United States Department of Agriculture

Forest Service
Region 5 Ecology Program
Sierra Cascade Province

The effects of underburning on *Boechera constancei* (Constance's rock-cress)

Plumas National Forest
Monitoring Summary (2004 - 2006)

May 3, 2016

Introduction

Boechera constancei (Constance's rock-cress) is a strict serpentine endemic that is considered seriously threatened in California (List 1B.1; California Native Plant Society 2016). It is known from approximately 48 occurrences, which are scattered throughout several parallel bands of serpentine in Plumas and Sierra counties (California Natural Diversity Database 2016). All but one of these occurrences are located on the Plumas National Forest (NF); the occurrence outside of the Plumas NF is in the southernmost part of the Lassen NF (California Natural Diversity Database 2016).

Occurrences of Constance's rock-cress are found primarily in undisturbed sites that are situated between 3,200 and 6,600 feet in elevation. They range in size from a few individuals on small serpentine outcrops to hundreds of individuals within larger areas of more productive serpentine soils. Occurrences that have not been impacted by management activities appear relatively stable over time; however analyses of monitoring data collected over a 20 year time period suggest that the number of plants can fluctuate from year to year, possibly in response to variation in precipitation or other climatic variables (USDA Forest Service 2007, 2008).

Although many serpentine species rely on fire to maintain the vegetative characteristics of their habitat, very few of the serpentine endemic plants in California are believed to be fire-dependent (Safford and Harrison 2004). In fact, many rare serpentine species are thought to be restricted to these harsh soils as a result of their intolerance to frequent or high intensity fires (Safford and Harrison 2008).

Beginning in the early 2000s, the Plumas NF planned and implemented a number of prescribed fire treatments within Constance's rock-cress habitat as part of a large-scale effort to promote the development of resilient forest conditions (USDA Forest Service 1999). As part of the continuing effort to improve rare plant management, we conducted monitoring to evaluate the effect of prescribed fire treatments on Constance’s rock cress abundance.

Methods

In August of 1997, ten permanent monitoring plots (10’ x 10’; 100 ft^2) were established in the Spanish Camp Timber Sale Area to evaluate the effects of prescribed fire on Constance's rock-cress (Figure 1). Plots were revisited annually between 2004 and 2006 and the total number of Constance's rock-cress rosettes recorded. Treatments were implemented in the spring of 2002 and 2005 and consisted of underburning, pile burning, and in some cases, thinning of small diameter trees prior to burning (Table 1).

