Meeting Forest Ecosystem Objectives with Wildland Fire Use

Daniel C. Laughlin and Peter Z. Fulé

The U.S. Department of the Interior (USDI), National Park Service has been a leading agency in the application of both prescribed fire and wildland fire use (WFU) for resource benefits (van Wagtendonk 1991; Stephens and Ruth 2005).

In 2003, Grand Canyon National Park fire use modules managed the largest and most complex group of WFU fires in the park's history, totaling more than 19,000 acres (7,690 ha) of North Rim old-growth forests that span from 7,300 to 8,800 feet (2,225 to 2,682 m) in elevation.

Since 1997, 202 permanent plots have been established in Grand Canyon National Park to study the relationships between:

- Fire history,
- Forest structure,
- Fuel load, and
- Understory plant communities.

The 2003 North Rim fires burned 83 plots across the entire elevation range, providing an excellent opportunity to evaluate low- to mixed-severity fire effects.

The North Rim of Grand Canyon National Park contains thousands of acres of unharvested old-growth forests that range from open ponderosa pine groves to dense spruce–fir–aspen stands. These stands provide researchers a unique setting to study the role of fire in forested ecosystems.

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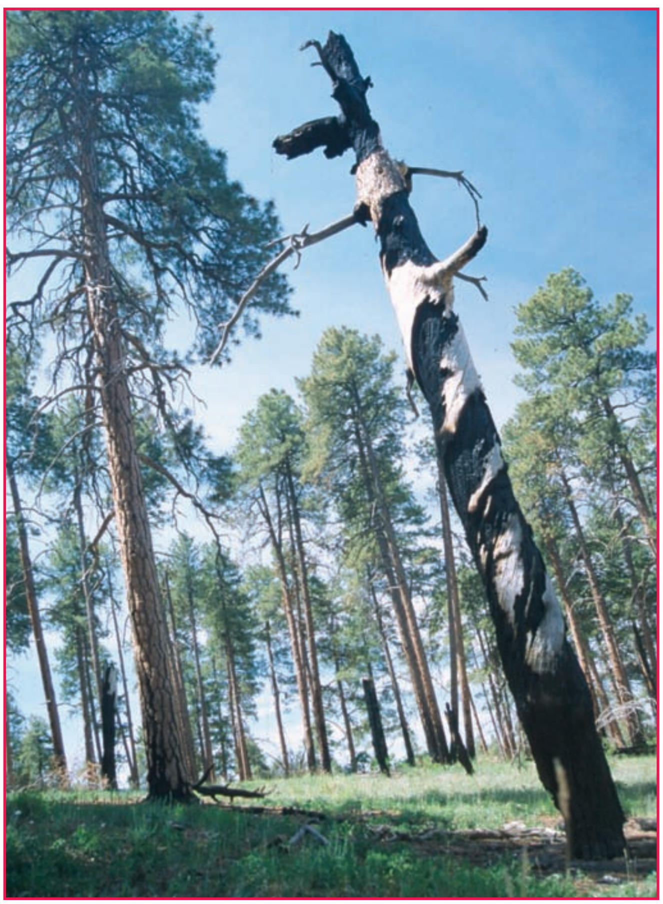
Three WFU Fires

In 2003, three lightning-initiated fires were managed by the USDI National Park Service as WFU fires to meet resource objectives:

1. **The Powell Fire.** This low-intensity surface fire occurred in lower montane ponderosa pine-Gambel oak forest (see photo), which has burned naturally several times in the past century (Fulé and others 2002, 2003a).

2. **The Rose/Big Fire Complex.** This was an intense surface fire



Old-growth ponderosa pine trees and standing snag on the recently burned Powell Plateau, Grand Canyon National Park. Photo: D. Laughlin, 2004.

with high scorching in upper montane mixed-conifer forest, which has been invaded by fire-intolerant white firs (Fulé and others 2004).

