313	1855	PEGR	2		2	
54	39.81966667	-109.1316833	1855	NEG				
55	39.81953333	-109.1322	1856	NEG				
56	39.81893333	-109.1329333	1858	PEGR		2	2	
57	39.81853333	-109.1328667	1858	NEG				
58	39.81803333	-109.1327	1850	PEGR	9	6	15	
59	39.81813333	-109.1331	1854	PEGR	7	3	10	
60	39.81856667	-109.1332167	1855	NEG				
61	39.81836667	-109.1337667	1854	NEG				
62	39.8186	-109.1339	1854	PEGR	4	2	6	
63	39.8187	-109.1343667	1854	NEG				
64	39.81836667	-109.1347333	1852	NEG				
65	39.81805	-109.1351333	1852	NEG				
66	39.8177	-109.1349167	1841	NEG				
67	39.81731667	-109.1348167	1841	PEGR	2	1	3	
68	39.81706667	-109.1351	1857	NEG				
69	39.81681667	-109.13535	1861	NEG				
70	39.81641667	-109.1356	1864	PEGR	1	7	8	
71	39.8159	-109.1358667	1875	PEGR	4	4	8	
72	39.8157	-109.13695	1887	NEG				
73	39.81568333	-109.1372833	1885	PESC				25
74	39.81573333	-109.1370667	1890	PEGR	3	7	10	
75	39.81591667	-109.1368667	1892	PEGR	4	2	6	
76	39.81605	-109.1365167	1893	PEGR	5	2	7	
77	39.81626667	-109.1369	1889	PEGR	5	6	11	
78	39.81645	-109.1376667	1892	PEGR	50	50	100	

Feature	Latitude	Longitude	Elevation	Plant Type or neg. data	PEGR Flw/Pnts	PEGR Non-Flw/Pnts	Total PEGR	PESC
79	39.8258	-109.1328667	1851	PEGR	6	1	7	
80	39.82605	-109.13275	1850	PEGR	1		1	
81	39.8264	-109.1327667	1848	PEGR	4		4	
82	39.82696667	-109.1322333	1849	PEGR	10		10	
83	39.82743333	-109.1322167	1845	PEGR	10	13	23	
84	39.82798333	-109.1324333	1853	PEGR	2	1	3	
85	39.82846667	-109.1321667	1847	PEGR	4		4	
86	39.82888333	-109.1319	1845	PEGR	7	3	10	
87	39.82916667	-109.1317833	1842	PEGR	3		3	
88	39.82985	-109.1317	1828	NEG				
89	39.82301667	-109.1321	1863	PEGR	6	4	10	
90	39.82301667	-109.1317333	1852	PEGR	7	2	9	
91	39.82303333	-109.1309	1835	PEGR	10	8	18	
92	39.82291667	-109.1304	1832	PEGR	7	8	15	
93	39.82258333	-109.1298167	1828	PEGR	15	3	18	
94	39.82281667	-109.1294	1828	PEGR	14	3	17	
95	39.82275	-109.1291	1830	PEGR	35	15	50	
96	39.82283333	-109.1286	1830	PEGR	6	4	10	
97	39.82315	-109.1282667	1826	PEGR	10	5	15	
98	39.82346667	-109.1276667	1826	PEGR	5		5	
99	39.82383333	-109.1281833	1834	NEG				
100	39.82426667	-109.1278333	1824	PEGR	9	3	12	
101	39.82423333	-109.12755	1826	PEGR	15	10	25	
102	39.82443333	-109.12705	1824	PEGR	7	2	9	
103	39.82493333	-109.1267	1826	PEGR	9	4	13	
104	39.82496667	-109.1262667	1826	PEGR	7		7	

