Prescribed fire and nonnative plant spread in Zion National Park

By Kelly Fuhrmann, Cheryl Decker, and Katie A. Johnson

PRESCRIBED FIRE IS A VALUABLE TOOL FOR MANAGING ecosystems because it promotes species diversity and productivity and reduces wildland fuels. In some communities, for example ponderosa pine, fire is critical for productivity. However, prescribed fire can also promote the spread of nonnative plant species and affect ecosystem composition, diversity, structure, and function. Land use history and climate change have contributed to the invasion of nonnative plant species into an expanding variety of ecosystems, including higher-elevation plant communities. This expansion of nonnative plants has the potential to change the fire regimes of the plant communities of which they are a part (Westerling et al. 2006). For instance, managers ignited the Clear Trap prescribed fire in a juniper-pinyon-ponderosa (*Juniperus osteosperma*, *Pinus edulis*, and *P. ponderosa*, respectively) system in Zion National Park in fall 2004 (fig. 1). Composed of the Clear Creek and Deer Trap burn units, the 4,400-acre (1,780 ha) Clear Trap fire is the largest prescribed burn undertaken to date in Zion National Park. It is also the first of several National Park Service (NPS) fire treatments in the East Zion Focus Area, a designated wildland-urban interface of high priority for protecting human life and property values at risk from wildland fire. The primary goals of this prescribed fire were to improve the defensibility of the park boundary and help restore fire to park ecosystems (NPS 2001). Though the focus of the burn was fuel reduction, in spring 2005 (the season after the burn), park natural resource managers identified another result: significant increases in nonnative plant species within the burn unit. As a result, in 2006 the vegetation program at Zion National Park enlisted the help of the NPS Northern Colorado Plateau Inventory and Monitoring Network to map the extent of nonnative plant infestations in this area.

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Figure 1. The Clear Trap prescribed fire burned approximately 4,400 acres in fall 2004. This view is representative of the mixed burn severity in ponderosa pine communities, in which the fire return interval is normally four to seven years, and in the pinyon-juniper communities, in which fire is much less frequent, with an average return of 160 years. Historically, fires in Zion National Park were suppressed.

Background

The 2005 fire management plan (NPS 2005) for the park identifies desired future conditions that are targeted through the implementation of objectives based on ecological parameters. Goals are: (1) fire processes in fire-dependent/adapted vegetation communities are managed to promote healthy and functional ecosystems; (2) vegetation succession reflects the natural range of variability under conditions that would occur under historical fire regimes; (3) fire is used as a tool to protect and enhance native vegetation communities; (4) fire program operations do not contribute to the spread of nonnative plants in Zion; and (5) resource managers develop native seed sources.

Since the Clear Trap prescribed burn in 2004, Zion National Park has experienced two of the largest wildfires in its history. In 2006 the Kolob Fire burned 10,500 acres (4,259 ha) and the Dakota Hill Fire burned 5,800 acres (2,347 ha) in 2007. Management response to these events included herbicide treatments with imazapic (Dakota Hill and Kolob) and seeding (Kolob) with native grasses and forbs such as bottlebrush squirreltail (*Elymus elymoides*), sand dropseed (*Sporobolus cryptandrus*), scarlet globemallow (*Sphaeralcea coccinea*), and Palmer penstemon (*Penstemon palmeri*) to combat the spread of nonnative plants, particularly cheatgrass (*Bromus tectorum*). The decision to apply large-scale aerial herbicides was uncharacteristic but deemed necessary to combat the dominance of cheatgrass, which increases in abundance and density after fire (Fuhrmann 2007).

Cheatgrass is aggressive in any disturbed site, without regard to aspect, moisture, or elevation (fig. 2, next page). It can successfully compete with native plant populations that have been removed as a result of a disturbance such as fire. Cheatgrass displaces native plant communities because, as a winter annual, it is able to establish earlier in the growing season, thus increasing competition and depleting soil resources until native annuals are eventually crowded out. When cheatgrass is dominant, wildfires can occur earlier in the season, when native perennials are more susceptible to injury by burning. Also, cheatgrass provides a continuous supply of fine fuel for rapid fire spread. Moreover, under appropriate moisture conditions, cheatgrass is a prolific seed producer. Over time, seed from individual plants builds into thick mats. When the grass stems are burned, only the top layer of this

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Figure 2. Cheatgrass grows aggressively in disturbed areas. Here, one year after the fire, it has infested a high-severity burn area within the Clear Trip prescribed fire.