3. **The Poplar Fire.** This was a mixed-severity fire in spruce–fir–aspen forests that have not burned in more than a century, which is not out of the historic range of fire return intervals for subalpine forests (Turner and Romme 1994; Fulé and others 2003b).

These wildland fire use fires have important management implications for Federal land management agencies.

To evaluate fire effects—with funding from the six-agency partnership Joint Fire Science Program and the USDA Forest Service—we measured all of the permanent plots that burned in these three fires and nearby unburned reference plots. In each plot we:

- Recorded the species and diameter of trees,
- Measured fuel loads using planar transects, and
- Measured plant cover and species composition of the understory plant community.

Management Implications

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Evaluating Wildland Fire Use Fire Effects

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Three 2003 Grand Canyon National Park fires burned 83 plots across the park's North Rim old-growth forests that range from open ponderosa pine groves to dense spruce–fir–aspen stands at 7,300 to 8,800 feet (2,225 to 2,682 m) elevation.

Ignited by lightning, these fires were managed by the U.S. Department of the Interior (USDI) National Park Service as wildland fire use (WFU) to meet resource objectives. As outlined below, they provided an excellent opportunity to evaluate low- to mixed-severity fire effects.

Forest Structure

The low-intensity fire in the ponderosa pine forest reduced total tree densities but did not significantly reduce total basal area because small trees (less than 5 cm) were disproportionately killed. The mixed-severity fire in the spruce–fir–aspen forests reduced both density and basal area of the forest and trees across all diameter classes.

Three of the 18 plots at high elevation incurred more than 90-percent tree mortality. Our permanent plots might underrepresent the actual proportion of high-severity fire in the Poplar Fire. Across all elevations, larger trees had a higher probability of survival than small trees. Pine and Douglas-fir had a higher probability of surviving the fire than aspen, white fir, Engelmann spruce, or subalpine fir.

Fuel Load

Forest floor depth (litter + duff) declined by an average of 43 percent in the ponderosa pine forest and 64 percent in the spruce–fir–aspen forests. Fine woody debris, material less than 3 inches (7.6 cm) in diameter, was also reduced by 35 percent and 40 percent, respectively. Coarse woody debris went down by an average of 40 percent in the ponderosa pine forest and 60 percent in the spruce–fir–aspen forests.

After burning, coarse woody debris averaged 4 tons/acre (9t/ha) in the ponderosa forest and 10 tons/acre (22t/ha) in the spruce–fir–aspen forests. In contrast, unburned control sites increased in coarse woody debris loading over the same time period, reaching levels of 10 tons/acre (22t/ha) in the ponderosa forest and 21 tons/acre (47t/ha) in the spruce–fir–aspen forests.

Understory Vegetation

In ponderosa pine forests, understory plant species richness and cover increased slightly 2 years after the fire, but was not much different than unburned forest. This suggests that old-growth ponderosa pine forest plant communities are resilient to changes in plant abundance following surface fire.

land management agencies. They were successful, both in terms of logistical operations and ecological outcomes. Unless they can meet resource objectives, WFU fires are not allowed to burn.

Our study's results suggest that many key objectives were met:

- Forest densities were reduced and large old-growth trees—especially from fire-resistant species—survived the fire much better than small, younger trees;
- Forest floor depth was reduced by 43 to 64 percent and coarse woody fuels were reduced by 40 to 60 percent; and
- Native plant cover and richness were not harmed, though community composition was altered toward greater occurrence of native annual plants.