Feature	Latitude	Longitude	Elevation	Plant Type or neg. data	PEGR Flw/Pnts	PEGR Non-Flw/Pnts	Total PEGR	PESC
105	39.82471667	-109.12575	1829	PEGR	1	14	15	
106	39.82498333	-109.1253833	1828	PEGR	6	6	12	
107	39.82533333	-109.1249833	1829	PEGR	4	1	5	
108	39.82538333	-109.1244833	1830	PEGR	6	1	7	
109	39.8256	-109.12385	1826	PEGR	6	2	8	
110	39.82618333	-109.124	1824	NEG				
111	39.82658333	-109.1238	1814	NEG				
112	39.82683333	-109.1240667	1813	NEG				
113	39.82745	-109.1240667	1810	NEG				
114	39.82763333	-109.1239667	1811	PEGR	11	12	23	
115	39.82813333	-109.1236167	1808	PEGR	7	3	10	
116	39.8285	-109.1234333	1808	PEGR	1		1	
117	39.82895	-109.1232	1799	PEGR	17	4	21	
118	39.82843333	-109.1235833	1806	PEGR	5	1	6	
119	39.82813333	-109.1238333	1807	NEG				
120	39.82733333	-109.12435	1814	NEG				
121	39.82681667	-109.12445	1825	NEG				
122	39.82606667	-109.1242833	1836	PEGR	5	4	9	
123	39.82563333	-109.1245167	1839	PEGR	2	1	3	
124	39.82548333	-109.1252167	1842	PEGR	4	3	7	
125	39.82508333	-109.1256833	1840	PEGR	6	4	10	
126	39.82535	-109.12635	1839	PEGR	11		11	
127	39.8253	-109.1267333	1837	PEGR	5	1	6	
128	39.82465	-109.1274333	1839	PEGR	1		1	
129	39.82478333	-109.128	1839	NEG				
130	39.8245	-109.1283167	1841	PEGR	7	5	12	

Feature	Latitude	Longitude	Elevation	Plant Type or neg. data	PEGR Flw/Pnts	PEGR Non-Flw/Pnts	Total PEGR	PESC
131	39.824	-109.1287333	1844	NEG				
132	39.82346667	-109.1289833	1846	NEG				
133	39.82336667	-109.1297	1841	PEGR	3	3	6	
134	39.82341667	-109.1300167	1839	NEG				
135	39.82343333	-109.1300333	1839	PEGR	8	7	15	
136	39.82321667	-109.1304333	1839	PEGR	16	11	27	
137	39.82333333	-109.1311833	1844	PEGR	3	2	5	
138	39.82273333	-109.1312333	1838	NEG				
139	39.82261667	-109.1312333	1834	PEGR	3	1	4	
140	39.82228333	-109.13115	1834	PEGR	15	13	28	
141	39.82216667	-109.13145	1834	PEGR	6	2	8	
142	39.82205	-109.1319667	1835	PEGR	1		1	
143	39.8437	-109.155	1779	PEGR PESC	10	1	11	4
144	39.8441	-109.15525	1768	PEGR	15		15	
145	39.84436667	-109.1554	1759	PEGR	5	4	9	
146	39.84458333	-109.1555833	1749	PEGR PESC	3	2	5	6
147	39.84485	-109.1558167	1739	PESC				20
148	39.84515	-109.1560667	1738	PEGR PESC	2		2	10
149	39.84535	-109.1561833	1742	PEGR PESC	5	1	6	20
150	39.84548333	-109.1564333	1741	PEGR PESC	5	1	6	25
151	39.84558333	-109.1568333	1739	PEGR PESC	1		1	30
152	39.84561667	-109.1568	1735	PEGR PESC	4	1	5	7
153	39.84553333	-109.1565167	1746	PEGR PESC	1	2	3	5
154	39.84548333	-109.1563333	1748	PEGR PESC	3		3	1
155	39.8454	-109.1561667	1749	PEGR PESC	1		1	10
156	39.84328333	-109.1547	1793	NEG				