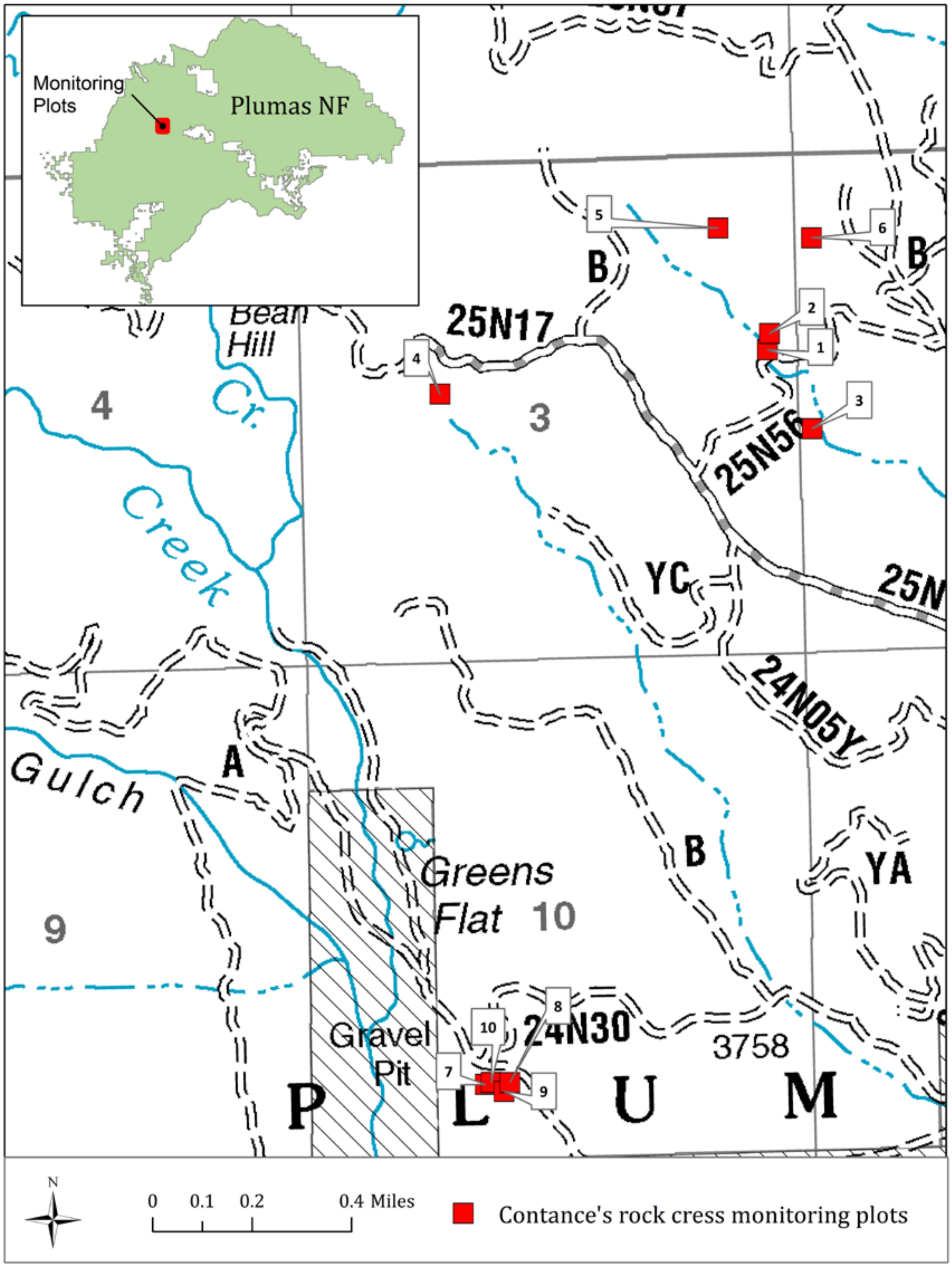

Figure 1. Constance's rock cress monitoring plots within the Spanish Ranch Underburn Project on the Plumas National Forest.

Treatment intensity was assessed qualitatively one to four years after burning. One of the plots (#10) was classified as high intensity due to a burn pile that was placed directly on top of the plot (Figure 12). Another plot (#2) was classified as moderate intensity due to a large snag that fell into the plot while burning (Figure 4). The remainder of the plots were classified as low intensity due to the fact that there were very little fuels present (i.e. rocky, serpentine habitat) and no high severity fire effects (e.g. on the vegetation or soil surface) evident post-treatment. One plot (#3) was left untreated to serve as a control (Figure 5).

Table 1. Summary of prescribed fire treatments in Constance's rock-cress monitoring plots

Plot #	Date of Treatment	Treatment Classification
1	Spring 2005	Low intensity
2	Spring 2005	Moderate intensity (snag fell into plot and burned at high intensity)
3	No Treatment	No treatment
4	Spring 2005	Low intensity
5	Spring 2005	Low intensity
6	Spring 2005	Low intensity
7	Spring 2002	Low intensity
8	Spring 2002	Low intensity
9	Spring 2002	Low intensity
10	Spring 2002	High intensity (burn pile placed directly on top of plot and partially burned

Analysis

To investigate the effects of underburning on Constance's rock cress, we first calculated the average number of individuals within each plot prior to and after treatment. Inconsistencies in data collection (e.g. counting unit) and treatment implementation schedules (2002 vs. 2005) created large variability in the quality and quantity of the data and precluded the use of yearly counts. We calculated the relative change in rock cress abundance using the log ratio score, which was calculated using the following equation (Bonate 2000):

$$Ln\ (post - treatment\ average) - Ln(pre - treatment\ average)$$

A one-way analysis of variance (ANOVA) was then used to investigate the effect of treatment intensity (high/moderate, low, and no treatment) on the relative change (log-ratio scores) in Constance's rock cress abundance. Pairwise comparisons were computed using Student's t-tests. All statistical analyses were completed in JMP 11.2 (SAS Institute Inc. 2013).