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Figure 3. National Park Service employees Alexia Savold and Fleur Nicklen survey invasive plants as part of the Clear Trap postburn assessment.

vegetative mat is affected, leaving bottom layers of seed and mulch ready to take advantage of newly available resources (light, water, and space). This advantage sets up an annual fire return cycle that is destructive to native plant species. The result can be conversion from native shrub and perennial grasslands to annual grasslands adapted to frequent fires. This adaptation to and promotion of frequent fires are what give cheatgrass its greatest competitive advantage in ecosystems that evolved with less frequent fires. The only true competition for cheatgrass is from a healthy, abundant native plant community that prevents opportunistic sprouting by nonnatives.

Methods

We incorporated four vegetation monitoring types—gambel oak (*Quercus gambelii*), ponderosa pine–pinyon pine, Utah juniper (*Juniperus osteosperma*), and big sagebrush (*Artemesia tridentata*)—identified in the fire management handbook monitoring protocols (NPS 1992; h3) into this analysis using FEAT/FIREMON Integration (FFI) (an integration of the National Park Service's fire ecology assessment tool [FEAT] [Lutes et al. 2009; Sexton 2003] and the USDA Forest Service's Fire Effects Monitoring and Inventory System [FIREMON] [Lutes et al. 2006] database tool [Lutes et al. 2009]). Ten forest plots (20 m × 50 m [66 × 164 ft]) and one brush plot (5 m × 30 m [16 × 98 ft]) are represented. Seven of the 11 plots were in a burn conducted for the first time in this area; the remaining four were in areas burned for the second time. The combining of monitoring types may lead to higher variability in some results, such as fuel loading. This, in conjunction with small sample size, offers an explanation for the resulting standard deviation ranges.

The primary objective of mapping postburn vegetation within the Clear Trap prescribed fire was to determine the relative abundance of invasive grass species. Network staff conducted field searches at as fine a scale as required to be confident that 90 to 100% of all invasive plant infestations 0.01 acre (40 sq m) or larger within each inventory area were detected (fig. 3). Search swath widths were adjusted as needed based on variations in terrain, walking speed, associated vegetation, and target species. The locations of all target species were documented using global positioning system units with 2- to 5-meter (6.6 to 16.4 ft) accuracy. Field crews marked and dated all inventoried areas on standard United States Geological (USGS) 7.5-minute topographic maps to assist in determining project progress and thoroughness of coverage (Dewey and Andersen 2006).

Results and discussion

Data assessment in relation to project objectives must be taken in context with small sample sizes, mosaic burning patterns, and standard deviation relationships. The fuels results (fig. 4) suggest that desired reduction of fuel loads was successful. Conditions may have been drier than anticipated. We identified an increase in percentage of surface cover of native grasses and forbs (fig. 5),