Feature	Latitude	Longitude	Elevation	Plant Type or neg. data	PEGR Flw/Pnts	PEGR Non-Flw/Pnts	Total PEGR	PESC
157	39.84285	-109.1544167	1797	NEG				
158	39.83825	-109.1485333	1821	NEG				
159	39.8394	-109.1483667	1812	NEG				
160	39.83986667	-109.1482	1809	NEG				
161	39.8405	-109.14845	1806	NEG				
162	39.8409	-109.1485667	1799	PEGR PESC	11	6	17	5
163	39.84106667	-109.14865	1797	PEGR PESC	4	2	6	2
164	39.8413	-109.1487167	1793	PEGR PESC	8	2	10	15
165	39.84148333	-109.1487	1789	PEGR	2		2	
166	39.84188333	-109.14865	1782	PEGR PESC	5	1	6	5
167	39.84203333	-109.14865	1778	PEGR	10	1	11	
168	39.84231667	-109.14865	1769	PEGR PESC	4		4	5
169	39.84071667	-109.1476667	1809	NEG				
170	39.84173333	-109.1471833	1810	NEG				
171	39.84231667	-109.1469333	1810	NEG				
172	39.84285	-109.1468833	1807	NEG				
173	39.84336667	-109.1463333	1794	PEGR PESC	2	2	4	10
174	39.84358333	-109.14615	1787	PEGR PESC	15		15	5
175	39.84378333	-109.1460167	1783	PEGR PESC	7	5	12	6
176	39.8441	-109.1458333	1780	PEGR	1		1	
177	39.84445	-109.1456667	1770	PEGR	4		4	
178	39.84458333	-109.14545	1766	PEGR	2	7	9	
179	39.84485	-109.1451333	1763	PEGR PESC		3	3	15
180	39.84506667	-109.14495	1766	PEGR PESC	1	4	5	30
181	39.84528333	-109.1448333	1766	PEGR PESC	2	4	6	26
182	39.84553333	-109.1447667	1764	PESC				70

Feature	Latitude	Longitude	Elevation	Plant Type or neg. data	PEGR Flw/Pnts	PEGR Non-Flw/Pnts	Total PEGR	PESC
183	39.84578333	-109.14475	1765	PESC				120
184	39.8461	-109.1447833	1766	PESC				67
185	39.8468	-109.1447667	1746	NEG				
186	39.84703333	-109.14465	1733	NEG				
187	39.84731667	-109.1448	1726	PESC				4
188	39.84771667	-109.1445667	1717	PEGR			7	
189	39.84755	-109.1440833	1714	PEGR			7	
190	39.84758333	-109.1433	1718	PEGR			7	
191	39.84733333	-109.1430833	1718	PEGR			7	
192	39.847	-109.1434	1725	PEGR			7	
193	39.84678333	-109.1434833	1727	PEGR			7	
194	39.84665	-109.1439667	1737	PEGR			7	
195	39.84636667	-109.14415	1748	PEGR			7	
196	39.84615	-109.14445	1757	PEGR			7	
197	39.84548333	-109.1299	1691	PEGR			7	
198	39.85096667	-109.1347833	1682	PEGR			7	
199	39.85088333	-109.1353	1683	PEGR			7	
200	39.85091667	-109.1358	1676	PEGR			7	
201	39.85005	-109.13535	1689	PEGR			7	
202	39.84936667	-109.1347833	1694	PEGR			7	
203	39.84898333	-109.1340833	1693	PEGR			7	
204	39.84905	-109.1335167	1692	PEGR			7	
205	39.8485	-109.1334667	1694	PEGR			7	
206	39.84816667	-109.1331167	1695	PEGR			7	
207	39.84781667	-109.1332833	1702	PEGR			7	
208	39.84771667	-109.1332167	1705	PEGR			7	

