

**Fire Use Over a Southwestern Elevational Gradient: Effects of 2003 Fires**  
**Summary Final Report to the Joint Fire Science Program, H1200040002**

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**Summary**

Wildland fire use (WFU) is the predominant policy for treating accumulated fuels and restoring the ecological role of fire at Grand Canyon National Park and many other National Park Service (NPS) sites. In 2003, a series of 4 lightning-ignited wildland fires were managed to burn over 19,000 acres on the North Rim. These fires burned over approximately 82 permanent plots (plot methods based on the NPS Fire Monitoring protocol) that had been established within the previous 2-6 years. The burned plots range in elevation from 7,500 to over 8,600 feet, representing all the high-elevation forest types in southwestern forests (ponderosa pine, mixed conifer, aspen, and spruce-fir). A wealth of data already existed about the plot network, including fire regimes, reconstructions of past forest structure, and modeling of changes in canopy fuels and fire hazard over time. We collected post-fire data and analyzed the relationships between pre-fire conditions, fire behavior, and fire effects. The information provided is serving as important input to the current planning processes for fire and resource management at the park, testing our understanding of previously published fire behavior simulations, and contributing to the scientific basis for making decisions about fire use alternatives in the park's forests. The project had the following four objectives:

- 1) *Remeasure approximately 82 permanent plots to assess effects of 4 wildland use fires in 2003. Plots range from ponderosa pine forest (~ 7,500 ft elevation) to mixed conifer to spruce-fir and aspen forest (~ 9,000 ft elevation).*

These plots were remeasured and trees were followed for two years post-fire, not just one. We also added 43 unburned plot at companion sites at low and high elevation. With separate funding, we added a study of the responses of the understory plant communities at the low- and high-elevation sites.

- 2) *Evaluate fire effects across a broad spectrum of forest and fuel variables (overstory trees, regeneration, forest floor and coarse woody debris), comparing the measured changes with detailed fire behavior and mapping information.*

At the low-elevation ponderosa pine-Gambel oak site, tree density declined significantly in the burned area, but basal area was unchanged. At the middle-elevation mixed-conifer site (which did not have an unburned companion) and the high-elevation spruce/fir/aspen site, both density and basal area declined. The thinning effect of fire was concentrated on smaller, shorter, and fire-susceptible trees.

Small-diameter trees (< 20 cm diameter at breast height) made up 79%-95% of all tree mortality. Shade-tolerant coniferous species favoring mesic conditions, especially true firs and spruce, experienced disproportionate mortality (31%-82% basal area decline), while fire-resistant ponderosa pine and Douglas-fir tended to survive (2%-8% basal area decline). Delayed mortality, trees on the burned sites that died between 2004, the first growing season following the fires, and 2005 accounted for only 4.2% of trees dying at the low site, but 15.6% and 11.2% at the middle and high sites, respectively. Regeneration density and forest floor depth and woody debris generally declined more sharply in burned than unburned areas, but patterns were more variable than the changes in overstory tree structure.

- 3) *Compare the actual effects of the wildland use fires with published pre-fire estimates of potential fire behavior.*

Fire intensity (measured by maximum bole char) and severity (basal area mortality) increased in mean and variability with increasing elevation. This pattern was similar to the natural pattern of fire behavior on these landscapes prior to recent anthropogenic disruption of fire regimes: moister conditions at higher elevations facilitated the development of mesic, productive forest types that burned less frequently but with greater severity than the xeric, lower-elevation forests. In an ongoing portion of the study, we are currently proceeding to compare the pre-fire simulations with ground-based and satellite-based assessments of fire severity.

- 4) *Summarize the consequences of the 2003 fires for input to ongoing assessments of wildland fire and resource management plans.*

Even though an unusually long fire-free period (1880-2003) had occurred at the middle- and high-elevation burned sites, fire effects were consistent with restoration of historical patterns, moving the ecosystems closer toward historical reference conditions while simultaneously reducing the living, dead, and ladder fuels that made the forest vulnerable to uncharacteristically severe fire. These changes help make the forests more resistant to the expected increases in fire size and severity under future climate conditions.

