Zion National Park
Kolob Fire
Post-fire Restoration Monitoring

Introduction and Background

These studies were conducted within the area burned by the Kolob fire, which started in June 2006 near the southwestern corner of Zion National Park in southern Utah (37°9.38' N, 113°29.35'W) (Fig 1). The fire burned 4,252 hectares within Zion, the majority (75%) being in pinyon-juniper woodland, the remainder in shrub/grassland. Due to a presence of *Bromus tectorum* (cheatgrass) and *Bromus rubens* (red brome) in the pre-fire areas and just outside the park, there was a concern that the grass-fire cycle would take hold in this area. To try to combat the invasion of Bromes, 3422 burned hectares received an aerial application of imazapic (Plateau®) herbicide at a rate of 0.59 L/ha (8.1 oz/acre) of imazapic in the fall of 2006 (Fig 1). One area, the Kolob Terrace Site (Fig. 1), was known to be occupied by Brome for at least several decades. Seed reserves of native species were likely scarce given the long-term presence of these exotics and their ability to monopolize the soil seed bank. To assist native succession, this region (193 hectares) received an additional aerial application (9.1 kg/ha) of a native seed mix comprised of *Sporobolus cryptandrus (*sand dropseed), *Elymus elymoides (*bottlebrush squirreltail*), Penstemon palmeri* (Palmer penstemon) and *Sphaeralcea ambigua* (desert mallow). All species are perennial, had a pre-fire presence and have some ability to compete with invasive bromes.

Three study sites were selected; two in pinyon-juniper (Kolob Terrace and Crater Hill) and one in a shrub-grassland area (Dalton Wash) (Fig. 1). Initial site selection was based upon stratification of the burned area by treatment type, vegetation type and geological groupings with the goal of reducing onsite environmental variability. All sites were located in areas of high fire severity as these areas were targeted for post-fire treatments. At the Kolob Terrace site, a randomized complete block design was implemented with each block containing four plots for a total of 12 blocks. Plots were 5 x 30 m and were randomly assigned to one of the following treatments: control, seeded, herbicide, seeded and herbicide. At the Crater Hill site a paired design of 22 pairs with untreated control and herbicide-treated plots was used. The Dalton wash site also had a paired design with 30 pairs, but the plots were 2 x 2 m.

Results

- Across all three sites the herbicide significantly reduced Bromus species in the understory for two to three years. In the seed bank the reduction was seen for only one year.
- The combined treatment of herbicide plus native seed appeared to have a greater effect on reducing Bromus compared to seeding or herbicide alone.
- In all years, the seed only treatment did not have significantly more biomass of the seeded species compared to the control, and the seeding treatment contributed very little to the presence of those species in the seed bank.
- Both the herbicide treatments had a significant negative effect on the seeded species for two to three years in the understory.
- When the entire understory plant community was considered (i.e., a multivariate analysis), the effects of the herbicide and herbicide plus seed treatments persist from one to two years. This

holds for the native plant community as well. The seed bank did not show a significant herbicide effect in any year.

- Native and non-native plants were both affected by the herbicide; perennials were negatively affected by the herbicide for at least one year. The exception to this was a native rhizomatous perennial grass, *P. jamesii*, which showed a positive response to the herbicide at one site.

Conclusions

Overall, the results of our study suggest that imazapic is effective in providing a short-term restoration window in areas invaded by *Bromus* species but can also impact non-target native species. We heavily caution against using imazapic on sites that are not moderately to highly invaded in order to prevent unintentional damage to the native plant community. Imazapic is not the silver bullet. *Bromus* species were not eliminated in this study and it is unclear whether the negative effects on the native species were worth the short-term reduction in *Bromus*. This balance may heavily depend on the proportion of native to invasive species in a given site, as well as the amount of biomass aboveground. It is also unclear if the reduction in *Bromus* species was enough to stop the spread of future grass fires longer than a year or two.

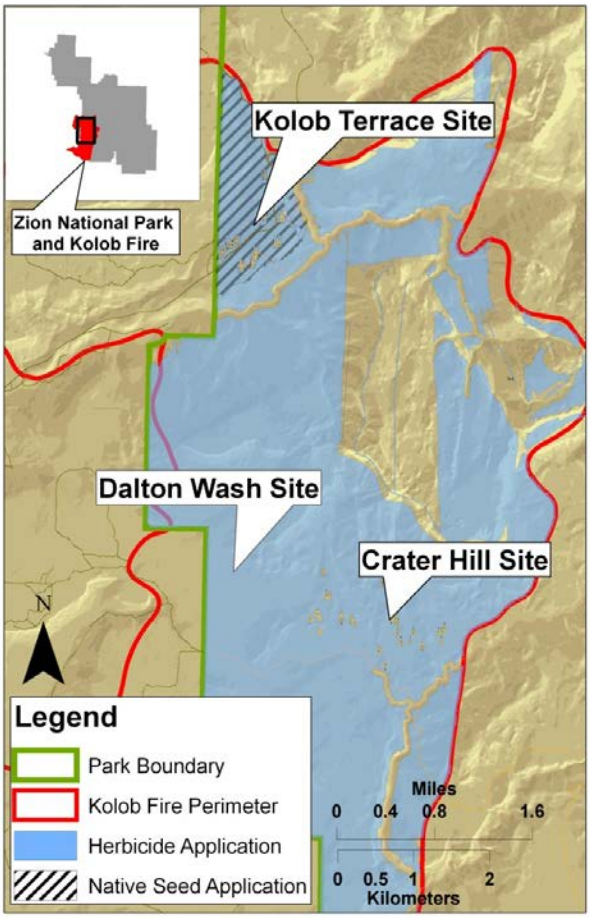

Figure 1. Treatments and study sites. Overview of the three study sites established to assess the post-fire herbicide effects within the 2006 Kolob Fire, Zion National Park. The 3422 burned hectares that received an aerial application of imazapic herbicide are shown in blue. An additional 192 hectares also received native seed treatment of four perennial species, which is represented by diagonal lines at the Kolob Terrace Road site.