Feature	Latitude	Longitude	Elevation	Plant Type or neg. data	PEGR Flw/Pnts	PEGR Non-Flw/Pnts	Total PEGR	PESC
209	39.84758333	-109.1332333	1708	PEGR			7	
210	39.84718333	-109.1334667	1709	PEGR			7	
211	39.84736667	-109.1338	1711	PEGR			7	
212	39.8464	-109.1333333	1725	PEGR			7	
213	39.84621667	-109.1333333	1730	PEGR			7	
214	39.84593333	-109.1332833	1737	PEGR			7	
215	39.84561667	-109.1332333	1743	PEGR			7	
216	39.84543333	-109.1332833	1748	PEGR			7	
217	39.84498333	-109.1334	1760	PEGR			7	
218	39.84453333	-109.13345	1763	PEGR			7	
219	39.84423333	-109.13345	1765	PEGR			7	
220	39.84373333	-109.1334833	1764	PEGR			7	
221	39.84331667	-109.13355	1763	PEGR			7	
222	39.84228333	-109.1337333	1766	PEGR			7	
223	39.8415	-109.13385	1766	PEGR			7	
224	39.84123333	-109.1335833	1759	PEGR			7	
225	39.84115	-109.1333167	1755	PEGR			7	
226	39.84076667	-109.1335333	1758	PEGR			7	
227	39.84033333	-109.1336167	1754	PEGR			7	
228	39.84016667	-109.1336	1752	PEGR			7	
229	39.83988333	-109.1336833	1761	PEGR			7	
230	39.83956667	-109.1338833	1764	PEGR			7	
231	39.83921667	-109.1344167	1767	PEGR			7	
232	39.83966667	-109.1343167	1771	PEGR			7	
233	39.84035	-109.1342667	1772	PEGR			7	
234	39.84123333	-109.1346167	1761	NEG				

Feature	Latitude	Longitude	Elevation	Plant Type or neg. data	PEGR Flw/Pnts	PEGR Non-Flw/Pnts	Total PEGR	PESC
235	39.8419	-109.13415	1758	PESC				35
236	39.84215	-109.1340333	1756	PESC				35
237	39.8425	-109.1338833	1755	PESC				45
238	39.8427	-109.13385	1755	PEGR PESC	1		1	10
239	39.8429	-109.1338	1755	PEGR	3	3	6	
240	39.84373333	-109.1338	1755	NEG				
241	39.84403333	-109.1337833	1753	PEGR	3	7	10	
242	39.84426667	-109.1338333	1754	PEGR	2	2	4	
243	39.84453333	-109.1339167	1750	PEGR PESC	1	3	4	3
244	39.84481667	-109.13405	1747	PEGR	8	4	12	
245	39.84501667	-109.1343	1750	PEGR	10	8	18	
246	39.84566667	-109.1345667	1745	PEGR PESC	1	1	2	145
247	39.84595	-109.1346833	1743	PEGR PESC	9	3	12	40
248	39.84623333	-109.135	1741	PEGR	2	4	6	
249	39.84656667	-109.1352833	1739	PEGR	3	11	14	
250	39.84711667	-109.1354167	1734	PEGR		3	3	
251	39.84721667	-109.1353	1741	PEGR	1	2	3	
252	39.84758333	-109.1355167	1732	PEGR	20	10	30	
253	39.8482	-109.1357167	1721	PEGR	20	2	22	
254	39.84825	-109.136	1713	PEGR	9	6	15	
255	39.84881667	-109.1369167	1692	NEG				
256	39.84835	-109.1371167	1703	PEGR	1	1	2	
257	39.84768333	-109.1372167	1715	NEG				
258	39.84671667	-109.13705	1722	NEG				
259	39.8458	-109.1368167	1726	NEG				
260	39.84558333	-109.1364833	1728	PESC				1

