Protecting the Parachute Penstemon During Closure of the Anvil Points Oil Shale Facility

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Figure 1. Parachute penstemon in flower.

Introduction

- To minimize impacts to Parachute penstemon during the closure of mines at the Anvil Points Facility, a mitigation plan was developed and implemented. In this report we describe and evaluate the methods used to prevent loss of existing plants, thereby preserving genetic diversity.

- **Anvil Points History and Background**
  The Anvil Points Facility, near Rifle, Colorado, was constructed to pioneer oil shale mining and processing research and development by government and private industry. Over 400,000 yd^3 of oil shale was mined and processed at the facility from 1947-82. Following a decline in private sector interest, the facility was decommissioned and demolished by 1986. The Anvil Points Facility has been characterized and studied as a Superfund Removal Action. A facility cleanup and closure plan was developed and implementation began in July 2008.

- **Parachute penstemon**
  Parachute penstemon (*Penstemon debilis*; Scrophulariaceae; Fig. 1) is a candidate for protection under the Endangered Species Act. There are four known locations of this species and the Anvil Points population is the largest occurrence on federal lands. Parachute penstemon is substrate specific and is found only on the steep white shale talus of the Green River Formation.

Methods

- *Mapping locations*: Field surveys were performed to inventory and map all accessible individuals located within 35 acres of habitat that includes the Anvil Points mine bench (Fig. 4).

- *Estimating natural overwinter mortality*: The locations of 80 inventoried Parachute penstemon were revisited in Sept. 2009 to estimate natural rates of mortality (Fig. 4). The presence or absence of an associated plant beside an undisturbed pin flag was used to indicate survival or mortality.

- *Protecting with mats*: Two areas of occupied Parachute penstemon habitat were within access routes to required cleanup sites [Adit 1 (n=23) and the Transformer Alcove (n=33; Fig. 4]. Penstemon within these areas were protected by covering them with interlocking panels of Dura-Base® composite matting (Fig. 3). Panels were set in place in Nov.-Dec. 2008 and removed in mid-Dec. 2008.

- *Transplanting at-risk plants*: Twenty-one Parachute penstemon were located directly in front of cleanup and closure sites [Mobil Adit (n=14) and Adit 3 (n=7); Fig. 4]. Affected individuals were removed and transplanted (Fig. 3) in Nov. 2008 (n=12) or Jun. 2009 (n=9).

- *Statistical Analysis*: An increase in risk of mortality associated with the protection measures was assessed using odds ratios. An odds ratio is calculated by dividing the mortality rate of a treatment group (i.e., mats or transplants) by the mortality rate of a control group. The odds ratio can be interpreted as the increase in the odds of an individual dying due to the treatment when compared to an individual in the control group. A comparison to a **Z**-distribution is used to assess the probability that the calculated ratio could have come about by chance .

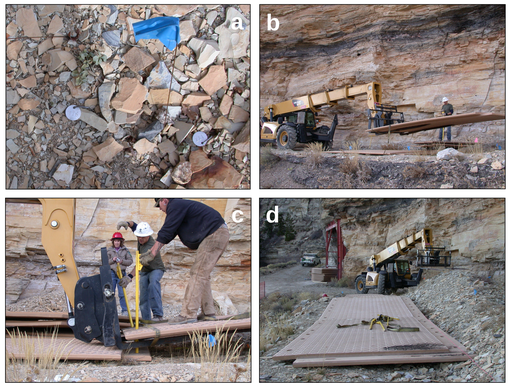

Figure 2. (a) Two tagged Parachute penstemon near Transformer Alcove, prior to covering with Dura-Base® construction mats. (b) Moving a mat into position. (c) Aligning interlocking panels. (d) Nearly completed driving surface to protect 33 Parachute penstemon.

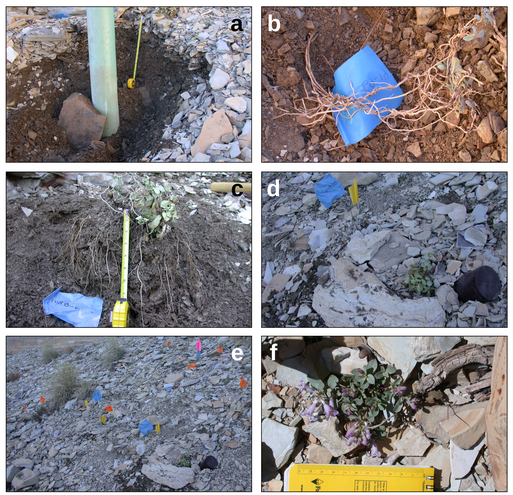

Figure 3. (a) Illustration of the extent of excavation required to remove some Parachute penstemon, and the use of a half-pipe to support a plant and root ball during excavation. (b) Partially excavated plant showing extensive shoots to right and roots to left. (c) Some plants had an extensive root ball. (d) Newly transplanted individual along with its Dri-Water® access tube in lower right. (e) Three newly transplanted individuals (yellow flags). (f) Flowering transplant as it appeared during Jun. 19, 2009 monitoring.