Results

With the exception of two monitoring plots (#7 and #8), the average number of Constance's rock cress decreased over the course of our study. The two largest declines were in plots that burned at moderate to high intensity (plots #2 and #10); however we also observed a decline in our control plot (#3), which was not burned (Table 2). This suggests that there may be factors other than the prescribed fire treatments (e.g. changes in precipitation patterns) that are influencing Constance's rock cress abundance over time.

Table 2. Pre and post-treatment count data from the 10 Constance's rock cress monitoring plots. Log ratio scores were calculated using the equation presented under the Methods section. Positive values, representing an overall increase in average number of plants after treatment, are represented in bold.

Plot #	Treatment intensity	pre-treatment count (average)	post-treatment count (average)	Log-Ratio Score
1	Low	30	26	-0.14
2	Moderate	27.5	2	-2.62
3	Control	23.5	15	-0.45
4	Low	9.5	4	-0.87
5	Low	24.5	23	-0.06
6	Low	76.5	54	-0.35
7	Low	117	193.5	**0.50**
8	Low	33	104	**1.15**
9	Low	67	52.5	-0.24
10	High	170	46.5	-1.30

Treatment intensity had a significant effect on Constance's rock cress abundance (p=0.03). Plots that burned at high to moderate intensity had significantly fewer individuals after treatment than those plots that burned at low intensity. Constance's rock cress abundance declined by an average of 83% in high to moderate intensity plots, whereas plots that burned at lower intensity had an average increase of 22%. Although neither treatment (high to moderate nor low intensity) differed significantly from the control plot, it is important to note that we only had one plot that was left unburned. This likely restricted our power to make comparisons between treated and untreated plots.

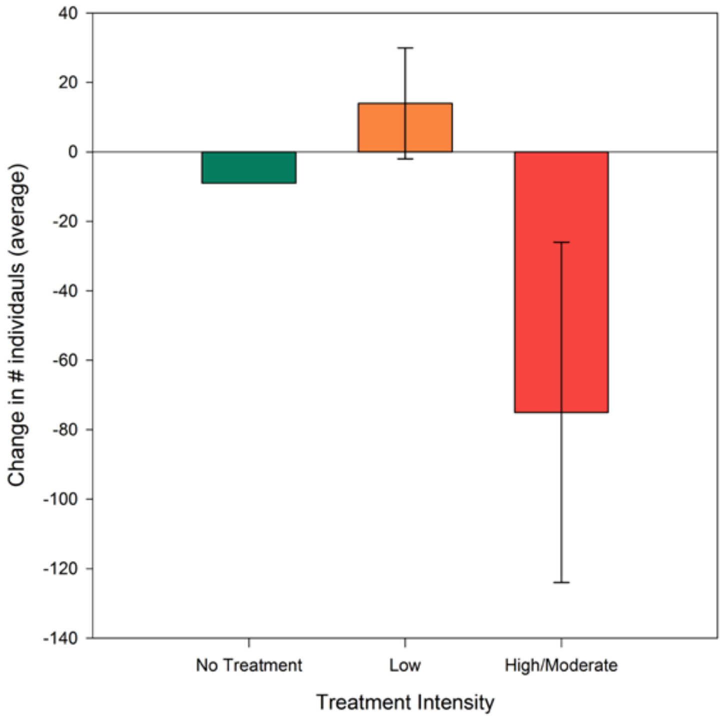

Figure 2. Average change in the number of Constance's rock cress individuals pre- and post-treatment under different prescribed fire intensities.