Feature	Latitude	Longitude	Elevation	Plant Type or neg. data	PEGR Flw/Pnts	PEGR Non-Flw/Pnts	Total PEGR	PESC
261	39.84495	-109.1359333	1730	NEG				
262	39.8442	-109.136	1737	NEG				
263	39.84446667	-109.1367833	1760	NEG				
264	39.84496667	-109.1370167	1755	NEG				
265	39.84571667	-109.1374	1741	NEG				
266	39.84625	-109.1376167	1736	PEGR	17	12	29	
267	39.84651667	-109.1376833	1734	PEGR	4	7	11	
268	39.84686667	-109.1378667	1732	PEGR	7	5	12	
269	39.84781667	-109.1376	1717	NEG				
270	39.81635	-109.1464333	1900	NEG				
271	39.81663333	-109.1454333	1893	NEG				
272	39.81678333	-109.14455	1892	NEG				
273	39.81733333	-109.1438333	1884	NEG				
274	39.81771667	-109.1431667	1878	PEGR	5	6	11	
275	39.81786667	-109.1433667	1875	NEG				
276	39.8177	-109.14385	1882	NEG				
277	39.81798333	-109.1438	1880	PEGR	5	4	9	
278	39.81838333	-109.14365	1879	PEGR	6	3	9	
279	39.81876667	-109.14345	1875	PEGR	7	2	9	
280	39.81928333	-109.1429333	1871	PEGR	2	6	8	
281	39.81956667	-109.1422833	1861	PEGR	9	7	16	
282	39.81968333	-109.1426167	1854	NEG				
283	39.81951667	-109.1430833	1856	NEG				
284	39.81945	-109.1433833	1856	NEG				
285	39.81876667	-109.144	1871	PEGR	10	3	13	
286	39.81836667	-109.1440667	1878	PEGR	5		5	

Feature	Latitude	Longitude	Elevation	Plant Type or neg. data	PEGR Flw/Pnts	PEGR Non-Flw/Pnts	Total PEGR	PESC
287	39.81801667	-109.1442667	1878	PEGR	4	4	8	
288	39.81765	-109.14455	1878	NEG				
289	39.81735	-109.1447	1884	PESC				2
290	39.81706667	-109.1454	1891	NEG				
291	39.81701667	-109.1459333	1897	NEG				
292	39.8173	-109.1456833	1897	NEG				
293	39.81766667	-109.1454	1893	NEG				
294	39.81823333	-109.1451833	1889	NEG				
295	39.8185	-109.1450833	1880	NEG				
296	39.81875	-109.1450333	1874	NEG				
297	39.817	-109.1466333	1894	NEG				
298	39.81733333	-109.14645	1893	NEG				
299	39.81766667	-109.1464333	1891	NEG				
300	39.8178	-109.1466833	1880	NEG				
301	39.81801667	-109.1466167	1873	NEG				
302	39.81846667	-109.1466	1879	NEG				
303	39.81878333	-109.1463	1874	NEG				
304	39.8185	-109.1470333	1888	NEG				
305	39.81826667	-109.1473833	1893	NEG				
306	39.81778333	-109.14765	1898	NEG				
307	39.81863333	-109.1478667	1894	NEG				
308	39.8194	-109.1474833	1893	NEG				
309	39.82001667	-109.1467667	1888	NEG				
310	39.82038333	-109.1461333	1891	NEG				
311	39.82058333	-109.1455333	1885	NEG				
312	39.82106667	-109.1448	1878	NEG				