Results

Over 600 Parachute penstemon were inventoried and mapped within the vicinity of the Anvil Points mine bench (Fig. 4). Of these, 84 were at risk of direct impact from mine cleanup and closure activities. An assessment of the protection efforts for 77 of these plants is presented below. An additional 7 plants were protected in other manners, but are not included as part of this study.

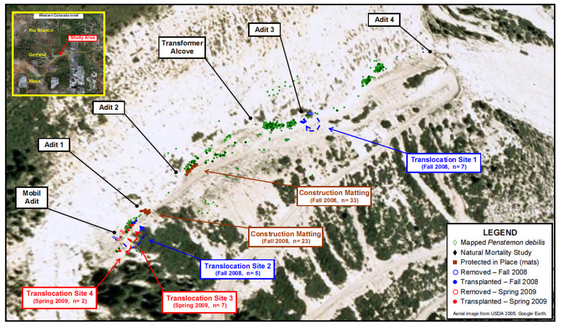

Figure 4. Locations of Parachute penstemon and other features on the Anvil Points Facility mine bench.

- *Natural mortality (control)*: Of the 80 plant locations sampled, 6 plants could not be re-identified and are presumed dead. (Table 1, Figs. 4 & 5)

- *Protected with mats*: The mortality rate (10.7%) of plants protected by synthetic construction mats was not significantly different from controls. (Table 1, Figs. 4 & 5)

- *Transplants*: Compared to controls, a transplanted Parachute penstemon was 3.85 times more likely to suffer mortality. (Table 1, Figs. 4 & 5)

- *Effect of season of transplanting*: The mortality rate (16.7%) of Fall 2008 transplants was not significantly different from controls. In contrast, Spring 2009 transplants were 6.17 times more likely to suffer mortality. (Table 1, Figs. 4 & 4)

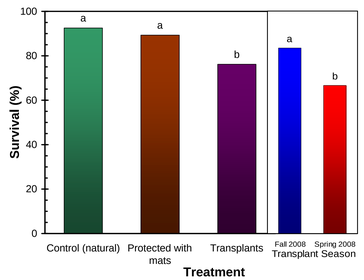

Figure 5. Survival rates of Parachute penstemon subject to several protection methods during mine cleanup and closure. Responses identified with the same letter are not significantly different ($\alpha \leq 0.10$) Colors correspond to treatments indicated in Fig. 4.

Table 1. Survival rates and mortality odds ratios of Parachute penstemon subject to different methods of protection from mine closure activities.

Treatment	n	Dead	Survival Rate	Odds Ratio	*Z*	*P*
Control (natural mortality)	80	6	92.5%	n/a	n/a	n/a
Protected with mats	56	6	89.3%	**1.48**	0.638	0.26
Transplants	21	5	76.2%	**3.85**	1.714	0.044
Transplants – Fall 2008	12	2	83.3%	**2.47**	0.822	0.21
Transplants – Spring 2009	9	3	66.7%	**6.17**	1.560	0.059

Abstract

Parachute penstemon (*Penstemon debilis*) is a candidate for listing as threatened or endangered by the U.S. Fish and Wildlife Service and is recognized as a Sensitive Species by the Bureau of Land Management Colorado State Director. This species' habitat is limited to the steep, white shale talus on the Mahogany Zone of the Parachute Creek Member of the Green River Formation. Of four known locations, the largest occurrence on federal lands is within the Anvil Points Facility near Rifle, Colorado. This facility to research and develop methods of oil shale mining and processing has been inactive since 1983. Beginning in 2008, a removal, clean up, and closure plan has been implemented to remediate and store waste shale and close the mine adits. Several steps were taken to protect this Parachute penstemon population since it is located near mine adits slated for closing. All penstemon plants on the historic mine bench were inventoried, flagged and mapped using GPS. Plants growing on access routes to adits were protected in place with synthetic mats. Plants growing directly in front of adits were transplanted to safe locations up to 30 meters distant. Protection with synthetic mats was very highly effective: over-winter survivorship was 89% which compares favorably to the 92.5% survival observed in non-disturbed plants. Survivorship of transplants varied from 67% to 83%, depending upon the season during which transplanting was performed. Protective measures such as these may be appropriate to minimize and mitigate unavoidable impacts to sensitive species subject to similar development activities.

Conclusions

- Avoiding direct impacts that carry the risk of mortality resulted in the highest rate of survival among sampled Parachute penstemon.

- When complete avoidance was not practical or feasible, the use of Dura-Base® composite mats was very highly effective in minimizing negative impacts to this rare plant. Mortality rates among plants protected by mats were not significantly different from controls (Fig. 5).

- When complete avoidance was not possible, and the use of Dura-Base® mats was not practical or feasible, transplanting was an effective tool for minimizing impacts to this rare plant.

- However, the efficacy of transplanting as a mitigation method was highly dependent upon the season during which transplanting was undertaken. Transplanting during the fall, as plants were senescing, was highly effective in minimizing negative impacts. Transplanting during the spring, when many shoots had not yet emerged above the surface, was much less effective in minimizing negative impacts.

- Monitoring of impacted individuals and areas is ongoing and is scheduled to continue through 2011.

- These techniques may prove useful for other situations in which development activities are expected to have negative impacts on vegetation.

Acknowledgments

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