**Deliverables (proposed and accomplished) are summarized in the following table:**

Proposed	Accomplished
Measurements on 82 permanent plots burned in WFU fires in 2003	<b>Completed.</b>
	<b>Additional accomplishment:</b> added measurement of 43 plots on unburned companion sites to improve statistical reliability of the study.
	<b>Additional accomplishment:</b> repeated tree condition measurements over two years to better assess delayed mortality from the fires.
	<b>Additional accomplishment:</b> obtained separate funding

	for a companion project measuring understory plant community changes at the same sites. Prepared manuscript for publication.
Detailed assessment of the effects of the 2003 wildland use fires: change in fuels, forest structure, short- and long-term ecological implications, differences over the elevational gradient.	<b>This report.</b>
Comparison of observed to expected fire behavior, based on the previously-funded JFSP fire behavior modeling analysis.	<b>In progress</b> , expected December 2006.
Annual progress summaries to JFSP	<b>Completed.</b>
Publication of technical notes in a forum suitable for a broad audience of managers, such as <i>Fire Management Today</i> or <i>Park Science</i> .	<b>Draft manuscript has been completed.</b> We expect to submit it by June 2006.
	<b>Additional accomplishment:</b> presentations to resource management professionals, researchers, community stakeholders, and students in Arizona, New Mexico, Colorado, and Spain.
Presentation of all products online through Northern Arizona University websites.	The products from this research project as well as our previously funded JFSP work are available online at: <a href="http://www.eri.nau.edu/cms/content/view/794/1006/">http://www.eri.nau.edu/cms/content/view/794/1006/</a>
Transfer of all permanent plot data in electronic form to Grand Canyon National Park (as was done with the pre-fire data collected with JFSP support).	<b>In progress.</b> We are preparing the new dataset to be added to the previous data, in cooperation with Lori Makarick at Grand Canyon.
Field trips with GCNP, Kaibab National Forest, and other resource professionals.	<b>Several field trips were completed</b> with staff from GCNP fire management (Ed Hiatt), the North Kaibab Ranger District, and students from Northern Arizona University and Vassar College. A large trip to the site is planned for the Natural Areas Conference in September, 2006.
GCNP staff will ensure that the data are fully utilized because this proposal represents a collaboration among the two major units concerned with fire management issues at the park: resource management and fire management.	<b>Completed.</b> Preliminary and final data from this project are being used in the ongoing fire management planning process at Grand Canyon.

### Presentations:

Fulé, P.Z. Restauración de bosques adaptados a incendios frecuentes. Seminar presentation, CREAM (Centre de Recerca Ecologica i Aplicacions Forestals), Universitat Autònoma de Barcelona, Bellaterra (Barcelona). March 8, 2006, Catalunya, Spain.

- Fulé, P.Z. Gestión de fuego y restauración de bosques: Norteamérica, México, España. Guest lecture, course in wildland fire management, Universitat de Lleida. February 6, 2006, Lleida, Spain.
- Fulé, P.Z. Gestión y usos de bosques en norteamérica. Guest lecture, class in forest management, Universitat de Barcelona. November 23, 2005, Barcelona, Spain.
- Fulé, P.Z., D.C. Laughlin, and C. Crocker-Bedford. Wildland Fire Use Effects Across an Elevation Gradient. Poster presentation at 2005 JFSP Principal Investigator Workshop, November 1-3, San Diego, CA.
- Fulé, P.Z. Fire and forest restoration. Forest Restoration Workshop, Jobs and Biodiversity Coalition, April 21, 2004, Silver City, NM.
- Fulé, P.Z. Fire and restoration in the greater Grand Canyon region. Colloquium in the Life Sciences, Colorado State University, Fort Collins, CO, March 1, 2004.

**Field trips:**

- Southwestern forest tour, Vassar College, Biology class, October 22-23, 2003.
- Tours with Northern Arizona University students, GCNP and Kaibab National Forest staff (2003-2005, dates not recorded).
- Tour for Natural Areas Conference, September, 2006.

**Publications (in preparation):**

- Laughlin, D.C., and P.Z. Fulé. Stability of understory plant communities following native disturbance in fire-adapted forests.
- Fulé, P.Z., and D.C. Laughlin. Effects of Wildland Use Fires across an elevational gradient, Grand Canyon National Park.