Feature	Latitude	Longitude	Elevation	Plant Type or neg. data	PEGR Flw/Pnts	PEGR Non-Flw/Pnts	Total PEGR	PESC
313	39.8231	-109.1442167	1884	NEG				
314	39.82221667	-109.1432667	1879	NEG				
315	39.82196667	-109.14305	1876	PEGR	16	1	17	
316	39.82185	-109.1429	1875	PEGR	30	5	35	
317	39.82158333	-109.1426667	1874	PEGR	19		19	
318	39.82136667	-109.1421	1876	PEGR	15		15	
319	39.82145	-109.14165	1874	PEGR	23	2	25	
320	39.82158333	-109.1412333	1872	PEGR	8	2	10	
321	39.82171667	-109.1409667	1868	PEGR	10	5	15	
322	39.82195	-109.14055	1861	PEGR	31	2	33	
323	39.82216667	-109.1399	1844	NEG				
324	39.82201667	-109.1406333	1860	PEGR	6	2	8	
325	39.82171667	-109.1411333	1868	PEGR	1	1	2	
326	39.82183333	-109.1415	1869	PEGR	3		3	
327	39.82165	-109.1419	1871	PEGR	3		3	
328	39.82176667	-109.14235	1874	PEGR	7	1	8	
329	39.82208333	-109.1426	1873	PEGR	8		8	
330	39.82263333	-109.1427333	1871	NEG				
331	39.82331667	-109.1435333	1880	NEG				
332	39.82386667	-109.14225	1882	NEG				
333	39.82416667	-109.1415667	1881	NEG				
334	39.82446667	-109.1406667	1880	NEG				
335	39.8241	-109.1401167	1873	NEG				
336	39.82415	-109.1396333	1870	NEG				
337	39.82438333	-109.1392667	1868	PEGR	8		8	
338	39.82446667	-109.13895	1867	PEGR	29		29	

Feature	Latitude	Longitude	Elevation	Plant Type or neg. data	PEGR Flw/Pnts	PEGR Non-Flw/Pnts	Total PEGR	PESC
339	39.82446667	-109.1384167	1867	PEGR	23		23	
340	39.82501667	-109.1380167	1857	PEGR	10		10	
341	39.82535	-109.1373167	1846	PEGR	17		17	
342	39.82585	-109.1368167	1836	PEGR	16		16	
343	39.8261	-109.1365333	1827	PEGR	14	2	16	
344	39.82666667	-109.1361	1819	PEGR	3	5	8	
345	39.82731667	-109.1357167	1809	PEGR		5	5	
346	39.8272	-109.13595	1812	PEGR	2	2	4	
347	39.8267	-109.13625	1817	PEGR	1		1	
348	39.82636667	-109.1366167	1821	PEGR				
349	39.8261	-109.1369833	1824	NEG				
350	39.82581667	-109.1372167	1833	PEGR	17	4	21	
351	39.8256	-109.1372833	1843	PEGR	4	4	8	
352	39.82706667	-109.13755	1863	NEG				
353	39.82656667	-109.1409	1860	PESC				1
354	39.827	-109.1406	1860	NEG				
355	39.82751667	-109.1403333	1861	NEG				
356	39.82791667	-109.1401333	1861	NEG				
357	39.82831667	-109.1397833	1864	NEG				
358	39.82888333	-109.1390333	1863	NEG				
359	39.82893333	-109.1385333	1855	PEGR	8		8	
360	39.82906667	-109.1381167	1852	PEGR	13	12	25	
361	39.8292	-109.13765	1851	PEGR	20	1	21	
362	39.82925	-109.1371833	1845	PEGR	8		8	
363	39.82911667	-109.1367833	1835	PEGR	18	1	19	
364	39.8289	-109.1364833	1824	PEGR	35	5	40	

Feature	Latitude	Longitude	Elevation	Plant Type or neg. data	PEGR Flw/Pnts	PEGR Non-Flw/Pnts	Total PEGR	PESC
365	39.82886667	-109.1362333	1820	PEGR	9	1	10	
366	39.82913333	-109.136	1819	PEGR	3		3	
367	39.82943333	-109.1359667	1816	PEGR	3	2	5	
368	39.82975	-109.1361833	1801	NEG				
369	39.83008333	-109.1360833	1800	PEGR	17		17	
370	39.83055	-109.1359333	1795	PEGR	8	1	9	
371	39.83088333	-109.1358167	1795	PEGR	7	3	10	
372	39.83126667	-109.1357167	1799	PEGR	22	9	31	
373	39.83158333	-109.13565	1803	PEGR	11		11	
374	39.83208333	-109.1354333	1801	PEGR	12		12	
375	39.83261667	-109.1352833	1790	PEGR	3	6	9	
376	39.83353333	-109.1347	1803	PEGR	7	4	11	
377	39.83353333	-109.1347	1803	PEGR	8	2	10	
378	39.83353333	-109.1347	1809	PEGR	8		8	
379	39.83353333	-109.1347	1819	PEGR	15	5	20	
380	39.83005	-109.1372667	1832	PEGR	32	2	34	
381	39.828	-109.1401833	1861	NEG				
382	39.82773333	-109.14045	1865	NEG				
383	39.82705	-109.1407667	1862	NEG				
384	39.82605	-109.1412	1860	NEG				
385	39.82545	-109.14155	1866	NEG				
386	39.82466667	-109.1415833	1875	NEG				
387	39.82386667	-109.1419	1881	NEG				
388	39.8085	-109.1460333	1940	NEG				
389	39.80843333	-109.1452667	1939	NEG				
390	39.80881667	-109.1446333	1934	NEG				

