Lessons From the Fires of 2000: Post-Fire Heterogeneity in Ponderosa Pine Forests

Natasha B. Kotliar[1], Sandra L. Haire[1], and Carl H. Key[2]

Abstract—*We evaluate burn-severity patterns for six burns that occurred in the southern Rocky Mountains and the Colorado Plateau in 2000. We compare the results of two data sources: Burned Area Rehabilitations Teams (BAER) and a spatial burn-severity model derived from satellite imagery (the Normalized Burn Ratio; NBR). BAER maps tended to overestimate area of severe burns and underestimate area of moderate-severity burns relative to NBR maps. Low elevation and more southern ponderosa pine burns were predominantly understory burns, whereas burns at higher elevations and farther north had a greater component of high-severity burns. Thus, much, if not most, of the area covered by these burns appears to be consistent with historic burns and contributes to healthy functioning ecosystems.*

Concern that the size and severity of the 2000 fires were "beyond the range of natural variability" in ponderosa pine (*Pinus ponderosa*) and mixed conifer systems has provided justification for ecological restoration programs. However, little is known about the spatial heterogeneity resulting from recent or pre-historic fires. Here we evaluate the effects of burn-severity patterns on landscape heterogeneity for burns that occurred in the southern Rocky Mountains and the Colorado Plateau in 2000. We compare the results of two data sources: Burned Area Rehabilitation Teams (BAER) and a spatial burn-severity model derived from satellite imagery.

Burn-severity maps were developed using the Normalized Burn Ratio (NBR). NBR is derived from comparisons of pre- and post-fire Thematic Mapper imagery (30 m resolution). Band 4 (near infrared) reflects changes in vegetation greenness and soil moisture, whereas band 7 (mid infrared) reflects soil type and moisture levels. Band 4 tends to decrease post-fire, whereas band 7 tends to increase post fire. NBR is based on the inverse relationship between bands 4 and 7: NBR = (band 4 – band 7)/(band 4 + 7). Delta NBR values are derived from differences in pre- and post-fire NBR scores, which in turn can be used as an index of burn severity (higher delta NBR indicates higher burn severity). The NBR methodology was developed to be repeatable and quantifiable, and it offers several advantages for quantifying burn severity compared to BAER maps, which are designed for rapid assessment and targeting of high-severity burns for rehabilitation (table 1).

We created burn severity maps using delta NBR for six burns (figure 1): Bobcat Gulch and Hi Meadow in Colorado, Viveash and Cerro Grande in New Mexico, and Outlet and Pumpkin in Arizona. Burns in general were dominated by ponderosa pine (*Pinus ponderosa*), but Douglas-fir (*Pseudotsuga menziesii*), aspen (*Populus tremuloides*), subalpine fir (*Abies lasiocarpa*), and Engelmann spruce (*Picea engelmannii*) were also present at some burns. Subalpine fir and Engelmann spruce were dominant at Viveash and at higher elevations at Outlet.

Preliminary analyses indicate that in general, BAER maps corresponded fairly well to NBR maps at these burns, but there were several discrepancies (table 2). At the southernmost burns (Pumpkin and Cerro Grande), which

[1]US Geological Survey, Fort Collins Science Center, Fort Collins, CO.
[2]US Geological Survey, USGS - Glacier Field Station Science Center, c/o Glacier National Park, West Glacier, MT.

Table 1—Comparison of attributes of six burn-severity maps created by Burned Area Rehabilitation Teams (BAER) and the general Normalized Burn Ratio (NBR) method.

BAER	NBR
Targets areas of high-severity burns for rehabilitation	All burn severities addressed equally
Categorical data (unburned/low, moderate, and high severity)	Continuous data
Burn-severity polygons	Grid of 30 m^2 pixels
Subjectivity involved in boundary definitions and severity classification; variation among burns in methodologies and data sources	Standardized methodology

were dominated by ponderosa pine, at least half of the area was classified as a low-severity burn by NBR. At these burns, BAER maps tended to underestimate areas of moderate-severity burns and overestimate high-severity burns compared to NBR. Outlet (large areas of aspen / spruce / fir forests) and Hi Meadow (upper montane ponderosa pine / Douglas-fir) were still predominated by low-severity burns, but moderate- and high-severity burns comprised a greater proportion of the burns than Pumpkin and Cerro Grande. BAER and NBR were similar at Outlet, but BAER maps indicated greater high-severity and less low-severity burns than NBR at Hi Meadow. Bobcat Gulch was similar to Hi Meadow, but had a fairly even distribution of area across all burn severities. BAER maps indicated greater high-severity and less moderate-severity area burned than NBR maps. Viveash (predominantly spruce / fir) was the most severe of all six burns and was largely a high-severity burn. The area of moderate-severity burn at Viveash was lowest in BAER maps. Visual comparisons of BAER vs. NBR maps indicate that small-scale patchiness is missed by BAER maps, and may reflect the differences observed in the two mapping techniques. The BAER mapping process may underestimate moderate-severity patches in particular, which tend to be relatively small.