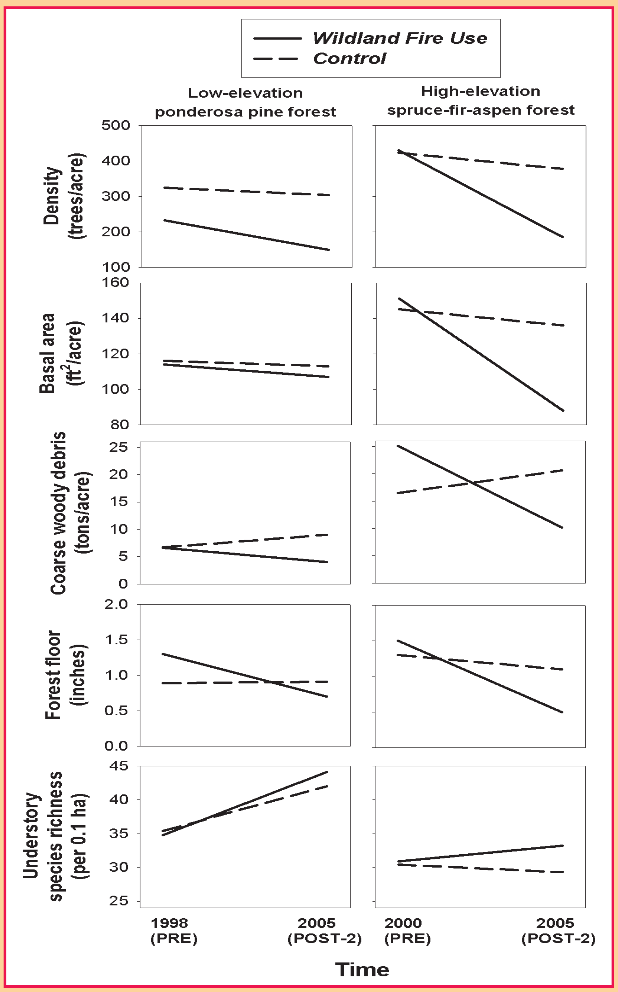
Fire effects were consistent with our general understanding of fire ecology in these systems. The low-intensity fire at low elevation killed primarily small-diameter pines and oaks, whereas the mixed-intensity fires at high elevation burned with greater severity, killing trees across all diameter classes.

> Land managers often face conflicting objectives when managing for native ecosystem dynamics in a time of widespread exotic plant invasions.

The fire induced a shift in community composition toward greater occurrence of native annual forbs. The non-native annual cheatgrass (*Bromus tectorum*), which was present on Powell Plateau well before the fire, increased in frequency across the plateau after the fire.

In spruce–fir–aspen forests, understory plant richness increased slightly in the burned forests whereas richness declined in the control. Community composition shifted dramatically toward greater occurrence of native annual forbs.

Plant species loss increased with fire severity, though most losses were short-lived. This suggests that plant richness and abundance recovered rapidly after the mixed-severity fire in spruce–fir–aspen forests, but the composition of the community is still different than pre-fire conditions.



Changes in forest structure, fuel load, and plant diversity in burned and unburned ponderosa pine and spruce–fir–aspen forests before and after wildland fire use.

Some negative effects, however, also occurred. After the fire, the frequency of cheatgrass increased across the remote Powell Plateau. Cheatgrass has been noted at this site since as early as 1941 (McDougall 1941). We detected a post-fire increase in the burned plots.

Native Ecosystem Dynamics

Land managers often face conflicting objectives when managing for native ecosystem dynamics in a time of widespread exotic plant invasions (Keeley 2006). It is uncertain whether cheatgrass could significantly affect the natural fire regime in ponderosa pine forests, but it can possibly reduce native plant cover and diversity over time.

Now that fuels and forest densities have been reduced by these fires, future ignitions can be managed more easily within these burns due to reduced fire intensities and more manageable fire behavior. Fires on the North Rim have consistently met resource objectives (Fulé and others 2004; Laughlin and others 2004; Huisinga and others 2005), though non-native species invasions and the loss of some old-growth trees in mixed-severity fires are causes for continued monitoring in the park.

Future ignitions can now be managed more easily within these burns due to reduced fire intensities and more manageable fire behavior.

The Grand Canyon's never-harvested forests are an important resource for understanding relatively undisturbed forest dynamics. Based on the results of the 2003 fires, we recommend the continued use and monitoring of wildland fire in these old-growth forests where natural processes can still operate at landscape scales.

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