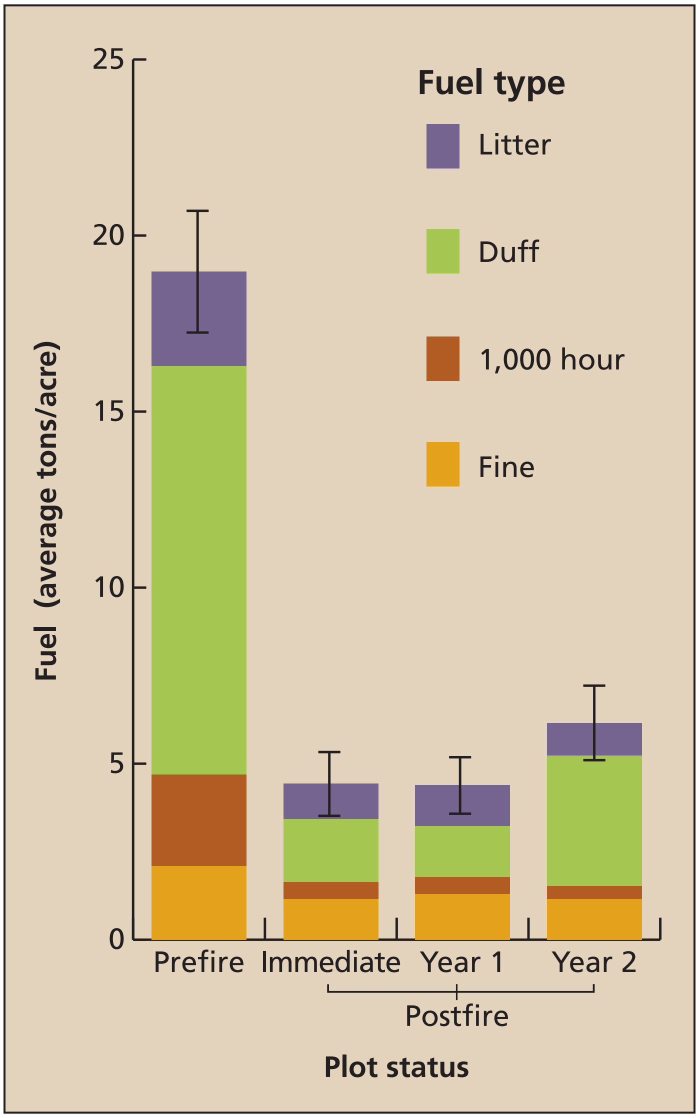

Figure 4. Total fuel loading (litter, duff, and 1,000-hour and fine fuels) within the Clear Trap fire was reduced by an average of 14.5 tons/acre (32.5 metric tons/ha) immediately after the fire. Two years later the fuel loading average has been reduced further to 6.1 tons/acre (13.7 metric tons/ha). Before the prescribed burn the average fuel load was 19 tons/acre (42.6 metric tons/ha).

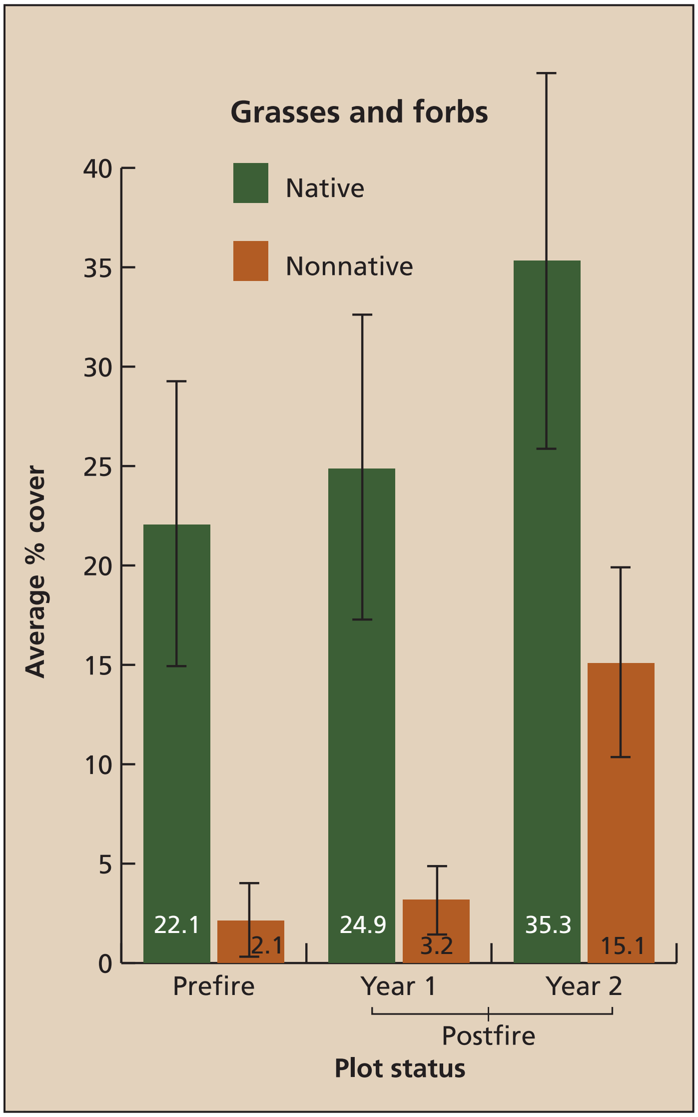

Figure 5. The percentage of native and nonnative plant species cover in the prescribed fire area also decreased two years after the burn. While native plant cover reduction met the burn plan goal (NPS 2001), nonnatives increased in quantity and extent, threatening the diversity and long-term recovery of native vegetation.

a goal that was met in the represented vegetation communities. In addition, identified increases in nonnative plant percentage of cover provide insight into a threat to native plant communities within the burn unit. This response may be partially due to an abundant snowpack in winter 2005. It may also be a result of seasonality of the burn in combination with high burn intensity in several areas where vegetation plots were located.