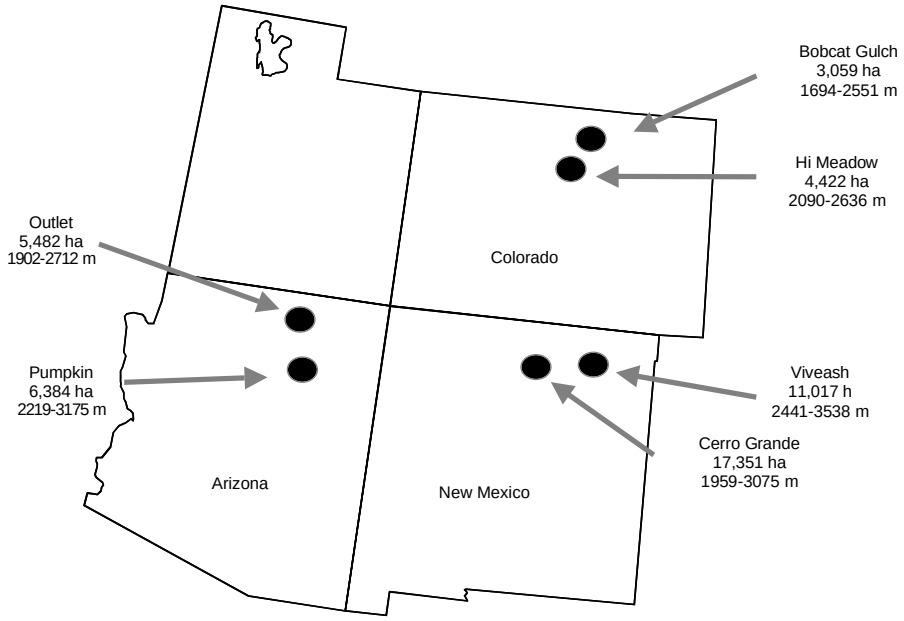

Figure 1—Burns of 2000. Approximate locations and area of study sites.

Table 2—Area (%) of burn severity classes using BAER and NBR methodologies.

		BAER burn severity			NBR burn severity[1]		
Burn	**Dominant cover types**	Low	Moderate	High	Low	Moderate	High
Pumpkin	Ponderosa pine	71%	2%	26%	65%	15%	20%
Cerro Grande	Ponderosa pine	57%	8%	34%	60%	20%	20%
Outlet	Ponderosa pine Spruce/fir	39%	34%	23%	40%	30%	25%
Hi Meadow	Ponderosa pine/Douglas-fir	2%	53%	45%	45%	35%	20%
Bobcat Gulch	Ponderosa pine/ Douglas-fir	30%	25%	45%	33%	33%	33%
Viveash	Spruce/fir	41%	11%	48%	15%	20%	65%

[1] Because NBR burn-severity values are continuous, we estimated the approximate area in each burn-severity category to compare to BAER categorical data.

Pronounced overall differences were observed among the six burns, which likely reflects variation in cover types, fuels, historic fire regimes, elevation, and topography. Lower elevation and southern sites (e.g., Pumpkin and Cerro Grande) had the greatest area of low-severity burns compared to higher elevation (e.g., Viveash) and northern sites (e.g., Bobcat Gulch and Hi Meadow). Although it has repeatedly been suggested that recent burns are beyond the range of natural variation, much, if not most, of the area covered by the burns are consistent with our current understanding of historic fire regimes. This is especially true of the burns occurring in more northern latitudes and higher elevation (Brown et al. 1999; Veblen et al. 2001).

It is important to recognize that although portions of some burns (e.g., Cerro Grande and Pumpkin) may have burned hotter than most fires in southwestern ponderosa pine forests prior to Euro-American settlement (Allen et al. 2002), large portions of these burns did not. Indeed, the area of these burns in low and moderate severity classes performed the desired functions of many prescribed fires. Furthermore, the broad spectrum of burn severity observed across the six burns is important for the integrity of ecological communities (Kotliar et al. 2002). Thus, taken overall, these burns were not as extreme or destructive as has been frequently suggested. Although restoration of historic forest structure to reduce the risk of wildfire may be justified in the wildland-urban interface, the premise that current wildland fires are beyond the range of natural variability and need to be controlled may not always be valid.

References

Allen, C.D.; Savage, M.; Falk, D.A.; Suckling, K.F.; Swetnam, T.W.; Sculke, T.; Stacey, P.B.; Morgan, P.; Hoffman, M.; Klingel, J.T. 2002. Ecological restoration of southwestern ponderosa pine ecosystems: a broad perspective. Ecological Applications. 12: 1418-1433.

Brown, P.M.; Kaufmann, M.R.; Shepperd, W.D. 1999. Long-term, landscape patterns of past fire events in a montane ponderosa pine forest of central Colorado. Landscape Ecology. 14: 513-532.

Kotliar, N.B.; Hejl, S.; Hutto, R.L.; Saab, V.A.; Melcher, C.P.; McFadzen, M.E. 2002. Effects of fire and post-fire salvage logging on avian communities in conifer-dominated forests of the western United States. Studies in Avian Biology. 25:49-64.

Veblen, T.T.; Kitzberger, T.; Donnegan, J. 2000. Climatic and human influence on fire regimes in ponderosa pine forests in the Colorado Front Range. Ecological Applications. 10: 1178-1195.