Feature	Latitude	Longitude	Elevation	Plant Type or neg. data	PEGR Flw/Pnts	PEGR Non-Flw/Pnts	Total PEGR	PESC
391	39.80916667	-109.1444	1929	NEG				
392	39.80941667	-109.1438167	1930	NEG				
393	39.80991667	-109.1436333	1920	NEG				
394	39.81013333	-109.1435333	1912	NEG				
395	39.81043333	-109.1434833	1899	NEG				
396	39.81073333	-109.14325	1891	NEG				
397	39.81138333	-109.1433333	1899	NEG				
398	39.81183333	-109.1432	1900	NEG				
399	39.8123	-109.1430667	1894	PESC				11
400	39.81248333	-109.1425667	1897	PESC				23
401	39.81268333	-109.1421167	1892	PESC				5
402	39.81215	-109.1422167	1879	NEG				
403	39.81176667	-109.14185	1886	NEG				
404	39.81146667	-109.1416	1890	NEG				
405	39.81133333	-109.1413	1885	PESC				7
406	39.81138333	-109.1409333	1890	NEG				
407	39.81135	-109.1404667	1896	PESC				1
408	39.81173333	-109.1399333	1893	PESC				8
409	39.81163333	-109.1398333	1892	PESC				18
410	39.81096667	-109.1407	1897	NEG				
411	39.8102	-109.1413333	1909	NEG				
412	39.80973333	-109.1418333	1917	NEG				
413	39.80961667	-109.1422667	1921	NEG				
414	39.80941667	-109.14255	1931	NEG				
415	39.80915	-109.1430333	1931	NEG				
416	39.80866667	-109.1441333	1937	NEG				

Feature	Latitude	Longitude	Elevation	Plant Type or neg. data	PEGR Flw/Pnts	PEGR Non-Flw/Pnts	Total PEGR	PESC
417	39.830123	-109.131597	1821	NEG				
418	39.830432	-109.131376	1820	PEGR	1	10	11	
419	39.831018	-109.131228	1819	PEGR	1	4	5	
420	39.831315	-109.131194	1816	PEGR		3	3	
421	39.831594	-109.131207	1827	PEGR		8	8	
422	39.832232	-109.13131	1831	PEGR		3	3	
423	39.832675	-109.131562	1828	PEGR	3	1	4	
424	39.831663	-109.131566	1833	NEG				
425	39.831104	-109.13162	1835	NEG				
426	39.830891	-109.13163	1830	PEGR	6	5	11	
427	39.830034	-109.131763	1826	NEG				
428	39.829235	-109.1319	1837	NEG				
429	39.828612	-109.132287	1846	NEG				
430	39.828302	-109.132565	1853	PEGR	6	2	8	
431	39.825097	-109.132952	1864	PEGR	1		1	
432	39.824631	-109.132363	1861	PEGR	3	5	8	
433	39.824109	-109.132321	1859	PEGR	5	4	9	
434	39.823755	-109.132328	1860	PEGR	5	2	7	
435	39.823313	-109.132288	1860	PEGR	5	2	7	
436	39.822787	-109.132508	1857	PEGR	1	1	2	
437	39.822197	-109.133213	1854	NEG				
438	39.821593	-109.134058	1872	NEG				
439	39.82019	-109.134458	1869	NEG				
440	39.81934	-109.135187	1887	PEGR	9		9	
441	39.818936	-109.135649	1887	PEGR	1	2	3	
442	39.818028	-109.136932	1887	NEG				