Survey crews recorded 413 acres (167 ha) of cheatgrass, comprising 77.2% of the acreage infested with nonnative plant species and 9% of the total area. Infestations were generally less than 0.1 acre (40.0 sq m) and consisted of dense patches scattered in open disturbed meadows or at the base of juniper trees (Dewey and Andersen 2006).

Crews found several nonnative species within the burn unit, but the most abundant target weed species was cheatgrass (table 1, next page). They found cheatgrass throughout the burn unit—in highly burned, moderately burned, and unburned areas (fig. 6, next page). It occurred more often in burned areas with minimal canopy cover. Patches ranged in size from 0.001 acre (4.0 sq m) to 5 acres (0.2 ha), but most were 0.1 acre (40.0 sq m) or smaller. In areas where burn severity was moderate to high, cheatgrass occurred in large, somewhat continuous patches. Areas that were

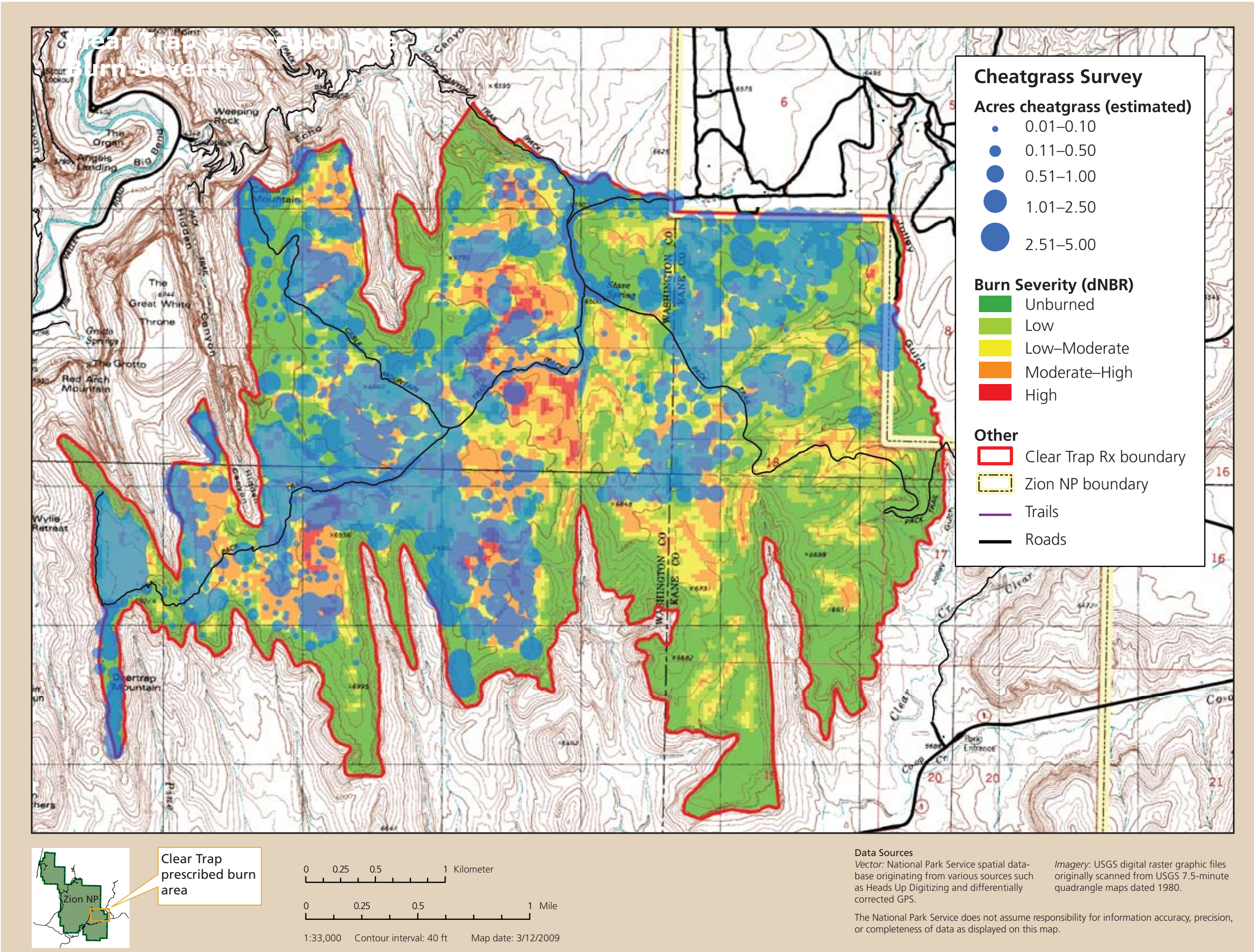

Figure 6. Clear Trap burn severity and cheatgrass survey results. The map depicts how cheatgrass locations correspond to the burn perimeter. Cheatgrass cover increased after the fire. The southeastern corner of the fire appears not to have been infested by cheatgrass. This area was not surveyed for invasives.