Discussion

Our monitoring data suggest that Constance's rock cress is tolerant of low intensity fire, but may be intolerant of high to moderate intensity fire. This finding has a number of management implications, particularly as wildfires continue to increase in both size and severity across the western United States. Over the past two decades, wildfires on the Plumas NF have affected some of the most extensive ultramafic terrain in the northern Sierra Nevada. Over a twelve year period, three fires on the Plumas and Lassen NFs (2000 Storrie, 2008 Rich, and 2012 Chips fires) burned through eight Constance's rock cress occurrences (27 sub-occurrences), impacting 17% of all documented occurrences.

The role of fire in Sierra Nevada serpentine ecosystems is not well-understood. Some studies suggest that landscape-scale disturbance processes, such as fire, may play a less important role in serpentine habitats than they do in more productive nonserpentine systems (Safford and Harrison 2008). Lower biomass accumulation and patchy vegetation structure on serpentine substrates often results in a very different fuel structure than adjacent nonserpentine systems (Safford and Mallek 2010). These conditions are evident in many of the Constance's rock cress occurrences, which range from rocky barrens to open low-growing shrub communities. These conditions can lower the availability and continuity of woody fuels, which can decrease fire severity and increase the fire return interval in serpentine habitats (Harrison et al. 2003, Safford and Harrison 2004, Safford and Mallek 2010).

The exclusion of fire for over a century within some of the Plumas NF Constance's rock cress occurrences has resulted in scattered areas with high concentrations of small conifer trees. Conifers on serpentine have been shown to modify the physical characteristics of their immediate surroundings by increasing the soil depth, organic matter, calcium to magnesium ratio, and lowering the pH (Chiarucci and DeDominicis 1995, Barton and Wallenstein 1997). Fire exclusion, and the subsequent increase in woody fuels, can also increase the risk of high severity fire in these systems. Our observations and analysis of data collected from the 2000 Storrie Fire and 2008 Rich Fire found that fire severity was similar on serpentine and nonserpentine areas in both fires, with 40 percent of serpentine substrates burning at high to moderate severities.

High severity fire in serpentine systems can have a number of negative consequences. Although many serpentine species rely on fire to maintain the vegetative characteristics of their habitat, very few of the serpentine endemic plants in California are believed to be fire-dependent (Safford and Harrison 2004). In fact, many rare serpentine species are thought to be restricted to these harsh soils as a result of their intolerance to frequent or high intensity fires (Safford and Harrison 2008). Our monitoring results, which suggest that Constance's rock cress is tolerant of low intensity fire, but intolerant of high intensity fire, reinforces this concept.

Management Recommendations

- Increase the resilience of Constance's rock cress occurrences to future high severity fire by reducing dead and live fuels in areas with elevated risk. Focus restoration activities in areas that have been previously burned at high to moderate severity or in areas where fire exclusion has led to the buildup of excessive fuels.

- Evaluate potential effects of prescribed fire on a site-by-site basis considering factors such as number of individuals, fuel load, burn season, and predicted intensity and duration of burn. Consider removing large woody debris from the immediate vicinity of Constance's rock cress plants.

- Keep hand piles away from (at least 20 feet) Constance's rock cress plants to protect individuals and seedbank from excessive heat.

- Develop monitoring plans to evaluate fire effects on individuals and populations whenever prescribed burning is planned and implemented.

Plot photos

Figure 3. Plot 1. Photo taken in 2006 one year after underburning (2005)

Figure 4. Plot 2. Photo taken in 2006 one year after underburning (2005)

Figure 5. Plot 3. Photo taken in 2006. No treatments were implemented in this plot.

Figure 6. Plot 4. Photo taken in 2006 one year after underburning (2005)

Figure 7. Plot 5. Photo taken in 2006 one year after underburning (2005)

Figure 8. Plot 6. Photo taken in 2006 one year after underburning (2005)

Figure 9. Plot 7. Photo taken in 2006 four years after underburning (2002)

Figure 10. Plot 8. Photo taken in 2006 four years after underburning (2002)

Figure 11. Plot 9. Photo taken in 2006 four years after underburning (2002)

Figure 12. Plot 10. Photo taken in 2006 four years after pile was placed on top of plot and partially consumed during burning (2002)

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