Feature	Latitude	Longitude	Elevation	Plant Type or neg. data	PEGR Flw/Pnts	PEGR Non-Flw/Pnts	Total PEGR	PESC
443	39.817547	-109.137177	1886	PEGR	2	5	7	
444	39.896238	-109.085736	1995	NEG				
445	39.896735	-109.084843	1993	NEG				
446	39.898384	-109.084462	0	NEG				
447	39.897614	-109.083178	2002	NEG				
448	39.897964	-109.082544	2004	PESC				11
449	39.898198	-109.082265	2003	PESC				48
450	39.898463	-109.081899	2010	PESC				7
451	39.896225	-109.081696	2010	NEG				
452	39.899548	-109.081821	2016	NEG				
453	39.900513	-109.083133	2008	NEG				
454	39.900032	-109.083793	2010	NEG				
455	39.899672	-109.084561	2008	NEG				
456	39.900228	-109.085377	2013	NEG				
457	39.901992	-109.085771	1989	NEG				
458	39.901985	-109.085566	1987	NEG				
459	39.902308	-109.085839	1971	NEG				
460	39.901996	-109.08633	1979	NEG				
461	39.900867	-109.08673	2006	NEG				
462	39.901906	-109.088117	1992	NEG				
463	39.90189	-109.089152	1993	NEG				
464	39.902558	-109.089624	1992	PESC				115
465	39.902629	-109.089937	1986	PESC				14
466	39.90285	-109.089684	1988	PESC				36
467	39.902845	-109.08967	1989	NEG				
468	39.903951	-109.089706	1998	NEG				

Feature	Latitude	Longitude	Elevation	Plant Type or neg. data	PEGR Flw/Pnts	PEGR Non-Flw/Pnts	Total PEGR	PESC
469	39.904486	-109.090179	2009	NEG				
470	39.904777	-109.090215	2003	NEG				
471	39.90574	-109.089815	1994	NEG				
472	39.907335	-109.090122	1995	NEG				
473	39.907853	-109.08962	1979	NEG				
474	39.908545	-109.089585	1978	NEG				
475	39.909288	-109.09023	1966	NEG				
476	39.908852	-109.090322	1979	NEG				
477	39.908652	-109.090302	1982	NEG				
478	39.907787	-109.090542	1991	NEG				
479	39.906395	-109.090415	2008	NEG				
480	39.906003	-109.090247	2007	NEG				
481	39.90464	-109.090295	2009	NEG				
482	39.90396	-109.080082	0	PESC				3
483	39.902945	-109.090571	2001	PESC				3
484	39.902414	-109.090434	1996	NEG				
485	39.901835	-109.089296	2004	NEG				
486	39.900962	-109.08765	2009	NEG				
487	39.900447	-109.086858	2014	NEG				
488	39.90008	-109.086345	2017	NEG				
489	39.902091	-109.091091	2002	NEG				
				Total	1684	736	2742	1217

Appendix C: Various photos of monitoring and survey project.



White-gray oil shale outcroppings of the Green River formation protruding from ridgeline edge.



2011 Survey area near 3 Mile Canyon.



View of survey area and wildlife.



Rattle snake found along the survey path.



Monitored *P. grahamii* at the Buck Canyon site.



Researcher with *P. grahamii* at the Buck Canyon site



Construction of a bridge over Evacuation Creek near the Watson site. Watson site runs parallel to the tape measure in the photo.



P. scariosus var. *albifluvis*



Researcher monitoring *P. scariosus* var. *albifluvis* at the White River site.



The White River site.