unburned or experienced low severity usually contained less cheatgrass. Most patches found on such sites were small—0.01 or 0.001 acre (405.0 sq m or 4.0 sq m)—and typically were located around the bases of unburned trees. This pattern suggests some kind of establishment or survival advantage associated with the microhabitat created beneath a tree's canopy, at least for cheatgrass growing under the conditions found in southern Utah (Dewey and Andersen 2006).

Table 1. Nonnative plant species infesting the Clear Trap prescribed fire, 2004

Common name	Scientific name
Ripgut brome	*Bromus diandrus*
Smooth brome	*Bromus inermis*
Downy brome	*Bromus tectorum*
Orchardgrass	*Dactylis glomerata*
Quackgrass	*Elymus repens*
Indiangrass	*Sorghastrum nutans*

Conclusions

The resulting composition of the vegetation community in the Clear Trap burn unit demonstrates the need for additional management considerations that incorporate the control of nonnative plant populations in the treatment of burned areas. Over time, different scenarios could result from this management-ignited fire disturbance. For example, if long-term dominance by invasive plant species allows for the selection of native individuals that can compete more effectively, populations may develop that are better able to coexist with invaders (Aarssen 1983; Mealor and Hild 2007). Conversely, invasive plants may come to completely dominate the invaded plant communities, changing disturbance regimes to promote the establishment of the invasive plant community (D'Antonio and Vitousek 1992; Brooks et al. 2004).

Results of this study show that an unintended conversion of fuel type or plant community composition may follow burns in juniper and ponderosa pine communities where nonnative plants such as cheatgrass live. This conversion compromised the intended goal of fuel reduction by increasing fine-fuel loading of nonnative plants. It also jeopardized native plant community composition and diversity. Future fire and resource planning should assess the benefits of using fire as a management tool in fire-adapted ecosystems susceptible to invasion by aggressive nonnative plants and provide for management needs in the pre– and post–prescribed fire environment. The invasion of nonnative cheatgrass illustrates the need to address related management issues (e.g., invasive plants) in conjunction with prescribed burning.

The following management implications (USGS 2002, p. 1) illustrate the range of variability in treatment outcomes and the additional attention necessary for controlling invasive plant infestations that may result from prescribed fire in semiarid Mojave Desert ecosystems:

- Introduction of fire where it has been suppressed often facilitates the invasion of fire-adapted invasive plants that can prevent the reestablishment of historical fire regimes.
- Fire can be used to control invasive plants if it kills adult plants, their overwintering tissues, or eliminates seed banks, but follow-up treatments are often necessary.
- Invasive species with the ability to survive fire or reestablish from long-lived seed banks should not be managed using fire in this semiarid climate.
- When targeting invasive plants for control, the potential benefits to other invasive species must always be considered.

Historical fire regimes in pinyon-juniper and ponderosa pine ecosystems that developed over thousands of years and have been shielded by elevation barriers from nonnative species invasions (such as cheatgrass) may, with climate changes, be more susceptible to invasion in modern times. This may alter the dynamics of the succession process (Miller and Tausch 2001; Allen et al. 2002) and limit biodiversity on the affected sites (Brown et al. 2007). A more thorough understanding of fire effects in juniper and ponderosa pine systems by fire managers is imperative to appropriately implement prescribed fire strategies. Nonnative plant species will continue to be a serious impediment to ecological integrity in the postfire environment. A proactive approach to postfire management of nonnative plants will be key to effectively addressing this expansive issue. Continued monitoring of fire effects within these systems and the development of weed management plans will help to improve understanding of this ecological dilemma.

Acknowledgments

The authors express their appreciation to Li Brannfors, Chad Hoffman, Linda Kerr, Mark Miller, and Joel Silverman for contributions to the development of this report.

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